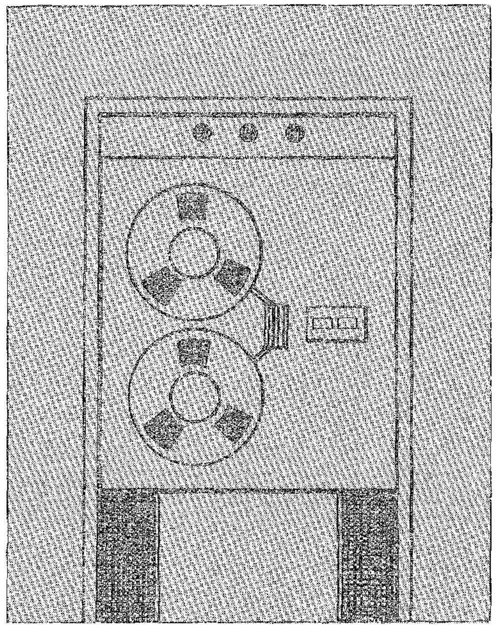
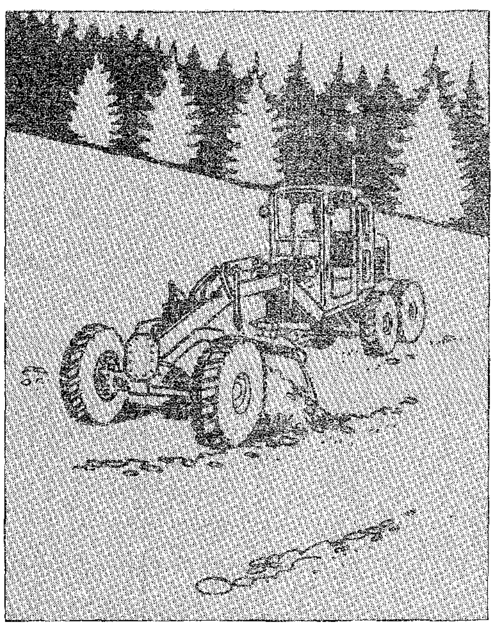
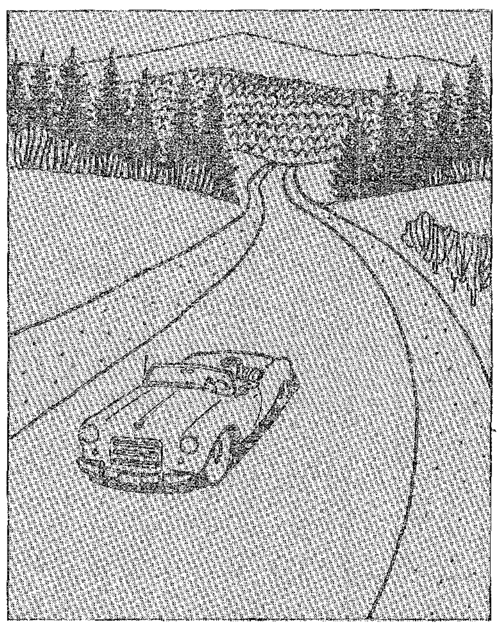
guide for manual of instructions for traffic surveys







U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration

Beginning in 1969 the U.S. Federal Highway Administration and the Direccion Nacional de Vialidad of Argentina, have carried on a cooperative program for the development of an efficient "*Rural Highway Planning System.*" This series of manuals are a result of that work.

Upon completion of the FHWA Mission in Argentina, this "*Rural Highway Planning System*" was almost completed and in the Spanish language. It was, therefore, decided this "planning system" had the potential of being of great value for use in other countries, especially Spanish-speaking countries. Therefore, the Federal Highway Administration has reworked the manuals and computer programs to make them more adaptable and published the manuals in both English and Spanish.

This project is indebted to the members of the FHWA Division who worked in Argentina and the engineers of the Vialidad Nacional who cooperated with the development of this work. Particular credit must be given to Leon E. Litz and John D. Cutrell who were responsible for the final revisions and publication of these manuals.

Norbert T. Tiemann
Federal Highway Administrator
U.S. Department of Transportation

Guide for

MANUAL OF INSTRUCTIONS

for

TRAFFIC SURVEYS

1976

An effective highway transportation planning process is the basis for, and is a necessary continuous part of efficient highway transportation management. This series of manuals and accompanying computer programs were developed to provide guidelines for establishing a system and the basic data collection programs and analysis that are a necessary beginning for accomplishing such a planning process. This series of manuals includes:

1. Outline of the Highway Transportation Planning Process
2. Guide for a Manual of Instructions for Road Inventory
3. Guide for a Manual of Instructions for Traffic Surveys
4. Guide for a Functional Classification of Highways
5. Guide for a Manual for Highway Adequacy Rating
6. Measuring Highway Improvement Needs and Priority Analysis
7. Computer Program User's Manual

It should be acknowledged that many of the procedures as described in these manuals have been taken from, or patterned after numerous published sources. Included in these sources are publications of the U.S. Federal Highway Administration, State Highway Departments and the U.S. National Association of County Engineers.

This manual describes in detail the process for inventorying the use of highways. Included in the inventory is the volume, distribution of type, and weight characteristics of the traffic using the highways. This information is needed during the process of planning, designing, and operation of an efficient highway program.

Table of Contents

THE TRAFFIC INVENTORY

A. INTRODUCTION

The planning of a highway improvement program should start with a foundation of knowledge about the physical nature and use of the existing highway system. This information is collected during the inventory process. This includes the inventory of the physical features and condition of the highways, as well as the use to which each section of highway is put. The inventory of the physical features and conditions are subjects of other manuals. This manual will outline the procedures to inventory highway use. The manual will be in three parts as follows:

1. *Mechanical Counting*—This section includes instructions for making traffic volume counts.

2. *Classification Counting*—This section includes instructions for making the necessary counts to determine the distribution of motor vehicles by type using the highways.

3. *Truck Weighing*—This section includes instructions for undertaking a truck weighing program to determine the weight characteristics of the different types of motor vehicles using the highways.

The inventory programs as described above will provide the minimum basic information needed to plan and operate an efficient highway transportation program.

B. METHOD

This manual will not make recommendations regarding the organization that will be needed to undertake the detailed operational procedures for accomplishing a traffic inventory. These are normally problems that have to consider local conditions and organizational practices for solution. It is the objective of this manual to assist in determining the number and location of counting or weighing stations that will be needed, and the length of time that each should be occupied. Also, included are examples of field forms upon which the traffic data should be recorded, and the instructions for completing these forms. These formats must be used in order to utilize the package of computer programs that have been developed to analyze the data. See the "Users Manual for Computer Programs" for examples of the outputs that will be produced by these programs.

The traffic surveys as described in this manual are comprehensive in scope and are recommended when a new territory or country is being studied for the first time. Such an extensive program may also be considered, if a resurvey is being made after a lapse of counting for several years, or because of a major change in economic conditions, etc. After the comprehensive traffic survey has been underway for three or four years, under normal conditions, it can be substantially reduced.

The Highway Planning Department should continually evaluate the costs of collecting and analyzing different types of data. These costs should then be compared to the value of the uses to which the data are put. If the costs of collecting a certain type of data exceeds the value of its use, one of the following solutions should probably be considered.

1. The program should be reduced in proportion to its need, and or,

2. A cheaper method for collecting the information should be explored, using latest technological advances.

I. MECHANICAL COUNTING

A. INTRODUCTION

The volume of traffic that is using each section of highway is basic information that is needed in the planning, design, maintenance, traffic control, programming, and general administration of a highway program. Therefore, the objective of a mechanical traffic counting program is to obtain, at a minimum of cost, the data that is needed to make estimates of traffic volumes which are within acceptable tolerances of accuracy.

Absolute accuracy in measuring traffic volumes on every section of highway would require counting vehicles continuously on those sections. Such a program would be prohibitively expensive. With the recurring pattern of traffic flows, daily, weekly, and seasonally, it is possible to utilize recognized statistical techniques which will provide volume figures for a minimum expenditure of manpower and money with the desired degree of accuracy.

Estimates of traffic volumes utilizing these techniques can be made by correlation of information obtained at selected locations representative of many kilometers of highways where traffic is counted. The three types of mechanical traffic counts are:

1. *Continuous Counts*—These counts are obtained, as the name implies, at locations where an automatic vehicle detector or sensor, recorder, and sometimes memory device are installed to count and record the number of vehicles passing a location during each hour (or some lesser period if desired) for each day throughout the year and normally over a number of years.

2. *Seasonal Counts*—These counts are made on sections of highways to determine which seasonal traffic pattern or group the section belongs to. Normally, after the determination has been established, the count is discontinued. These counts are made using automatic traffic detectors and recorders, usually for seven consecutive days and repeated on a predetermined schedule of *six, or twelve times each year.*

3. *Coverage Counts* — These counts are needed at each location that an estimate of ADT is desired. Traffic volume information is needed at sufficient locations to be representative of each significant section of each system of highways. Automatic traffic detectors and recorders may also be used at these locations, installed for a period of 24 or 48 consecutive hours, usually once each year. It should be noted, however, that the smaller, accumulative (non-recording) type mechanical counters are usually used to make coverage counts of short duration. These accumulative counters are much cheaper, easier to haul, and require less time to put into operation and to pick up. The disadvantage is that the counts are not mechanically recorded at periodic intervals. It is, therefore, more difficult to get counts of exactly 24 or 48 hours. It is also more difficult to detect if there has been an error in the count.

The number of counting locations that any country will need for comprehensive coverage will depend primarily upon the diversity of travel patterns within the country. An efficient and accurate method for determining the traffic patterns and guidance on the number and location of count stations are described in the "Guide for Traffic Volume Counting Manual." This guide which was prepared by the U.S. Federal Highway Administration, includes detailed guidelines on procedures to follow for developing an efficient mechanical traffic counting program.

B. METHOD

A copy of the "Guide for Traffic Volume Counting Manual" is included as Appendix C.

II. CLASSIFICATION COUNTING

A. INTRODUCTION

In order to be able to plan, design, construct, and operate an efficient system of highways, it is important to have accurate estimates of the present and future traffic demand on this system. This needed traffic information includes traffic volumes, physical characteristics, and weight characteristics of the highway travel. This section of the traffic inventory manual concerns determining the distribution of vehicles by type that are using each section of highway.

Vehicles of different sizes and weights have different operating characteristics which must be considered in highway design. Besides being heavier, trucks generally are slower and occupy more road space; and consequently, impose a greater traffic load on the highway than do passenger vehicles. The overall effect on traffic operations of one truck is often equivalent to several passenger vehicles. Thus, the larger proportion of trucks in a traffic steam, the greater the traffic load, and the more highway capacity is required. Therefore, this information is of particular importance when determining the geometric and structural design of the highway facility and in determining its economic values. It is also basic to the determination of ton-miles of commodity movement by highway, and is necessary information for the solution of most all highway economic and design problems.

B. METHOD

At the present time the primary method used for motor vehicle classification is by observation. Manually counting the distribution of vehicles is generally considered expensive, and more efficient machine methods have been developed. However, most existing classification counting programs are still being accomplished using manual methods.

The program outlined below may be considered as a maximum practical scope. It is recommended only when a new territory or country is being studied for the first time. The recommended number of stations and duration of counts for a comprehensive program are as follows:

1. At continuous count and seasonal control stations located on roads having an average volume of 2,000 or more vehicles per day, 24-hour counts on two weekdays; one Saturday, and one Sunday, are made four times a year seasonally spaced. This would total 16 full days count each year.

2. At the remaining continuous count stations, 16-hour, ordinarily at 6 a.m. to 10 p.m., counts should be made on one weekday, one Saturday and one Sunday, four times during the year, seasonally spaced.

3. At the remaining seasonal control stations, 8-hour counts, ordinarily 10 a.m. to 6 p.m., should be made on one weekday four times during the year, seasonally spaced.

4. Classification data may also be collected for special requirements as needs of the highway department. Such special studies are usually to provide information on a one-time basis rather than continuing basis.

5. Vehicle classification counts should, also, be made in conjunction with the truck weight study. As a minimum, classification counts should be made during the same period as the weighing operations. It is desirable, however, that the classification counts should be made for a 24-hour period encompassing the period in which weighing operations are conducted.

6. After 2 or 3 years data are available using the above schedule it should be statistically analyzed to determine how much the program may be reduced without significantly reducing the accuracy of the data.

The data collected for this study should be coded on Form CVT 1. See Appendix A for a copy of this form. (See page 13.) The instructions for completing this form follow.

C. FORM CVT 1 CLASSIFICATION OF MOTOR VEHICLES

Form CVT 1 is the field form upon which motor vehicle classification count data are coded. Detailed instructions for completing this form follow.

NOTE: Code a zero under any column where a number is not needed.

CARD TYPE—COLUMNS 1 & 2:

The code 40 will be preprinted on the forms. It identifies the type of card to be used for recording motor vehicle classification data.

DATE—COLUMNS 3 THROUGH 8: The day, month and year that the classification counts are taken are shown in these columns.

DAY OF THE WEEK—COLUMN 9: This column is to show the day of the week that the survey is made using the following code:

Monday =L	Friday =V
Tuesday =M	Saturday =S
Wednesday =W	Sunday =D
Thursday =J	

DURATION OF THE COUNT IN DAYS—COLUMN 10: This column is to show the number of consecutive days that the classification count is taken. For example, if the count is made for only one day, or fraction thereof, a 1 would be coded, if a count is made for two consecutive days, or fractions thereof, a 2 would be coded, etc.

DISTRICT—COLUMNS 11 & 12: Enter the District or State Code:

Example:

01 Buenos Aires (North Zone)	14 San Luis
02 Cordoba	15 Misiones
03 Tucuman	16 Santiago del Estero
04 Mendoza	17 Entre Rios
05 Salta	18 Chaco
06 Jujuy	19 Buenos Aires (South Zone)
07 Santa Fe	20 Rio Negro
08 La Rioja	21 La Pampa
09 San Juan	22 Formosa
10 Corrientes	23 Santa Cruz
11 Catamarca	24 Tierra del Fuego
12 Neuquen	
13 Chubut	

STATION NUMBER—COLUMNS 13 THROUGH 15: After the vehicle classification program has been developed, the location of each station is usually plotted upon a map and given a number. The station number is then coded under these columns.

JURISDICTION—COLUMN 16: Jurisdiction (or level of government which has responsibility for the road) is coded in this column.

Example:

1 National	6 National Park
2 Provincial	7 Port Authority
3 Departmental	8 Airport Authority
4 Municipal	Ø Other
5 Military	

ROUTE—COLUMNS 17 THROUGH 20: Enter the route number. Use the route codes which have been developed for the road inventory.

REFERENCE POINT — COLUMNS 21 THROUGH 24: Record in these columns the reference point or milepoint at which the classification count station is located. When it is determined in the field of the exact location that a count will be made, the reference or milepoint of this location can be determined by measuring its distance from the nearest fixed reference which was located during the field inventory.

DIRECTION—COLUMN 25: This column will show the direction of travel of the traffic. When codes 1 and 2 are used, two Forms CVT 1 are completed, one for each direction of travel. When code 3 is used only one Form CVT 1 is used. Code one of the following:

1. Distribution of vehicles for one direction only (ascending mileage—The general direction used when making the road inventory).

2. Distribution of vehicles for one direction only (descending mileage—The opposite general direction used when making the field inventory).

3. Distribution of vehicles for both directions of travel.

HOUR—COLUMNS 26 & 27: Under these columns are coded the hours of the day. Therefore, the number of vehicles that passed the station between midnight and 1 a.m. will be recorded on the first line. The vehicles that passed between 1 a.m. and 2 a.m. will be recorded on the second line, etc.

PASSENGER CARS—COLUMNS 28 THROUGH 31: The number of passenger cars are coded under these columns.

PANELS, PICKUPS & LIGHT TRUCK (4-TIRE)—COLUMNS 32 THROUGH 35: The number of panels, pickups and light trucks (4-tired) are coded under these columns.

BUSES—COLUMNS 36 THROUGH 39: The number of buses are coded under these columns.

(2 AXLE 6 TIRE)—COLUMNS 40 THRU 42: The number of 2 axle 6 tire trucks are coded under these columns.

(3 AXLE SINGLE UNIT TRUCK)—COLUMNS 43 THROUGH 45: The number of 3 axle single unit trucks are coded under these columns.

(2 AXLE TRUCK—2 AXLE TRAILER—COLUMNS 46 THROUGH 48: The number of 2 axle trucks pulling 2 axle trailers are coded under these columns (2–2).

(2 AXLE TRUCK—3 AXLE TRAILER—COLUMNS 49 THROUGH 51: The number of 2axle trucks pulling 3 axle trailers are coded under these columns (2–3).

(3 AXLE TRUCK—2 AXLE TRAILER—COLUMNS 52 THROUGH 54: The number of 3 axle trucks pulling 2 axle trailers are coded under these columns (3-2).

(3 AXLE TRUCKS--3 AXLE TRAILER—COLUMNS 55 THROUGH 57: The number of 3 axle trucks pulling 3 axle trailers are coded under these columns (3–3).

(2 AXLE TRACTOR PULLING 1 AXLE TRAILER—COLUMNS 58 THROUGH 60: The number of 2 axle tractors pulling 1 axle trailers are coded under these columns (2S1).

(2 AXLE TRACTOR PULLING 2 AXLE TRAILER—COLUMNS 61 THROUGH 63: The number of 2 axle tractors pulling 2 axle trailers are coded under these columns (2S2).

(3 AXLE TRACTOR PULLING 2 AXLE TRAILER)—COLUMNS 64 THROUGH 66: The number of 3 axle tractors pulling 2 axle trailers are coded under these columns (3S2).

OTHER VEHICLE TYPES—COLUMNS 67 & 68: The other types of vehicles that cannot be coded under any of the previous columns should be coded under these columns.

CLIMATIC CONDITION—COLUMN 69: The climatic condition that exists during each hour of counting operation should be coded as follows:

1 Good
2 Cloudy
3 Rain
4 Snow
5 Fog

COMMENTS

Describe under comments anything that may effect or be significant to consider when evaluating the counts. For example, an accident or a nearby section of the road under construction may affect the distribution or volume of vehicles and should be noted.

III. TRUCK WEIGHING

A. INTRODUCTION

As previously indicated, accurate estimates of present and future traffic demand is basic information that is needed to properly administer a highway program. Such an administration requires making decisions on such matters as design criteria, equitable tax bases, regulation of vehicle operation, and the determination of the relative position of highway transportation in the national economy. Vital information that is needed during the evaluation of these decisions is to know the intensities and frequencies of loads being applied to the highways, the dimensions of the vehicle, and the commodities carried.

Truck weight studies provide basic information needed for estimating ton-miles of cargo hauled via highway, year to year changes in axle and gross weight frequencies, and comparison of the characteristics of actual usage with administrative policies. These policies include allocations of highway costs and revenue, size and weight evaluations, establishment of geometric design criteria as related to the size and weight of vehicles. The collection of weight data over time, also, provides important indications of changing patterns in transportation by highway in comparison to other modes of transportation.

B. METHOD

The two general methods that are currently used for obtaining weight data are permanent platform scales and portable scales. In countries which are initiating truck weighing programs it is probable that light weight portable scales will be initially used for their truck weighing program for planning purposes. Portable scales may be easily hauled in pickup trucks or other light vehicles. They can be easily moved and require only one man to operate each scale. Most portable scales can only weigh one end of an axle. In order to weigh both ends of an axle, or all axles of a truck or truck combination simultaneously, two or more portable scales must be used in combination. Scales generally may be placed on the roadway or shoulder, and the truck wheels are positioned on the scale platform. For best results, scale sites should be prepared so that scale platforms are level with the roadway.

Platform scales are generally used at permanent locations and primarily for the purpose of enforcing weight and revenue laws. These permanent stations are generally located at points selected to intercept the greatest percentage of truck traffic. These scales may have platforms large enough to weigh the full truck at one time or just single or tandem axles. If these scales are used to collect planning data then enforcement of the weight laws should be discontinued during this period of weighing for planning purposes. This is to ensure obtaining an unbiased sample of the loading practices of trucks using the highway.

1. *Locating Truck Weight Stations*

Selecting a suitable site and proper installation of a truck scale are crucial factors in obtaining reliable truck weight data. For all types of installations, permanent and temporary there are certain basic requirements for obtaining true weights.

The weighing site should be located on a generally straight and level section of road to provide the safety and ease of operation that is necessary. The site should be perfectly level for a minimum of 75 feet upstream and downstream from the center of the scale. This will enable most all vehicles to be on a level plane when being weighed. The centerline of the approaches entering and leaving the scale must also be straight for at least the same distance to assure straight alignment of the longer vehicles while crossing the scale.

Locating weight stations at the end of a long downgrade should be discouraged in order to avoid excessive braking to stop. Brakes will sometimes catch fire on a heavy vehicle that is required to stop near the bottom of a long steep downgrade. Placing the weight stations at the crest of a vertical curve may be satisfactory if proper sight distance, alignment, and level approaches can be provided. The design and placement of prepared sites should be consistent with traffic engineering practices based on traffic volume and speed.

Normally truck weight data for planning purposes is obtained by operating portable scales at various locations for short periods of time during each year. Portable truck weight stations should be located so as to provide data representative of different classes or systems of highways. Other considerations in selecting station locations include traffic volumes, geographic distribution, functional classification of highways, adjacent land use, and distances between stations. Stations should be located so as to minimize bias due to high truck volumes or due to specialized usage or other causes, and should represent different vehicle type mixes within a system to the extent practicable. Care should be taken to locate stations so it is difficult to bypass the stations.

2. *Number of Weighing Stations Needed for Planning Purposes and Operating Schedule*

The following may be used as a guide in determining the minimum number of rural stations required to provide sufficient weight data for planning purposes.

Classification of Highway	*Kilometers (Rural)*	*No. of Stations*
Principal Arterial	Under 800	3
	800–2,000	5
	over 2,000	7
Primary Arterial	Under 2,000	3
	2,000–8,000	5
	over 8,000	7
Secondary Arterial	Under 4,000	3
	4,000–10,000	5
	over 10,000	7
Collectors	Under 8,000	3
	8,000–20,000	5
	over 20,000	7

Additional stations may be added where it is believed the above stations are not sufficient to provide data representative of the loading practices on the different classes or systems of rural roads.

3. *Station Layout*

The following activities should be considered when laying out a truck weight station for planning purposes both permanent and portable:

a—Sampling of trucks
b—Interviewing the truck drivers
c—Measuring activities
d—Weighing activities

Vehicle classification counting is generally accomplished independently of the other truck weighing activities.

When weighing trucks at night, *it is absolutely essential to have adequate lighting.* This is necessary to enable the station personnel to obtain and record the data correctly and efficiently, as well as for the safety of the entire operation.

Roadside signing is important for both permanent and temporary weighing stations. The signing should indicate that the weighing is for planning purposes only and that all trucks are subject to weighing, not just the heavier trucks and no penalties will be levied. As a minimum, signs should instruct truckers to reduce speed, advise that weighing operations for planning purposes only are in progress, and indicate turnoff points.

A flagman will be needed to direct traffic. Signs should be appropriately spaced for the operating speed of the highway.

4. *Period of Operation*

If there has been no previous comprehensive weighing program for planning purposes, the following guideline should be followed:

a. Each station should be operated 16 hours, 8 hours during the period 6 a.m. to 6 p.m., and 8 hours during the period 6 p.m. to 6 a.m., four times a year seasonally spaced on a weekday, except that the night operations may be limited to those roads carrying an important amount of commercial traffic during the night hours. Additional weighing may also be made on Saturday and Sunday if it is believed that the loading characteristics of trucks are substantially different on weekends than on weekdays.

b. After 2 or 3 years data have been collected using the above schedule, it should be statistically analyzed to determine if there is a significant difference in loading practices between hours of the day, seasons of the year, and road systems. If there is not a significant variation in the loading practices the above schedule of operation can be substantially reduced.

5. *Weighing Procedure*

A properly installed and adjusted platform scale is probably the most accurate and dependable method for obtaining static weights of trucks. Prior to commencing weighing operations the weighman should check the zero load balance with no load on the platform; this check should also be made frequently during weighing operations. The total vehicle weight and weights for each axle should be obtained. It is important to obtain weights of each axle of a tandem pair. Research has shown that the total weight carried by a tandem pair is not evenly distributed between the two axles. Weights for individual axles of a tandem pair are obtained by splitting the tandem—weighing the truck with one axle of the tandem on the scale and one off. For large combinations, this procedure will require positioning the truck several times on the scale and taking scale readings for each position. Brakes should be released before taking a weight reading.

Weighing trucks with portable scales presents a number of problems not encountered in platform scale operations. There are several variations in portable scale set-ups that could affect accuracy due to weight transfer even though all factors are favorable. The different methods of setting up portable scales are:

a. Two scales set in a pit so the platform of each scale is level with the approaches. The pit extends the full width of the roadway lane or approach and the scales are so placed that the outside wheels of an axle when resting on the scale platforms will carry the entire weight bearing on that axle. By adding the weight readings for each scale the total weight of the axle is obtained. Each axle of a truck or combination is weighed separately and when added together will give the total weight of the truck or combination.

b. Two scales set on a hard level surface with short ramps on each side of each scale. When a truck or combination is weighed on this set-up, each axle while being weighed would be elevated several inches above the other axles. Obviously there would be an undesirable weight transfer, especially with liquid or fluid loads.

c. Two scales set on a hard level surface with long ramped planks on each side of each scale so that both axles of tandems would be at the same elevation while each is being weighed. This method is an improvement over method "b" but there may still be considerable weight transfer as each axle is moved. There are many types of springs, rubber bumpers and axle suspensions that further complicate efforts to secure true weights on scale set-ups using planks or short ramps.

d. The preferred method is to have four or more scales, one for each wheel, set on a hard, level surface with planks and ramps to keep all axles level and on the same plane while all axles are being weighed simultaneously. Of all the planked set-ups (b, c, or d) this method is probably the most accurate.

The reliability and usefulness of truck weight data depend on the care with which vehicles are weighed. Available data show that for the greatest consistency all wheels of the truck or combination should be on the same horizontal plane with brakes released at the time of weighing. If brakes must be set when weighing with portable scales, they should be released after the vehicle has been stopped on the scales and then reset. To provide reliable data for all axles, the weight of each axle of a tandem axle group should be determined separately since available design and weight information indicate that a large proportion of these assemblies places an appreciably greater load on one of the two axles.

Normally only one weighman is required on a platform scale. With portable scales, one man is required for each scale. Although two men can handle four scales, this practice is not recommended due to the inefficient and slow operation that results.

6. *Measurements*

The distance between axles for each truck weighed should be measured to permit more accurate calculation of pavement and bridge loadings. Axle spacings should be measured with the vehicle components drawn out in a straight line.

7. *Sampling the traffic stream*

It is important that a representative sample of each vehicle type be weighed at each station. The distributions of axle and gross weights by weight intervals and the percentages of loaded vehicles of each type are determined solely from the sample of vehicles selected for weighing. If possible all trucks should be weighed.

A procedure which has been used successfully to assure unbiased probability sampling at locations where volumes are so great that all passing trucks cannot be weighed is suggested. Using this procedure, each shift of operation is subdivided into short intervals. Intervals of 10 or 15 minutes have been used. The frequently occurring vehicles are assigned one or more intervals each hour on a systematic probability sampling basis. During the assigned period every passing vehicle of the designated type is stopped and weighed. Vehicle types for which periods have been designated are not stopped during undesignated periods. Usually the infrequent vehicle types are stopped and weighed during all periods so that 100 percent samples of these types are obtained. Sampling rates which have been practicable at typical locations provide for weighing of 2-axle, 4-tire trucks (both panels and pickup trucks and other 4-tire) during every fourth interval; 2-axle, 6-tire trucks every third interval; weighing of tractor semi-trailer or truck and trailer combinations during three intervals out of every four; and weighing of all other vehicle types during all intervals. Thus, more than one of the vehicle type categories designated for sampling may be designated for a given interval. At lower volume locations it may be desirable to sample 100 percent of all semi-trailer or truck and trailer combinations. Where volumes are extremely high it may be necessary to reduce sampling rates. When a single vehicle or a fleet of similar trucks passes a station several times a day no vehicle need be weighed more than twice, once loaded and once empty, and a sample of three empty and three loaded truck weighings is adequate for the fleet. All passing vehicles should be counted.

When weighing both directions of a highway, three alternate procedures are available. The preferred method is to weigh each direction independently of the other in separate operations; i.e., one or more 8-hour shifts in one direction and one or more 8-hour shifts in the other direction. This procedure is normally used on divided highways. For example, on Monday trucks may be weighed from 6 a.m. to 2 p.m. in one direction. This same operation would be repeated on Tuesday for traffic in the opposite direction. On Wednesday weighing operations may continue in this original direction from 6 p.m. to 2 a.m. This operation would be repeated on Thursday for the opposing traffic. Therefore, a 16 hour weekday sample would be obtained for each direction of travel.

The second method is to weigh two hours in one direction, then weigh two hours in the other direction, etc., until the 8-hour shift is complete. When using this method it is desirable to have two sets of equipment available to minimize change-over time.

The third method is to weigh both directions of traffic at the same time using scales located on one side of the road. If this method is used, extreme care must be taken to provide adequate safety to the traffic. This will require adequate signing and flagmen. This method can be used only on undivided two-lane highways.

8. *Vehicle Classification Counts at Weight Stations*

Manual vehicle classification counts should be made at all truck weighing stations for planning purposes. Counts should be made for both directions of travel and at least during the period that weighing operations are underway. Part II of this manual outlines the procedures and forms to be used for making these manual counts.

C. FIELD FORM AND INSTRUCTIONS FOR CODING

The data collected for this study should be coded on Form PC–1. (See Appendix "B" for a copy of this form.) Instructions for completion of this form follow:

PARTY CHIEF: Write the name of the party chief.

SHEET __ OF __ SHEETS FOR THE HOUR: A new sheet is started when the weighing operations begin for each shift, and, also, for each hour. The sheets are then numbered to show the number of sheets upon which data are recorded for each hour. At the end of each hour the total number of sheets that have been used during the hour can be recorded on each sheet.

CARD TYPE—COLUMN 1: This information will be preprinted on the forms. It identifies that it is the card type that is used upon which truck weight data for planning purposes will be coded.

DATE—COLUMN 2 THROUGH 6: These columns are used to record the date of the survey. Where a number is not needed in any box, a zero should be recorded rather than leaving it blank.

HOUR—COLUMNS 7 AND 8: These columns are used to record the hour during which the data were collected. Again during the first 9 hours of the day a zero will be recorded in column 7 rather than leaving it blank.

DISTRICT—COLUMNS 9 AND 10: Enter the District Code.

Example:

01 Bs. As. (north zone)
02 Cordoba
03 Tucuman
04 Mendoza
05 Salta
06 Jujuy
07 Santa Fe
08 La Rioja
09 San Juan
10 Corrientes
11 Catamarca
12 Neuquen
13 Chubut
14 San Luis
15 Misiones
16 Santiago del Estero
17 Entre Rios
18 Chaco
19 Bs. As. (south zone)
20 Rio Negro
21 La Pampa
22 Formosa
23 Santa Cruz
24 Tierra del Fuego

JURISDICTION—COLUMN 11: Enter the route jurisdiction code.

Example:

1 National
2 Provincial
3 Departmental
4 Municipal
5 Military
6 National Park
7 Port Authority
8 Airport Authority
Ø Other

ROUTE—COLUMNS 12 THROUGH 15: Enter the route number. Use the route codes which have been developed for the road inventory. The route code is the same as the one used for road inventory.

MILE POINT—COLUMNS 16 THROUGH 19: These columns are used to record the location of the weighing station. The location can be determined by using table 9 of the inventory outputs. This table shows the mile point for all primary reference points. The location of the weighing station can be determined by measuring its distance from the nearest reference point.

VEHICLE TYPE—COLUMN 20: The vehicle type should be coded in these columns using the following codes:

Code	*Vehicle Type*
0	Automobiles and jeeps
1	Panels and pickup (4-tire)
2	Single unit truck (2-axle)
3	Single unit truck (3-axle)
4	Single unit truck plus trailer
5	Tractor with semi-trailer
6	Other types of trucks
7	Buses

BODY TYPE—COLUMNS 21 AND 22: These columns are used to record the type of body. The following codes should be used:

Code	*Body Type*
11	*Panel*—A fully enclosed body of limited capacity which includes drivers compartment.
12	*Pickup*—A small open box or express box.
13	*Light utility*—A body designed to carry readily accessible tools, equipment, and supplies in integrally constructed compartments, with or without other cargo spaces.
15	*Carryall or Minibus*—An enclosed utility body with side windows and one or more removable seats designed for transporting either passengers, light cargo, or both. (Station wagons are considered to be passenger cars and are not included in this category.)

GENERAL TRUCK AND SEMI-TRAILER

21	*Platform, Flat, or Stake*—A body having a floor without sides or roof.
22	*Lowbed Trailer*—A truck trailer with a platform body constructed to provide a low loading height and designed for the transportation of extremely heavy or bulky property.
23	*Rack*—A body with fixed slatted sides and headboard.
24	*Livestock Rack*—A rack body with or without roof designed primarily for transportation of livestock.
32	*Open Top Box or Van*—A body with high closed sides and ends and a movable top, which usually is a tarpaulin cover.
33	*Grain*—A low side open box, designed primarily to transport grains or other dry fluid commodities in bulk.
34	*Dump*—A low side open box, designed primarily to transport dry fluid commodities in bulk, which can be tilted to discharge its load.
35	*Hopper*—A body which is capable of discharging its load by gravity or mechanical power through means other than tilting and usually loaded from the top.
41	*Van*—A fully enclosed body designed primarily for transportation of packaged commodities, household goods, etc.
51	*Tank*—A body designed to haul bulk liquid commodities.
91	*Bus*—A body designed for carrying passengers.
99	*Other*—All vehicles which are weighed and the body type cannot be coded using one of the above codes may be coded other.

PLACE OF REGISTRATION—COLUMNS 23 AND 24: The province or State where the vehicle was registered should be coded in this column.

Example:

01	Bs. As. (north zone)	14	San Luis
02	Cordoba	15	Misiones
03	Tucuman	16	Santiago del Estero
04	Mendoza	17	Entre Rios
05	Salta	18	Chaco
06	Jujuy	19	Bs. As. (south zone)
07	Santa Fe	20	Rio Negro
08	La Rioja	21	La Pampa
09	San Juan	22	Formosa
10	Corrientes	23	Santa Cruz
11	Catamarca	24	Tierra del Fuego
12	Neuquen		
13	Chubut		

FUEL TYPE—COLUMN 25: The type of fuel that the engine uses should be coded under this column using one of the following codes:

Code	*Engine Type*
1	Gas
2	Diesel
3	Other

AGE—COLUMNS 26 AND 27: Record the age of the vehicle to the nearest year.

EMPTY WEIGHT—COLUMNS 28 THRU 30: Record the registered empty weight of the truck. This will usually include the weight of the body. The weight is coded in tons and tenths thereof.

Example:

Kilograms	*Code*
1,030	010
3,240	032
11,310	113

TYPE OF COMMODITY CARRIED—COLUMNS 31 THROUGH 33: The type of commodity being carried should be written in the space provided. The code for this commodity will then be entered in the office.

FORM OF CARGO—COLUMNS 34 AND 35: Code the form in which the cargo is being carried under these columns.

Example:

01 Bulk
02 Boxes of Cartons
03 Bottles
04 Barrels or Drums
05 Sacks or Bags
06 Bundled, Banded, Baled, etc.
07 Coiled
08 Planks, Layers, etc.
09 Blocks
10 Tanks
00 Other not specified above

ORIGIN OF CARGO—COLUMNS 36 THROUGH 39: The origin of the cargo should be specified. This origin, province, and city, or (State and city) should be written in the space provided. The code for this place will be entered in the office.

DESTINATION OF CARGO—COLUMNS 40 THROUGH 43: The destination of the cargo should be specified. The destination, province, and city or (State and City) should be written in the space provided. The code for this place will be entered in the office.

NOTE: If the origin and destination of the cargo has many locations, such as a local delivery, freight truck, it should be so noted.

WEIGHT OF AXLES—COLUMNS 44 THROUGH 61: The weight of each axle should be recorded in the respective columns. The weight should be recorded in thousands of kilograms, expressed to the first decimal.

Example:

	Kilograms	*Code*
Axle Weight	470	005
Axle Weight	1,270	013
Axle Weight	11,480	115

HEIGHT—COLUMNS 62 AND 63: The height of the truck or load, whichever is higher, the coding should be recorded in meters and tenths.

Example:

	Meters	*Code*
Measured Height is	2.6	26
Measured Height is	3.14	31
Measured Height is	4.37	44

DISTANCE BETWEEN AXLES—COLUMNS 64 THROUGH 77: These columns are used to record the distance between axles. These columns should be recorded in meters and coded to the nearest tenth of a meter.

Example:

	Meters	*Code*
Measured Length is	2.52	025
Measured Length is	6.72	067
Measured Length is	14.30	143

TOTAL LENGTH OF VEHICLE—COLUMNS 78 THROUGH 80: The total length of the vehicle should be shown in these columns. Measurements should be made from the extremities on each end of the vehicle or combination.

Example:

	Meters	*Code*
Measured Length is	5.00	050
Measured Length is	9.83	098
Measured Length is	18.73	187

HIGHWAY PLANNING DIVISION
TRAFFIC INVENTORY SECTION
VEHICLE CLASSIFICATION STUDY

CARD TYPE [ ][ ] (1 2)   DATE DAY [ ][ ] (3 4)   MONTH [ ][ ] (5 6)   YEAR [ ][ ] (7 8)   DAY OF THE WEEK [ ] (9)   DURATION OF COUNT (DAYS) [ ] (10)

DISTRICT [ ][ ] (11 12)   STATION NO [ ][ ][ ] (13 14 15)   JURISDICTION [ ] (16)   ROUTE [ ][ ][ ][ ] (17 18 19 20)   REFERENCE POINT [ ][ ][ ][ ] (21 22 23 24)

DIRECTION [ ] (25)

HOUR	PASSENGER CARS	PANELS, PICK-UPS & LIGHT TRKS (4 TIRED)	BUSES	SING. UNIT TRKS		SING. UNIT TRK & TRAILER				TRACTOR-SEMI TRAILER			OTHER VEHICLES	COND. CLIMATIC	COMMENTS
				11	12	11 – 11	11 – 12	12 – 11	12 – 12	111	112	122			
26 27	28 29 30 31	32 33 34 35	36 37 38 39	40 41 42	43 44 45	46 47 48	49 50 51	52 53 54	55 56 57	58 59 60	61 62 63	64 65 66	67 68	69	
0 1															
0 2															
0 3															
0 4															
0 5															
0 6															
0 7															
0 8															
0 9															
1 0															
1 1															
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1 5															
1 6															
1 7															
1 8															
1 9															
2 0															
2 1															
2 2															
2 3															
2 4															

APPENDIX A
PLAN CTV 1

CHECKED BY ________ DATE ________

APPENDIX B
FORM PC-1

NATIONAL HIGHWAY DEPT.
DIVISION OF INVESTIGATIONS & TRAFFIC
TRUCK WEIGHING STUDIES

CHIEF ______ | SHEET __ OF __ SHEETS FOR THE HOUR | CARD TYPE [1]

DAY [2 3] | MONTH [4 5] | YEAR [6] | HOUR [7 8]

DISTRICT [9 10] | JURISDICTION [11] | ROUTE [12 13 14 15] | REFERENCE POINT [16 17 18 19]

VEHICLE						LOAD				AXLE WEIGHTS						VEHICLE DIMENSIONS						
																	DISTANCE BETWEEN AXLES					
TYPE OF VEHICLE	BODY TYPE	PLACE OF RGSTR	FUEL	AGE OF VEHICLE	EMPTY WEIGHT	TYPE OF MERCHANDISE	FORM OF CARGO	ORIGIN	DESTINATION	1ST AXLE	2ND AXLE	3RD AXLE	4TH AXLE	5TH AXLE	6TH AXLE	HEIGHT	1-2	1-3	1-4	1-5	1-6	TOTAL LENGTH OF VEHICLE
20	21 22	23 24	25	26 27	28 29 30	31 32 33	34 35	36 37 38 39	40 41 42 43	44 45 46	47 48 49	50 51 52	53 54 55	56 57 58	59 60 61	62 63	64 65	66 67 68	69 70 71	72 73 74	75 76 77	78 79 80
MERCHANDISE						ORIGINATING PROVINCE				CITY OR PLACE					DESTINATION PROVINCE				CITY OR PLACE			
MERCHANDISE						ORIGINATING PROVINCE				CITY OR PLACE					DESTINATION PROVINCE				CITY OR PLACE			
MERCHANDISE						ORIGINATING PROVINCE				CITY OR PLACE					DESTINATION PROVINCE				CITY OR PLACE			
MERCHANDISE						ORIGINATING PROVINCE				CITY OR PLACE					DESTINATION PROVINCE				CITY OR PLACE			
MERCHANDISE						ORIGINATING PROVINCE				CITY OR PLACE					DESTINATION PROVINCE				CITY OR PLACE			
MERCHANDISE						ORIGINATING PROVINCE				CITY OR PLACE					DESTINATION PROVINCE				CITY OR PLACE			
MERCHANDISE						ORIGINATING PROVINCE				CITY OR PLACE					DESTINATION PROVINCE				CITY OR PLACE			
MERCHANDISE						ORIGINATING PROVINCE				CITY OR PLACE					DESTINATION PROVINCE				CITY OR PLACE			
MERCHANDISE						ORIGINATING PROVINCE				CITY OR PLACE					DESTINATION PROVINCE				CITY OR PLACE			
MERCHANDISE						ORIGINATING PROVINCE				CITY OR PLACE					DESTINATION PROVINCE				CITY OR PLACE			

CHECKED BY ______ DATE ______

APPENDIX "C"

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

Bureau of Public Roads

GUIDE

FOR

TRAFFIC VOLUME COUNTING MANUAL

3rd Edition

March 1970

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Glossary of Terms

VPD—(Vehicles per day). Number of vehicles that pass a particular point on the road during a period of 24 consecutive hours.

ADT—(Annual average daily traffic). Annual average number of vehicles during 24 consecutive hours that pass a particular point on the road over the period of 365 days.

Annual average daily traffic is calculated by averaging the average daily traffic for each of the 12 months. The average daily traffic for the month is calculated using the equation:

$$\text{Average day of month} = \frac{\text{5 Av. Weekday} + \text{Av. Saturday} + \text{Av. Sunday}}{7}$$

Where Av. weekday = average daily volume for all weekdays of month
Av. Saturday = average daily volume for all Saturdays of month
Av. Sunday = average daily volume for all Sundays of month

This procedure is considered the simplest feasible method for providing comparable values when counts for certain days are unusable.

Vehicle miles—Normally obtained by multiplying the ADT by 365 and by multiplying the mileage of road to which the ADT is applicable.

Error of estimate—The difference between the estimated value and the true value. The true value is generally unknown.

Estimate of ADT $= y_i$. This is an estimate produced by any estimating procedure.

True ADT $= Y$. This is known exactly at points where machine counts are made continuously all during the year.

Best estimate of true ADT $= Y'$. This is the estimate that is obtained at points that are counted for repeated but intermittent periods of time during the year.

Error of estimate $= y_i - Y$ or $y_i - Y'$. This is the difference between the estimated value of ADT based upon one observation and the "true" value. The "true" value either is known or the best combination estimate based upon several periods of observation.

$$\text{Relative error} = \frac{(y_i - Y)}{Y}\,100 = x_i \quad \text{or} \quad \frac{(y_i - Y')}{Y'}\,100 = x_i$$

Number of estimates of ADT $= n$

Average relative error of estimates of ADT $= \bar{x} = \dfrac{\sum_{i=1}^{n} x_i}{n}$ (Studies indicate that, in a large sample of relative differences, the value of $\bar{x}$ is sufficiently close to zero as to be treated as a negligible quantity.)

Standard deviation $= \sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$ (This is the ordinary statistical formula for the standard deviation applicable to any random sample of observations. When the observations are relative errors of estimates of ADT and x is equated to zero the formula can be simplified as follows:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i)^2}{n-1}}$$

If a zero value is adopted $\pm\sigma$ is approximately equal to ⅔ of the area under the normal distribution curve which is the familiar bell shaped curve.)

Standard error of estimate $= SE = \frac{\sigma}{\sqrt{n}}$ (Since x_i is a percent, both σ and SE are in percent)

Σ = the sum of the quantities within the expression.

Continuous count station—A place along a road where a traffic counting machine is installed for the purpose of counting and recording by periods not longer than one hour, the number of vehicles passing this location for continuous long periods of time, usually several years.

Seasonal control station—A place along a road where a traffic counting machine is installed for the purpose of counting and recording (usually by the hour) the number of vehicles passing this location for repeated intermittent periods of time. These periods, usually of consecutive seven days duration, are repeated on a predetermined schedule which divides the year into four, six or twelve equal periods.

Coverage count station—A place along a road where a traffic counting machine is installed for the purpose of counting the number of vehicles passing this location usually during a period of consecutive 48 or 24 hours. Sometimes coverage counts are extended to 5 consecutive weekdays or 7 consecutive days on primary highways under 2000 ADT. Manual counts are also used for coverage count purposes.

Random selection—Every combination of samples of a given size from a population, no matter how small or how large, has an equal chance of being selected.

68 percent confidence limit—In a non-technical sense, it is meant that the mean value of a particular sample has a chance of being one of 68 in a hundred of being different from the population mean by not more than the value of one standard deviation. A more technical description is as follows:

The purpose for sampling is to estimate some value, (parameter), of the population. A sample mean is an estimate of the mean of the population. As such, it differs from the population value by some unknown amount, which may be as small as zero or very large. Using the sample data, and on the basis of statistical theory, an interval can be calculated around the sample estimate, in which the unknown population value lies. The truth or falsity of that statement for any given sample is unknown. However, theory indicates that if this *process* is repeated many times, then a definite proportion of the interval statements will be true. The confidence that we have in the statement for any one sample is the confidence we have in the proportion resulting from the process. An interval calculated by a process that would yield interval statements that were true 68 percent of the time is a 68 percent confidence interval. The upper and lower bounds of a confidence interval are the confidence limits. The size of the interval is a function of the standard error of estimate calculated from the sample data.

Weekday traffic—The number of vehicles that passes a given point on the road during a consecutive 24-hour period from Monday to Friday inclusive.

Road or highway section—A section of road or highway between two intersections or junctions with other roads or highways. The section may include all lanes for traffic in both directions or the lanes assigned to traffic going in only one direction.

Chapter I.—INTRODUCTION

The purpose of this guide is to provide efficient procedures for making accurate estimates of annual average daily traffic (ADT) volumes based on sample counts.

ADT is a fundamental traffic measurement for the determination of vehicle-miles of travel on the various categories of rural and urban highway systems. ADT values for specific road sections provide the highway engineer, planner, and administrator with essential information needed for the determination of design standards, the systematic classification of highways, and the development of programs for improvement and maintenance. Vehicle-mile values are important for the development of highway financing and taxation schedules, the appraisal of safety programs, and as a measure of the service provided by highway transportation. To realize the full benefits of the efforts involved in obtaining and analyzing traffic data, they must be summarized and promptly made available for widespread use. Only in this way can informed decisions be made so that highway transportation will make its maximum contribution to the economic growth of the State and Nation.

Statistical analysis and experiences in the application of statistically controlled procedures in over 30 States form the foundation upon which this guide has been developed. Measurements of the error of estimate made in these States have indicated that the procedures they had been using, as a rule, resulted in errors as great or greater than those determined by the procedure set forth in this guide. In the majority of these States, the cost of obtaining traffic volumes by using the procedure presented in this guide was less than by the use of their earlier traffic counting methods, particularly when the old procedure involved the use of extensive seasonal machine counts for control purposes.

This guide sets forth methods which can be used to produce traffic volume estimates with the accuracy indicated necessary for design purposes and economic analyses at a minimum of cost and effort.

Only at continuous count stations and under perfect conditions can true ADT be determined with absolute accuracy, assuming no mechanical failures and correct vehicle classification data are available when axle counts must be converted to vehicles. Any count of less than one-year duration must be regarded as a sample. The sample then can be interpreted to bear a certain relation to the ADT or to some other needed measure, and adjustments can be made accordingly.

When a sample is adjusted to represent the ADT, it becomes an estimate of ADT. The measure of accuracy of the estimate is the difference between the estimate and the true average volume of traffic, if known. This difference is the error of estimate.

At coverage stations the true ADT is never known. However by simulating sample coverage counts at continuous count stations where the true ADT is known, the error of estimate of ADT at coverage stations can be approximated by the application of statistical methods. Ordinarily there are no means of knowing the accuracy of an individual estimate. But by using certain statistical principles, the accuracy of a large number of estimates can be determined in terms of probability of frequency of errors of specific magnitude. These magnitudes of errors are attributable to the method of sampling and estimating. Errors due to any imperfections or malfunctioning of traffic counting equipment are not considered in these guidelines.

The effect of these errors remains the same irrespective of the methods used in estimating. Thus, there are objective means of establishing the superiority of one method of estimating over another as far as accuracy of sample estimates of traffic volume is concerned.

Every State has its own problems concerning traffic volume information. There is no single procedure that would solve all these problems. There is, however, a method of attack which, when properly applied, will produce appropriate answers to questions as to the number of stations, length and frequency of counts, and the accuracy of the results. A working knowledge of basic statistical principles and formulas is necessary to develop the most efficient procedures and to extract the maximum accuracy from the data.

Observations indicate that there are substantial differences in the urban and rural variations of traffic volume within specified time periods. Therefore, it is necessary to consider separately counting and estimating of traffic volumes on rural roads and on urban roads and streets.

Chapter II.—RURAL HIGHWAYS

A. Highways with ADT Volumes Greater Than 500

The traffic counting procedure established as a part of the original statewide highway planning surveys, and later modified by the various States to suit individual needs, invariably have produced useful results. In the more than 30 States where the errors of estimates of the ADT have been measured, it was found that the standard deviations of these errors were usually in the ±12 to ±17 percent range for roads carrying approximately 500 ADT or more. As a result of theoretical study, research, and extensive field applications, a basic procedure has been developed which generally reduces the standard deviation of the errors of estimate to ±10 percent for these higher volume roads, always at a reduced cost as compared with previous methods. The procedure that is presented for high volume roads can be divided into three major steps:

1. Grouping continuous count stations into similar patterns of monthly traffic volume variation,
2. Assigning road sections to groups of similar patterns of monthly variation, and
3. Locating and operating traffic counting stations.

These three steps in succession are discussed in this section.

1. *Grouping Continuous Count Stations Into Similar Patterns of Monthly Traffic Volume Variation*

The major premise of the suggested procedure for high-volume roads is that it is possible to establish a series of consecutive road sections having similar patterns of monthly traffic volume variation. Route sections displaying similar patterns may be concentrated in a particular area of a State; other patterns may be found statewide. Road sections which are determined to have similar patterns of monthly traffic volume variation provide the basis for the adjustment of coverage counts made at points within these routes. These coverage counts are adjusted to ADT by means of a group mean factor determined for all the road sections within the group.

A simple way of searching for continuous traffic counting stations with similar patterns of monthly traffic volume variation is the "array method" and is described and illustrated as follows:[1]

a. In Table 1, the monthly adjustment factors (that is, the ratio of ADT to the average weekday traffic of the month), are shown assuming 12 permanent locations of automatic traffic recorders for stations A through L, which represent road sections carrying ADT of 500 vehicles or more. These permanent continuous counting stations are not listed in any particular order.

b. Arrange the factors by months in ascending order, as shown on Table 2.

c. For each month determine a group of stations such that the difference between the smallest and the largest monthly factor does not exceed the range of 0.20 in the values of factors. This is based on

[1] In the illustrative example, coverage counts are made only during the period of April through November. Therefore, adjustment factors for coverage counts are needed for these eight months and only for that period. The similarity of patterns of adjustment factors for a full year is required for grouping of road sections if factors for 12 months are used.

the criterion of ± 0.10[1] from the assumed mean. There are several possible groupings in each month. Determine for each month that group having the largest number of stations within this 0.20 range and designate the separation of these stations by horizontal lines, as shown on Table 2. For instance, for April a group from 1.00 through 1.19 includes 10 stations; whereas, if the groupings were made from 1.19 through 1.38, only three stations would have been included. (Stations outside the horizontal lines often form independent groups with a smaller number of components.)

d. The final grouping should be such that all or as many as possible of the same stations would fall into the same group for each of the months. With this prerequisite in mind, it is found that although stations C, D, and E are within the 0.20 range, between 1.00 and 1.19 in April, they do not fall into the group defined for some other months. For instance, station E with 0.93 is outside the limits of the range 0.64–0.76 in August; also, it is outside the range in July. (Table 3 illustrates the groups finally defined.)

It should be noted that in November station L has a factor 1.36 which is outside of the range 1.10–1.30. Investigation disclosed that in November there was construction which caused a reduction of traffic volume at station L. Also, it was found that in the previous year the factor was 1.19 which would have kept station L well within the range of this group. For these reasons station L was included in group I.

It is also noted that in group I for the month of June the range is 0.21 which indicates that strictly speaking, either station H or station J is outside the range. However, investigation of field records and data from previous years did not disclose any abnormalities of the counts at these two stations. Since the excess over the 0.20 criterion is only .01, obviously it could not have any significant effect on the group mean factor. Therefore, it was decided to keep both stations H and J in group I.

e. For each group compute the average of the factors for each month to arrive at the month group mean factor as shown in Table 4.[1]

The reasons why station L was included have been previously discussed. However, because of the highly localized nature of the construction work which affected the November factor at station "L," the value of 1.36 was not included in the computation of the mean factor of 1.16 for November for group I. For the month of June all seven values were used computing the group mean factor of 0.88. The exclusion of either station H or station J would have affected the value of the mean only by 0.01 which is negligible.

In exceptional cases such as noted in stations H, J, and L, of the example, the .20 range may be slightly deviated from if the condition warrants.

When a computer is available, groupings may be done separately for every month during which vehicle coverage count stations are operated. This would mean that the number of groups would most likely vary from month to month. For instance, from Table 2 it can be seen that there would be only one group in October; only two groups in April, May, June, September, and November; and by rearranging the grouping procedure, July and August can also be placed into two groups.

[1] This $\pm .10$ value should not be confused with the design standard deviation of ± 10 percent in the error of estimate of ADT. The criterion of ± 0.10 is designed to produce a part of the standard deviation of ± 10 percent. The remaining part of this standard deviation of ± 10 percent is attributable to the sampling error.

[1] It should be noted that adjustment factors are in terms of average weekday traffic. Coverage counts are usually made on weekdays; when Saturday and Sunday are included, only the weekday counts should be used for estimating ADT. As a rule, the variations of Saturday and Sunday volumes within a month are greater than that of the weekdays, thus the ADT estimates based on counts which include weekends tend to be less accurate than those based on weekdays.

2. *Assigning Road Sections to Groups of Similar Patterns of Monthly Variation*

Assign a certain color to each group and mark on a map the location of each continuous count station with the appropriate color for its group. This is illustrated on Figure 1. Stations of the same group usually fall along a continuous route or routes. Connect the road sections on these continuous routes designating them by the color of the stations which fall upon it. When grouping is done separately for each month, there should be a map for each month on which the groupings are thus designated.

The number of continuous count recorders is not ordinarily sufficient to assign to pattern groups all road sections in the State with an ADT volume greater than 500. In the majority of the States there are seasonal control stations. These are stations at which traffic counts are made at equally spaced intervals of time during the year. Some road sections which cannot be grouped by continuous count recorders may be classified by seasonal control stations. This is accomplished in the following manner:

a. For each seasonal control station, compute the ratios of the ADT to the average weekday of the month, excluding all holidays during which the count was made. (This is illustrated in Table 5. Note that this is exactly the same procedure illustrated in Table 1 for continuous count stations.)

b. The stations are then arrayed as shown in Table 6. (This is the same procedure illustrated in Table 2 for continuous count stations.)

c. Compare each of the resulting ratios with the corresponding mean determined from continuous count stations. Using the criterion of ±.15[1] difference from the mean ratio of continuous count stations, allocate all seasonal control stations to the groups determined by the analysis of continuous count stations. The resulting allocation is shown in Table 7. An example of assigning a seasonal control station to a group follows:

Station 5 is shown in group I in Table 7. By reference to Table 5 the ratio for the month of April is .97. As shown in Table 4 the mean April factor for group I is 1.11. Thus the difference between the factors is .14. This same procedure was followed for the remaining months and the difference between the factors for station 5 and the mean factors for the corresponding months for group I were not greater than .15. Therefore, station 5 could belong to group I.

A more objective method of allocating a seasonal control station to a group may be used. This method is based on the principlie of "least squares." (See Table 8, page 48.)

d. Indicate on the map the location of each seasonal control station, using the color of the group to which the station belongs. Many of the seasonal control stations will fall into patterns which were determined by continuous count stations and thus verify the allocation of these road sections. Others may provide information to allocate the road sections for which no information is available from the continuous count stations. The patterns for some seasonal control stations may not fall into any predetermined group as noted in Table 7.

e. If the State does not have seasonal control stations to make necessary assignments of road sections to groups, it is important to establish seasonal control stations for one year to make these assignments. Best results will be obtained by counting seven consecutive days in each month. Stations counted less frequently than once each month may be difficult to assign to groups.

The seasonal control stations that do not fall into any predetermined group should be carefully examined. For example, it may

[1] Since seasonal control stations are samples rather than complete months, the group may be extended to the range of ±.15 rather than ±.10 used for the continuous count stations.

be found that the majority of the months agree with a previously determined pattern. In such cases records for several preceding years should be examined and compared in order to determine if the disagreement in some of the months is a matter of repetition rather than being peculiar to one particular year. This was illustrated by the study of the records for stations L and H.

If records are available, the process of grouping continuous count stations and, if necessary, seasonal control stations as described above should be repeated for two or three preceding years. Because of the persistence of the monthly ratios over a period of years, it may be expected that the great majority of the road sections will fall into the same monthly pattern groups year after year. In one State, after studying four years counts, it was found that about 94 percent of the road sections retained their groupings and only about 6 percent needed to be changed. It is recommended that groupings of continuous recorders and seasonal control stations be checked every year.

Ordinarily the changes in the group patterns can be visually determined when the control stations have been plotted on a map by means of the color-coded group symbols. However, there may be situations when the exact point of change is not easily ascertained. This may occur near urban areas. In such situations it is desirable to establish additional control to define this point of change. An illustration of this condition in a rural area is shown at the bottom of Figure 1. This route was assigned to group I, based on the data from continuous count stations B and G. However, there was no certainty that all of the sections of this route so assigned actually belong to that group. In the long-range program of assignment of road sections to a group, it is necessary to verify the assumed road section designation by establishing necessary seasonal control stations. This was accomplished in this instance by establishing seasonal control stations 32, 33, 34, 37, and 39, which substantiated the original assumption that all sections between major intersections on this route belong to group I.

Experience substantiates the applicability of the theory of configurations which indicate that in the majority of cases the seasonal control stations fall into the groups previously determined by the continuous count station data.

For the purpose of illustration, another example of where a change in grouping is indicated is shown on Figure 1 for seasonal control stations 19 and 21. There are two questions arising from this situation. One is the assignment of the road sections between Richardsville and Frazer, and the other is the assignment of the road west of Richardsville as indicated by the pattern of station 19. The data from station 31 indicate that previous assignment of the road between Richardsville and Frazer to group I was correct. On the other hand, it is observed from the data obtained at stations 16, 17, and 18 that the road sections west of Richardsville belong to the same group as station 19.

After accomplishing the above described procedures, the ungrouped road sections with an ADT exceeding 500 as noted on Figure 1, are road sections with unusual or extreme patterns of monthly variations of traffic volume. Normally these are roads leading into resort or recreational areas. The road sections exhibiting such patterns usually are limited in extent and a single continuous or suitable seasonal control count station is ordinarily sufficient to obtain the necessary adjustment factors for each such section.

The planning of traffic volume measurement is based on two fundamental characteristics which have been established by many studies.[1] These characteristics are:

(1) The pattern of monthly variations of traffic volume persists over long stretches of highway.

(2) The pattern of monthly variations of traffic volume persists over long periods of time.

[1] Refer to bibliography items 1 and 2.

It can be expected that at intermediate points along each rural route, the monthly variations will be similar to those established by the continuous count stations along the route of its group. Therefore, each group mean factor should be applied to the coverage count stations which are located on road sections of this group. For example, in Figure 1 all coverage count stations operated during May on road sections of group I would use a factor of 0.97 (see Table 4). This method should result in estimates of ADT with a standard deviation of estimates not exceeding ±10 percent.

3. *Locating and Operating Traffic Counting Stations*

a. Continuous Traffic Counters

After all road sections have been allocated to groups of similar monthly patterns of traffic variation, it may be possible to eliminate or relocate some of the continuous count stations. This decision, however, should be made only after careful determination of all purposes served by these stations. These considerations should include:

(1) Continuous count stations, in addition to providing adjustment factors for expansion of coverage counts, may be needed for long-range determination of traffic trends at a particular point.

(2) It may be desirable to determine accurate peak hour counts at a particular station.

(3) Other local information may be used.

(4) The road sections for which records are not available should be studies. Either permanent or seasonal control stations should be located on these sections in future years so as to enable the proper classification of these road sections by groups. If seasonal count stations are operated, each count should be for one-week duration.

(5) It may be desirable to retain continuous count station locations to determine the rates of change or travel.

(6) In general, a minimum of six continuous counting stations should be located in each group of road sections with an independent set of monthly factors.

b. Seasonal Control Stations

After all road sections have been grouped as described above, the number of seasonal control stations can be significantly reduced. When there is reason to believe that a seasonal pattern on a particular road section is changing or has changed, seasonal control or continuous count stations should be used to determine this change.

c. Coverage Count Stations

(1) The bulk of the ADT data comes from coverage count stations since they are located wherever specific traffic volume information is desired. In a comprehensive traffic volume survey, information is needed for each section of road between intersections. To achieve this it is theoretically necessary to have traffic counts at every other intersection. However, data collected at coverage count stations represent samples in time. Estimates of ADT based on these samples are subject to sufficient sampling error as to justify the following rule:

"Locate coverage count stations at alternate intersections. However, it may not be necessary to locate a coverage count station at alternate intersections providing the traffic volumes do not vary by more than 10 percent between road sections under consideration. Also coverage stations may be omitted when changes of traffic volume are evenly distributed over a series of consecutive road intersections. Traffic volumes for the intervening sections can be estimated by prorating the volumes at the end sections."

(2) The following may be used as a guide to determine the coverage count stations that are needed:

(a) Make coverage counts at every other intersection or as needed as described above. This coverage counting program may be made in one year or in several year cycles up to five years. A maximum cycle of three years is recommended. Assuming a three-year cycle, one-third of the coverage counts would be made each year.

(b) If only vehicle mileage information is needed then a much smaller coverage than described under (a) would be required. For example, the rural vehicle mileage by counties was needed within 5 percent standard error of the mean. This was accomplished by locating coverage count stations at an average of 10 miles apart.

(c) In general, approximately 25 coverage count stations will be required for each 100 miles of rural roads. Depending on the topography and the pattern of location of roads, variations from this coverage may be encountered in some of the States.

B. Highways with ADT Volumes Between 25 and 500

Roads carrying less than 500 ADT must be treated differently than roads with higher traffic volumes, since past studies have shown that the standard error of estimate increases at a much greater rate than the traffic volume is less than 500 ADT.[1] This relation can be illustrated graphically by the following figure.

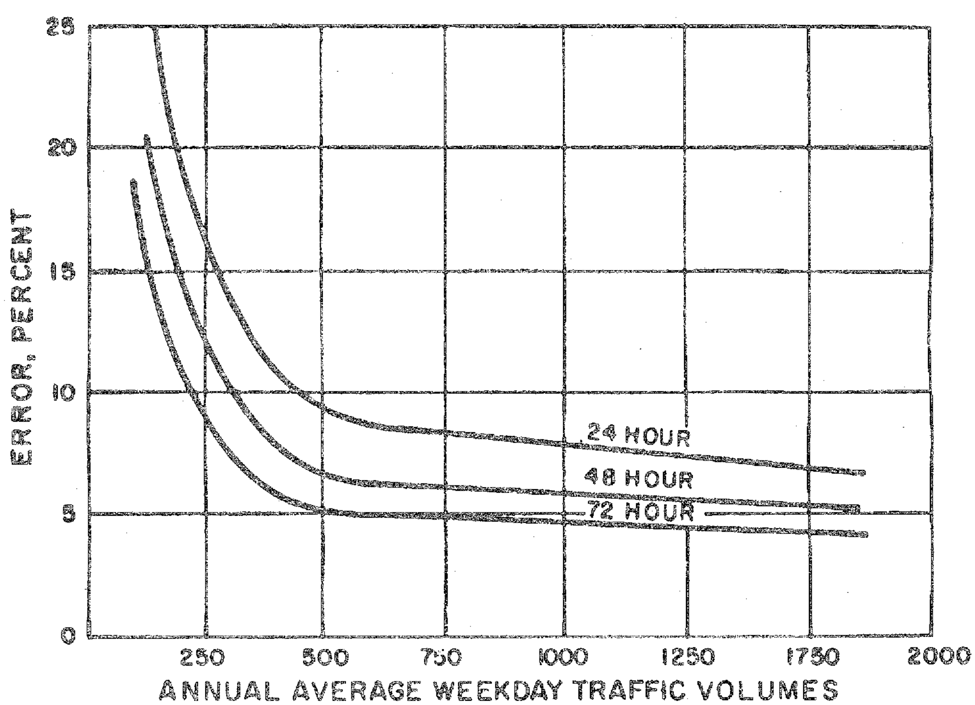
1. *Control Station Operations*

It has been determined from past experience that all rural road sections regardless of the administrative system with volumes between 25 and 500 ADT can generally be represented by one group, for the purpose of computing monthly adjustment factors to obtain estimates of ADT.[1] On this basis, the following steps should be undertaken:

a. Continuous count station locations on lower volume roads may be chosen arbitrarily to provide adequate geographical representation. Analysis of one or two year's data will help determine if any of

[1] Refer to bibliography item No. 3.

[1] Refer to bibliography item No. 4.



the locations should be changed, or if additional stations are required. Five or six such stations will be adequate in most States to compute the average adjustment factors for estimating the ADT at the coverage count stations.

b. Seasonal control stations may be used instead of continuous counting stations. If continuous count stations are used, a minimum of 5 or 6 is required. If seasonal control stations are used and a count is taken in every month, 5 or 6 seasonal control stations are also sufficient. If counts are taken every other month at seasonal control stations, then the number of stations should be doubled. Therefore, 10 or 12 stations may be required. Moreover, the schedule should be so arranged that an equal number of counts are taken in each month, statewide. Similarly, if counts are taken every third month, 3 times the number of continuous counts are required.

Providing a State has a sufficient number of existing continuous count stations on State highways carrying less than 500 ADT or on low-volume roads on other administrative systems, these stations could be used to provide the necessary average adjustment factors for low-volume roads.

Continuous count stations and seasonal control stations normally should not be located on roads carrying less than 100 ADT. The factors obtained on sections having 100 to 500 ADT can be applied to all roads carrying ADT of 25–500.

2. *Coverage Count Stations*

Procedures for locating coverage count stations on roads carrying in excess of 500 ADT also apply to low-volume roads. An exception to this policy is that coverage count stations are not usually located on roads carrying an ADT of 25 or less. Locate coverage count stations at alternate intersections. However, it may not be necessary to locate a coverage count station at alternate intersections providing the traffic volumes do not vary by more than 25 percent between road sections under consideration. Note the similarity to the procedure for roads carrying an ADT of 500 or more. (Chapter II, A–3 (C) page 27.)

When the adjustment factors obtained from these control stations are applied to coverage count stations on a low-volume system, it may be expected that 68 percent of the estimates of ADT will have an error within 20–25 percent. More precise estimates may be expected for the higher volume roads within this traffic volume range.

C. Roads with ADT Volumes Less Than 25

Other sources of information should be used for the estimation of traffic volumes on the extremely low-volume roads. Such sources may include culture, previous records, and the application of the overall rate of change in traffic volume over a period of years. However, there may be roads within a State or an area that have such economic importance that fewer than 25 vehicles may represent an appreciable measure of service and that service should be more accurately measured. In such cases, traffic counts of longer than 48-hour duration are usually necessary to achieve any practical degree of accuracy, and five- or seven-day counts may be necessary. The control stations which were used for the computation of the average adjustment factors needed to compute ADT volumes for roads in the 25–500 ADT group can be utilized to determine ADT for roads with ADT volumes less than 25. When greater accuracy is desired, a repeat coverage count may be justified. In some cases a continuous count recorder may be necessary to produce the desired degree of accuracy.

D. Adjustment Factors

1. The group mean ratio of the ADT to the average weekday traffic volumes of the month is an adjustment factor that would be applicable to samples of 24-hour averages of 48-hour counts on weekdays, and 24-hour averages of five consecutive weekdays.

If computers are used then weekly adjustment factors may be applied. These factors are the group mean ratios of ADT to the average weekday of the week during which the coverage counts are made. Even factors for individual weekdays of the year can be used. However, these individual weekday factors in a few States where they have been used, do not produce a significant increase in the accuracy of ADT estimates.

For all coverage counts taken on road sections that have been assigned to groups of similar monthly variations, a group mean factor should be applied. These group mean adjustment factors are computed separately for each group from continuous count or control count station data. This procedure has been discussed previously, (either monthly or weekly). For example, the use of a monthly factor would be as follows:

> A coverage count of 48-hour duration on weekdays was made on a road section of group I in September, the count showed 4,286 vehicles. The 24-hour mean, therefore, equals 2,143 vehicles. From Table 4 the adjustment factor is 0.89. The estimate of ADT for this coverage station is 2,143 x 0.89 = 1,907.

2. When coverage counts are made for a period of seven consecutive days a suitable adjustment factor must be applied. If hourly recording counters are used, the factor should be representative of the average *weekday* of the month or week. When cumulative counters are used the factors must be representative of the average *day* of the month or week. A major consideration in selecting a coverage count period is the strong possibility of lost data when rubber tube detectors are left in place for extended periods. Little, if any, accuracy can be gained by including Saturdays and Sundays in the coverage period.[1]

There is a period of about four weeks in the spring and another in the fall when the 24-hour weekday rural traffic volume differs from the ADT for that same station by a standard deviation of less than ±10 percent. Therefore, this count could be considered an estimate of the ADT without any further treatment. However, it is considered impractical to recruit sufficient help only for these short periods of time. If this procedure is used, caution should be exercised in the selection of these 4-week periods as the representative traffic volumes vary somewhat from year to year and from station to station. The usual practice is to conduct traffic coverage counting for a period of seven or more consecutive months and in some States the year-round.

Adjustment factors determined from control stations in rural areas should be applied to all rural roads. For the suburban sections, it is desirable to determine the adjustment factors from data obtained either from continuous count recorders or from a few seasonal count stations located in these areas. Until data are available from these recorders, it is usually adequate to average the factors obtained in the rural areas with those in the particular city and apply these average values to suburban areas. Generally, the monthly variations of traffic volumes in suburban areas approach those of the cities. It has also been observed that monthly traffic volume fluctuations in the cities are much smaller than they are on the rural road sections, so that the urban factors tend to approach unity for each month. This implies that the monthly variations in the suburban areas are usually smaller than those observed in the rural sections of the same route.

E. Analysis

1. *Editing*

a. Manual Editing

Every field report must be carefully examined in the office and all notations thereon must be carefully read. This will eliminate all counts that are obviously unsatisfactory. All counts for which there are indications that they were taken under abnormal circumstances should not be used. Each count should be compared with the record of the same station for the previous year. If the two differ by

[1] Refer to bibliography item No. 8 for the effect on ADT estimate accuracy of varying the coverage count duration.

30 percent or more for roads carrying greater than 500 ADT, such counts should ordinarily not be used unless justified by known changes in the area. Counts which differ by more than 20 but less than 30 percent may be used, but all sections in this range must be subjected to very careful scrutiny.

On roads carrying less than 500 ADT, the counts differing by 60 percent or more from the previous year should ordinarily not be used. However, if the difference is between 20 and 60 percent, such counts may be used with caution upon evidence that they may be satisfactory.

b. Machine Editing

In States where computers and qualified personnel trained in statistical methods are available, machine editing procedures can be used.[1] The principle of this editing procedure is as follows:

(1) Using available historical data of traffic counts at a particular location, compute a relationship between ADT and the year by means of linear regression techniques. Five to ten years of historical data are desirable for the purpose.

(2) Extend the function of the year of the current count and determine the difference between the value yielded by the function and the current value.

(3) If this difference is smaller than twice the standard error of estimate about the regression line, the count can be accepted without further investigation. If the difference is larger than twice the standard error of estimate about the regression line, then the current count is subject to investigation. Its final acceptance or rejection will be made upon the results of this investigation.

The first two steps outlined above can be accomplished by use of computers. The only phase of the procedure outlined under (3) above that cannot be accomplished by the use of a computer is the analysis of the rejected count. This analysis may require both field and office checking, either a recount or an investigation, to determine the cause of the exceptional change in traffic volume counts.

2. *Mechanical Data Processing*

The use of electronic data processing equipment is most desirable for further analysis subsequent to editing. The selection of the adjustment factor and the factoring of the field count can be accomplished by using this equipment. Computers may also be used to improve somewhat the accuracy of the results—instead of using monthly adjustment factors, weekly or daily adjustment factors can be produced without appreciable additional costs.

3. *Smoothing Out*

After all the coverage counts have been converted into estimates of ADT, it may be expected that about 68 percent of the estimates will have errors not greater than 10 percent for the high-volume roads and not greater than 20 percent for the low-volume roads.

After all ADT volumes have been estimated, a smoothing out process will usually be necessary for adjacent road sections. This process can be accomplished as follows:

a. Post all ADT estimates on a map.

b. Each successive road section should now be studied in comparison with the adjacent road sections, keeping in mind the influence of traffic from the location of the cities and intersecting roads.

c. If the difference between traffic volumes on two successive sections of road appear to be too large to be justified by the circumstances, the traffic volumes should be adjusted to give a more logical distribution based on the evidence. This is accomplished by increasing or decreasing the volume at one or both stations.

d. This smoothing out process can also be guided by the traffic volumes on road

[1] Refer to bibliography item No. 5.

sections beyond the section immediately under study.

This smoothing process tends to increase the accuracy of the estimates of ADT. In the final evaluation of the errors involved, it is believed by those concerned with highway traffic that ⅔ of the final estimates will usually not be greater than 5 percent in error for high-volume roads and not greater than 10 percent in error for low-volume roads; and that 95 percent of the estimates will not be more than 10 percent in error for high-volume roads and not more than 20 percent in error for low-volume roads. Some of the reasoning which supports this opinion is as follows:

(1) In the examination of successive road sections a sudden large unexplainable change in traffic volume is easily observed and eliminated.

(2) Comparison with historical data may indicate an unexplainable large change in traffic volume which is easily observed and eliminated.

(3) The elimination of the obviously large errors of estimate will, by itself, reduce the average error of the remaining estimate.

4. *Improvement in Accuracy*

A greater degree of accuracy in estimating ADT can be accomplished as follows:

a. Using weekly factors instead of monthly factors. This procedure is presented on page 31, under "Mechanical Data Processing."

b. Use of repeat counts as noted on page 29, under "Roads with ADT Volumes Less Than 25."

c. Taking five- or seven-day coverage counts as noted on page 29, under "Roads with ADT Volumes of Less Than 25." See also bibliography item No. 8.

The above are procedures in which improvement in accuracy in the estimate of ADT can be obtained. However, when considering methods to improve accuracy the cost should be kept in mind. A fairly accurate rule that can be used in attempting to improve precision by increasing the sample size is that "to reduce the error by one-half using the same sampling procedures would require increasing the effort and probably the cost by four times."

Chapter III.—URBAN ROADS AND STREETS

A. Urban Planning Process Relationships

Prior to the formalization of the comprehensive urban planning process in 1962, most urban areas did not have adequate traffic counting programs. As the emphasis on urban comprehensive planning increased, however, an understanding was gained concerning the use and value of good urban traffic counts and more formally structured programs evolved. These programs have been tailored to the needs of the urban planning process and are typically considered in two frames of references.

First, traffic counts are needed in those phases of the urban planning process which deal with the verification and/or development of transportation models. For this purpose, traffic counts are collected at the same time the data input for model development are collected to insure that the origin-destination data are truly representative of existing traffic conditions. Because the transportation models are crucial to the development and realization of a future year transportation plan, they must be calibrated with base year data and reevaluated at least once every five years to determine their applicability for continued use. Traffic counts which yield independent estimates of travel patterns and growth are used to evaluate the ability of the entire travel forecasting process to simulate actual travel. Because of the importance of the reevaluation phase in the continuing urban transportation planning process, traffic estimates for *all* arterial links on the transportation network are required.

The second frame of reference is with respect to those years between the model development and/or reevaluation phases. In these intermediate years, there is a need to monitor change. The surveillance of traffic volumes allows one to identify changes in travel growth trends for the total as well as subareas. If the identified changes in travel patterns and growth differ significantly from the simulated travel developed by the transportation planning process, the reevaluation phase referred to earlier will begin before the maximum 5-year interval. Since a base of traffic estimates was developed under the first frame of reference, the number of counts needed for surveillance will be considerably fewer than for the modeling and reevaluation phases. A comprehensive counting program should be designed to satisfy the needs of both frames of reference.

In some urban areas, a large number of counts already exist which provide useful traffic information. These existing traffic estimates, however, should be analyzed to determine their adequacy as a data base. An analysis of the existing counts may result in the selection of new stations and continuation of old stations of the various types needed for producing the desired traffic estimates. Urban transportation planning studies are cooperative efforts involving several jurisdictions. State highway departments should insure that an adequate traffic counting program is conducted.

B. Considerations for Urban Counting

The need to develop the capability for estimating annual average traffic on urban streets has increased concurrently with the increased emphasis on urban transportation planning. This need is being satisfied by the establishment of traffic counting programs that can be used to help identify the traffic growth as well as to verify the continued use of transportation models. For estimating annual average traffic, the urban traffic counting program is usually designed with the following considerations:

(1) A sufficient number of continuous, seasonal, and coverage counts should be taken to make necessary estimates of the average daily traffic (ADT) and vehicle-miles of travel (VMT). The traffic counts should be located on a representative portion of each functional system by geographic area. Areas that exhibit rapid growth rates should receive a proportionally greater number of traffic counts than areas that have stabilized. The placement of count locations according to functional system will enable VMT to be tabulated by functional system both for the total areas and subareas. An analysis of the counts on a subarea basis should provide the means for measuring the relative travel growth within and through the subareas.

2. Estimates of the ADT at each cordon line and screenline crossing should be provided by the program. Since the screenline and cordon count data were used to verify the validity of the original survey data, it is reasonable to maintain an annual surveillance of survey control lines. All screenline and cordon crossings should have as a minimum one coverage count per year. Certain crossings may be considered for seasonal control locations while others could be considered for continuous counter locations.

3. In many urban areas, estimates of directional peak hour traffic are of considerable value. Peak hour traffic volumes can be used to help calibrate peak hour models and to aid the traffic analyst in determining the proper relationships between peak hour volumes, design volumes, and the ADT. Such counts, if supplemented with manual classification counts at selected points on the functional systems, will provide the necessary data for traffic engineering analyses at intersections under study.

4. The counting program should result in traffic volume estimates on the arterial street network which reflect the criterion of ±5 percent error on the 68 percent confidence limit and VMT estimates of ±5 percent at 95 percent confidence limit.

A traffic counting program which incorporates these considerations should result in an adequate number of traffic volume estimates for transportation planning purposes. VMT and ADT estimates based on the more extensive counting schedule required for the development and verification phases would become updated bases on which to build.

C. ADT Estimating Procedures

Traffic counting programs cover continuous, seasonal coverage, turning movement, and classification counts. Continuous and seasonal counts are taken to determine patterns of seasonal, daily, and hourly variations in traffic volumes which are typical of roads and streets in the study area. Adjustment factors developed from these counts are then applied to short term counts to obtain estimates of average daily volumes. Coverage counts are taken to obtain information at sufficient locations to be representative of each section of city streets on the transportation study traffic assignment network. However, in order to provide an estimate of total travel, it will also be necessary to collect traffic counts on a sample of those streets not on the traffic assignment network. When required in the planning process, classification and directional distribution data should be collected at a sufficient number of volume counting stations to be representative of all significant variations within the study area. When it is necessary to determine turning movements and classification of traffic by vehicle type during the peak hour, 2- to 4-hour counts which include the peak period may be made.

Before the planning process gained full impetus, the majority of cities were satisfied with ADT estimates having an error of about ±10 percent at the 68 percent confidence limit. To test the need for control stations for adjustment, observations were made concerning 24-hour coverage counts on high volume streets in 13 cities which are located in three States.[1]

[1] Refer to bibliography item No. 6.

These counts were taken on weekdays spread throughout the year. A subsequent analysis which deleted those traffic counts taken in inclement weather or other days with extremely abnormal traffic conditions indicated that the normal traffic volumes on weekdays could be considered the same as the ADT without the application of adjustment factors. Since the accuracy of these counts were within the acceptable ±10 percent standard error of estimate, it was not essential to have control stations for further adjustment.

It is possible, however, to reduce the error of estimate of ADT from a 10 percent to a 7 percent standard error of estimate by application of monthly adjustment factors based upon the data obtained at control stations. This determination was based upon an analysis of traffic data gathered in 11 cities located in one State. From a large number of continuous count stations distributed throughout the 11 cities of this State, 9 stations were selected at random. From the data obtained at these continuous count stations, the monthly adjustment factors were computed and applied to all coverage counts made in these cities. Such a procedure is considered applicable to cities of over 2,000 population and streets carrying over 500 ADT.

No refinements of accuracy are usually required for lower volume streets (streets with an ADT of less than 500). If no adjustment factors are applied to coverage counts, the percentage errors of estimate of ADT would be expected to be in excess of ±10 percent but less than ±20 percent. If mean monthly adjustment factors obtained from the continuous count stations located on high volume streets were applied to coverage counts on low volume streets, the standard deviation may be expected to be about ±10 percent.

Regardless of the ADT estimating procedures used, a few urban routes may require special treatment and investigation, particularly if a greater degree of accuracy is required. Among these are streets serving resort and recreational facilities or other areas of high seasonal concentration of traffic.

An urban traffic counting program could utilize the grouping procedure described in chapter II. This procedure should produce annual average traffic estimates with standard deviation of ±5 percent. However, it is quite likely that data from a sufficient number of continuous recorders and seasonal control stations will not be available to produce reliable group mean factors or to assign the roads and streets to groups. Lacking previous control data, locations for continuous recorders should be selected subjectively to be representative of geographical location, functional classification of streets, and jurisdictional responsibility. Stations may be selected according to the following:

1. *Geographic Location*—Central business district, fringe area, outlying business district, and residential area as defined on page 19 of the Highway Capacity Manual (1968).

2. *Functional Classification*—Principal arterials, minor arterials, collectors, and locals as described in the 1968 National Highway Functional Classification Study Manual by the Bureau of Public Roads, April 1969.

3. *Jurisdictional Responsibility* — State highway or non-State highway.

Station locations selected in this manner should not be considered permanent. After one year's operation, analysis of the data and grouping of the stations will show which stations should be continued on a permanent basis and which should be moved. The analysis will also indicate where additional control data are necessary.

It is difficult to provide a rule-of-thumb for determining the desirable number of continuous recorders and seasonal control stations to be operated in an urban area. However, current experience indicates that a total of 8 to 12 locations or 4–6 locations per pattern group, including seasonal control stations should be sufficient. In beginning a new program, it might be wise to collect more seasonal counts during the first period; that is, at least until the final count locations are determined.

D. Types of Traffic Counts

Since a continuous and seasonal counts were discussed in sufficient detail in the rural section, a detailed discussion of coverage counts only will be presented in this section.

For the development and verification of the transportation models, the number of traffic count stations will vary according to the number of miles of all roads and streets that are included in the traffic assignment network. When an urban study makes VMT estimates for the entire street system, including collectors and locals, a larger number of coverage counts will have to be taken utilizing sampling techniques on these remaining streets.

In the intermediate years or surveillance period, fewer counts will be necessary. In these intermediate groups, estimates can be made using the broad group of traffic counts as a base. As the planning process continues, this base of traffic counts will be reestablished at the same interval the models are reevaluated. Variations from these guidelines may be found in some cities depending on the general plan of the city street layouts, length of the city blocks, and topography.

1. *Machine Counts*—In an urban traffic counting program, machine counts should be of 24- to 48-hour duration on weekdays. If it is operationally convenient, traffic counting machines could be located on each leg of an intersection. It is not necessary to make counts on each leg at each and every intersection since the volume of each leg of an uncounted intersection can be determined from an adjacent intersection. Even counting traffic at every other intersection may not be necessary.

For example, on long streets carrying large volumes of traffic, considerable savings can accrue by locating stations only at points where there is a significant break in traffic volume. Since the design of the traffic counting procedure for a transportation study is based on the criterion of ± 5 percent error on the 68 percent confidence limit, stations may be omitted when the differences between the traffic volumes at successive stations are expected to be ± 5 percent or even as much as ± 10 percent. In such cases, the traffic volumes between counting stations can be interpolated to provide estimates without actually counting traffic on all sections of streets.

2. *Manual Counts*—Often special conditions in cities make machine counts impractical. For example, the mechanical efficiency of a machine may be seriously affected by the stop and go traffic of a congested intersection, by multiple lanes, by parking cars, or by tampering with the counters.[2] Where such conditions exist, it is necessary to count traffic manually.

In central business districts, traffic counts can often be conducted economically by taking very short manual counts at consecutive intersections.[3] These short counts should not be used on streets carrying less than 2,000 ADT. Short counts should be a minimum of 6-minute duration and should be repeated every hour for 8 hours. At each short count station, traffic should be recorded for each leg of the intersection if possible. After the 6-minute count is completed, the enumerator should move to the next station along the street of the major traffic movement.

If a man can move in four minutes from one station to another, he can count six stations in an hour which also mean six stations in a day. Assuming four streets intersecting at each station, it means that he can provide traffic data for 24 street sections. It is advantageous to arrange the counting schedule so that the man can return to the first station upon finishing the count at the last station of the circuit of six. This cannot be done, of course, unless there are stations on adjacent streets running parallel to the major traffic movement.

To estimate the total volume of traffic during the 8-hour period of count, the traffic volume for the eight 6-minute periods should be added and the sum multiplied by 10. To estimate the 24-hour volume of traffic, it is necessary to have one 24-hour

[2] Many times children tamper with counters and spoil the count record. It is suggested that machine counts not be scheduled near school or other places where children gather.

[3] Refer to bibliography item No. 7.

machine count located along the route where 6-minute counts are taken. Ratios of the 24-hour traffic volume to the 8-hour traffic volume during which the very short counts were taken are obtained from the 24-hour control station counts. The appropriate ratio is applied to the 8-hour traffic volume and an estimate of the 24-hour traffic volume is calculated.

Estimates of 24-hour ADT volume obtained by this procedure can be expected to have an error of ±12 percent on a 68 percent confidence level. Since greater accuracy is usually required, monthly adjustment factors should be applied. Additional accuracy may also be obtained by extending the period of count to more than 6 minutes or by taking more than 8 hours for the period of count or both.

E. Turning Movement and Classification Counts Combined with ADT Estimates

When it is necessary to determine turning movement and classification of traffic by vehicle type and at the same time provide a sufficiently large sample of estimating ADT, 4-hour continuous manual traffic counts should be used. These 4-hour counts should be scheduled so that they include either the morning or afternoon hour of peak volume. When such 4-hour manual counts are made, it is necessary to get a 24-hour machine count somewhere in the vicinity of the street sections so that the ratios of the 24-hour volume of traffic to the counted volumes can be obtained.

The 24-hour estimates of the volume of traffic obtained by this procedure are not quite as accurate as those derived from short counts taken every hour for eight hours. This procedure can be expected on the basis of experience to produce estimates that will have an error of about 13 or 14 percent on the 68 percent confidence limit.

F. Traffic Counting in Small Urban Areas

In the small urban areas, many of the foregoing procedures can be used. In many of these areas, considerations necessary for comprehensive urban planning, such as assignment networks and models, will not be a major factor in determining the magnitude of the traffic counting program. Consequently, the number of counts and degree of coverage will not be as great. It is likely that ADT estimates having a ±10 percent error on the 68 percent confidence limit will be satisfactory. Estimates of VMT with a ±5 percent error at the 95 percent confidence limit should still be obtainable.

G. Office Procedures

It is a good practice to post all traffic volume estimates on a city map reconciling the traffic volume estimates on adjacent sections along the same route. The "smoothing out" procedure which was discussed on page 31 will produce final estimates of ADT that can be expected to be more accurate than the original traffic estimates.

Chapter IV.—GENERAL NOTE

The greater the familiarity with local conditions the better judgment can be exercised in the final decisions in estimating traffic volumes. The probability principles built into the procedures suggested in this guide will eliminate major errors of judgment and reduce the errors to chance alone. Further research can somewhat improve and refine the procedures. However, because the inherent properties of chance variations have already been accounted for in this guide only minor or primarily local improvements can be expected.

When making an estimate of traffic volumes all available information should be utilized including counts for special purposes. These may include special counts for such purposes as:

Manual classification counts
Capacity counts
Ramp and turning movement counts
Special counts for construction, etc.
Screenline counts

There are several methods under investigation whereby the data collected by the traffic counting mechanisms are automatically transferred into the central headquarters. Also under consideration is complete automation of most office analyses, including editing of field data, preparation of arrays (such as shown in Tables 2 and 6) and grouping of continuous count and seasonal control stations (as shown in Tables 3 and 7); as well as statistical tests of significance of differences, analysis of variance, chi square tests, and others as needed. Computers may be utilized for such routine mass operations as factoring coverage counts into estimates of ADT and regrouping control stations separately for each month. However, regardless of the automation that is used expert judgment must always be applied.

Table 1.-- ADT ÷ Average weekday traffic volume of the month at continuous count stations

Station number	April	May	June	July	August	September	October	November
(A)	1.08	0.99	0.91	0.73	0.71	0.86	1.00	1.13
(B)	1.19	1.03	.90	.66	.64	.90	1.09	1.15
(C)	1.00	.93	.91	.83	.85	.99	1.05	1.02
(D)	1.03	.92	.88	.86	.86	.89	.95	1.10
(E)	1.07	.90	.79	.90	.93	1.00	1.08	1.15
(F)	1.05	.98	.91	.68	.67	.92	1.03	1.10
(G)	1.16	.97	.83	.70	.74	.81	1.04	1.22
(H)	1.09	.87	.76	.69	.72	.85	.95	1.18
(I)	1.44	1.15	.90	.57	.51	.75	1.15	1.32
(J)	1.04	.95	.97	.77	.75	.95	1.07	1.16
(K)	1.38	1.14	.98	.70	.65	.82	.98	1.07
(L)	1.19	.99	.85	.71	.76	.97	1.00	1.36

Table 2.-- The array of factors for continuous count stations

April	May	June	July	August	September	October	November
(C) 1.00	(H) 0.87	(H) 0.76	(I) 0.57	(I) 0.51	(I) 0.75	(H) 0.95	(C) 1.02
(D) 1.03	(E) .90	(E) .79	(B) .66	(B) .64	(G) .81	(D) .95	(K) 1.07
(J) 1.04	(D) .92	(G) .83	(F) .68	(K) .65	(K) .82	(K) .98	(D) 1.10
(F) 1.05	(C) .93	(L) .85	(H) .69	(F) .67	(H) .85	(A) 1.00	(F) 1.10
(E) 1.07	(J) .95	(D) .88	(K) .70	(A) .71	(A) .86	(L) 1.00	(A) 1.13
(A) 1.08	(G) .97	(B) .90	(G) .70	(H) .72	(D) .89	(F) 1.03	(B) 1.15
(H) 1.09	(F) .98	(I) .90	(L) .71	(G) .74	(B) .90	(G) 1.04	(E) 1.15
(G) 1.16	(A) .99	(C) .91	(A) .73	(J) .75	(F) .92	(C) 1.05	(J) 1.16
(B) 1.19	(L) .99	(A) .91	(J) .77	(L) .76	(J) .95	(J) 1.07	(H) 1.18
(L) 1.19	(B) 1.03	(F) .91	(C) .83	(C) .85	(L) .97	(E) 1.08	(G) 1.22
(K) 1.38	(K) 1.14	(J) .97	(D) .86	(D) .86	(C) .99	(B) 1.09	(I) 1.32
(I) 1.44	(I) 1.15	(K) .98	(E) .90	(E) .93	(E) 1.00	(I) 1.15	(L) 1.36

Table 3.-- Groups of stations within .20 range

April	May	June	July	August	September	October	November
Group I - (A), (B), (F), (G), (L), (H), and (J)							
(J) 1.04	(H) 0.87	(H) 0.76	(B) 0.66	(B) 0.64	(G) 0.81	(H) 0.95	(F) 1.10
(F) 1.05	(J) .95	(G) .83	(F) .68	(F) .67	(H) .85	(A) 1.00	(A) 1.13
(A) 1.08	(G) .97	(L) .85	(H) .69	(A) .71	(A) .86	(L) 1.00	(B) 1.15
(H) 1.09	(F) .98	(B) .90	(G) .70	(H) .72	(B) .90	(F) 1.03	(J) 1.16
(G) 1.16	(A) .99	(A) .91	(L) .71	(G) .74	(F) .92	(G) 1.04	(H) 1.18
(B) 1.19	(L) .99	(F) .91	(A) .73	(J) .75	(J) .95	(J) 1.07	(G) 1.22
(L) 1.19	(B) 1.03	(J) .97	(J) .77	(L) .76	(L) .97	(B) 1.09	(L) 1.36
Group II - (I) and (K)							
(K) 1.38	(K) 1.14	(I) .90	(I) .57	(I) .51	(I) .75	(K) .98	(K) 1.07
(I) 1.44	(I) 1.15	(K) .98	(K) .70	(K) .65	(K) .82	(I) 1.15	(I) 1.32
Group III - (C), (D), and (E)							
(C) 1.00	(E) .90	(E) .79	(C) .83	(C) .85	(D) .89	(D) .95	(C) 1.02
(D) 1.03	(D) .92	(D) .88	(D) .86	(D) .86	(C) .99	(C) 1.05	(D) 1.10
(E) 1.07	(C) .93	(C) .91	(E) .90	(E) .93	(E) 1.00	(E) 1.08	(E) 1.15

Table 4.-- Monthly group mean factors

Group	April	May	June	July	August	September	October	November
Group I	1.11	0.97	0.88	0.71	0.71	0.89	1.03	1.16
Group II	1.41	1.14	.94	.64	.58	.78	1.06	1.20
Group III	1.03	.92	.86	.86	.88	.96	1.03	1.09

Table 5.-- ADT ÷ average weekday traffic volume of the month at seasonal control stations

Station number	April	May	June	July	August	September	October	November
1	1.25	1.29	1.09	.78	.60	.67	1.00	1.20
2	1.19	1.06	.90	.91	.83	.82	.99	1.23
3	1.03	.96	.80	.80	.88	.92	1.02	1.18
4	1.31	1.27	1.00	.78	.65	.58	.88	1.30
5	.97	.89	.88	.71	.69	.76	1.00	1.12
6	1.08	.91	.87	.73	.69	.81	.99	1.11
7	.99	.82	.80	.74	.70	.79	.98	1.15
8	1.12	.93	.79	.80	.73	1.00	1.10	1.14
9	1.20	1.10	.76	.79	.78	.93	1.03	1.21
10	.96	.88	.87	.69	.72	.83	1.05	1.20
11	1.60	1.39	.47	.50	.36	.34	1.00	1.63
12	1.13	1.11	.99	.68	.68	.76	1.11	1.18
13	1.15	1.09	1.02	.69	.68	.86	1.16	1.16
14	1.00	.82	.90	.67	.73	.90	.95	1.17
15	1.20	1.08	1.00	.59	.79	1.01	1.07	1.09
16	1.16	.87	.72	.75	.80	1.00	1.04	1.20
17	.99	.78	.75	.76	.90	1.03	1.09	1.09
18	.98	.80	.87	1.00	1.00	.90	.90	1.00
19	1.03	1.03	.91	.82	1.00	.98	1.17	1.00
20	1.25	1.02	.99	.69	.61	.81	1.05	1.08
21	1.22	1.03	.98	.68	.63	.79	1.03	1.05
22	1.07	1.00	1.01	.70	.68	.92	1.09	1.11
23	1.47	1.16	.95	.50	.55	.59	1.00	1.33
24	1.13	.97	.75	.58	.61	.91	1.02	1.21
25	1.09	.85	.78	.66	.71	.89	1.01	1.09
26	1.18	.97	1.00	.84	.69	.95	1.06	1.17
27	1.05	.85	.87	.81	.72	.79	1.00	1.23
28	1.01	1.00	.92	.85	1.01	.89	.89	.89
29	3.07	3.07	.29	.38	.29	2.00	2.50	2.78
30	1.12	1.00	.86	.84	.90	.95	.94	.99
31	1.19	.99	.92	.68	.74	1.05	1.06	1.20
32	1.04	.94	.89	.78	.64	1.01	1.09	1.01
33	1.26	1.00	.75	.55	.55	1.05	1.10	1.30
34	1.10	.98	.88	.67	.70	.98	1.02	1.25
35	1.53	1.14	.93	.50	.49	.91	1.20	1.09
36	1.49	1.02	.80	.63	.57	.92	1.10	1.07
37	1.19	1.05	.90	.60	.75	.90	1.09	1.24
38	1.00	1.11	1.00	.73	.80	.89	1.00	1.20
39	1.26	.95	.74	.59	.65	1.03	1.11	1.30

Table 6.-- The array of factors for seasonal control stations

Sheet 1 of 2

April		May		June		July		August		September		October		November	
Station	Factor	Station	Factor	Station	Factor	Station	Factor	Station	Factor	Station	Factor	Station	Factor	Station	Factor
10	.96	17	.78	29	.29	29	.38	29	.29	11	.34	4	.88	28	.89
5	.97	18	.80	11	.47	11	.50	11	.36	4	.58	28	.89	30	.99
18	.98	7	.82	16	.72	23	.50	35	.49	23	.59	18	.90	18	1.00
7	.99	14	.82	39	.74	35	.50	23	.55	1	.67	30	.94	19	1.00
17	.99	25	.85	17	.75	33	.55	33	.55	5	.76	14	.95	32	1.01
14	1.00	27	.85	24	.75	24	.58	36	.57	12	.76	7	.98	21	1.05
38	1.00	16	.87	33	.75	15	.59	1	.60	7	.79	2	.99	36	1.07
28	1.01	10	.88	9	.76	39	.59	20	.61	21	.79	6	.99	20	1.08
3	1.03	5	.89	25	.78	37	.60	24	.61	27	.79	1	1.00	15	1.09
19	1.03	6	.91	8	.79	36	.63	21	.63	6	.81	5	1.00	17	1.09
32	1.04	8	.93	3	.80	25	.66	32	.64	20	.81	11	1.00	25	1.09
27	1.05	32	.94	7	.80	14	.67	4	.65	2	.82	23	1.00	35	1.09
22	1.07	39	.95	36	.80	34	.67	39	.65	10	.83	27	1.00	6	1.11
6	1.08	3	.96	30	.86	12	.68	12	.68	13	.86	38	1.00	22	1.11
25	1.09	24	.97	6	.87	21	.68	13	.68	25	.89	25	1.01	5	1.12
34	1.10	26	.97	10	.87	31	.68	22	.68	28	.89	3	1.02	8	1.14
8	1.12	34	.98	18	.87	10	.69	5	.69	38	.89	24	1.02	7	1.15
30	1.12	31	.99	27	.87	13	.69	6	.69	14	.90	34	1.02	13	1.16
12	1.13	22	1.00	5	.88	20	.69	26	.69	18	.90	9	1.03	14	1.17
24	1.13	28	1.00	34	.88	22	.70	7	.70	37	.90	21	1.03	26	1.17

Table 6.-- The array of factors for seasonal control stations (cont.)

Sheet 2 of 2

April		May		June		July		August		September		October		November	
Station	Factor	Station	Factor	Station	Factor	Station	Factor	Station	Factor	Station	Factor	Station	Factor	Station	Factor
13	1.15	30	1.00	32	.89	5	.71	34	.70	24	.91	16	1.04	3	1.18
16	1.16	33	1.00	2	.90	6	.73	25	.71	35	.91	10	1.05	12	1.18
26	1.18	20	1.02	14	.90	38	.73	10	.72	3	.92	20	1.05	1	1.20
2	1.19	36	1.02	37	.90	7	.74	27	.72	22	.92	26	1.06	10	1.20
31	1.19	19	1.03	19	.91	16	.75	8	.73	36	.92	31	1.06	16	1.20
37	1.19	21	1.03	28	.92	17	.76	14	.73	9	.93	15	1.07	31	1.20
9	1.20	37	1.05	31	.92	1	.78	31	.74	26	.95	17	1.09	38	1.20
15	1.20	2	1.06	35	.93	4	.78	37	.75	30	.95	22	1.09	9	1.21
21	1.22	15	1.08	23	.95	32	.78	9	.78	19	.98	32	1.09	24	1.21
1	1.25	13	1.09	21	.98	9	.79	15	.79	34	.98	37	1.09	2	1.23
20	1.25	9	1.10	12	.99	3	.80	16	.80	8	1.00	8	1.10	27	1.23
33	1.26	12	1.11	20	.99	8	.80	38	.80	16	1.00	33	1.10	34	1.25
39	1.26	38	1.11	4	1.00	27	.81	2	.83	15	1.01	36	1.10	37	1.24
4	1.31	35	1.14	15	1.00	19	.82	3	.88	32	1.01	12	1.11	4	1.30
23	1.47	23	1.16	26	1.00	26	.84	17	.90	17	1.03	39	1.11	33	1.30
36	1.49	4	1.27	38	1.00	30	.84	30	.90	39	1.03	13	1.16	39	1.30
35	1.53	1	1.29	22	1.01	28	.85	18	1.00	31	1.05	19	1.17	23	1.33
11	1.60	11	1.39	13	1.02	2	.91	19	1.00	33	1.05	35	1.20	11	1.63
29	3.07	29	3.07	1	1.09	18	1.00	28	1.01	29	2.00	29	2.50	29	2.78

Table 7.-- Distribution of seasonal control stations by groups of similar monthly variations as determined from the mean factors in Table 4

Sheet 1 of 2

April		May		June		July		August		September		October		November	
Group I - Stations 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 20, 21, 22, 24, 25, 26, 27, 31, 32, 33, 34, 37, 38, and 39.															
(10)	.96	(7)	.82	(39)	.74	(33)	.55	(33)	.55	(5)	.76	(14)	.95	(32)	1.01
(5)	.97	(14)	.82	(24)	.75	(24)	.58	(20)	.61	(12)	.76	(7)	.98	(21)	1.05
(7)	.99	(25)	.85	(33)	.75	(15)	.59	(24)	.61	(7)	.79	(6)	.99	(20)	1.08
(14)	1.00	(27)	.85	(9)	.76	(39)	.59	(21)	.63	(21)	.79	(5)	1.00	(15)	1.09
(38)	1.00	(10)	.88	(25)	.78	(37)	.60	(32)	.64	(27)	.79	(27)	1.00	(25)	1.09
(32)	1.04	(5)	.89	(8)	.79	(25)	.66	(39)	.65	(6)	.81	(38)	1.00	(6)	1.11
(27)	1.05	(6)	.91	(7)	.80	(14)	.67	(12)	.68	(20)	.81	(25)	1.01	(22)	1.11
(22)	1.07	(8)	.93	(6)	.87	(34)	.67	(13)	.68	(10)	.83	(24)	1.02	(5)	1.12
(6)	1.08	(32)	.94	(10)	.87	(12)	.68	(22)	.68	(13)	.86	(34)	1.02	(8)	1.14
(25)	1.09	(39)	.95	(27)	.87	(21)	.68	(5)	.69	(25)	.89	(9)	1.03	(7)	1.15
(34)	1.10	(24)	.97	(5)	.88	(31)	.68	(6)	.69	(38)	.89	(21)	1.03	(13)	1.16
(8)	1.12	(26)	.97	(34)	.88	(10)	.69	(26)	.69	(14)	.90	(10)	1.05	(14)	1.17
(12)	1.13	(34)	.98	(32)	.89	(13)	.69	(7)	.70	(37)	.90	(20)	1.05	(26)	1.17
(24)	1.13	(31)	.99	(14)	.90	(20)	.69	(34)	.70	(24)	.91	(26)	1.06	(12)	1.18
(13)	1.15	(22)	1.00	(37)	.90	(22)	.70	(25)	.71	(22)	.92	(31)	1.06	(10)	1.20
(26)	1.18	(33)	1.00	(31)	.92	(5)	.71	(10)	.72	(9)	.93	(15)	1.07	(31)	1.20
(31)	1.19	(20)	1.02	(21)	.98	(6)	.73	(27)	.72	(26)	.95	(22)	1.09	(38)	1.20
(37)	1.19	(21)	1.03	(12)	.99	(38)	.73	(8)	.73	(34)	.98	(32)	1.09	(9)	1.21
(9)	1.20	(37)	1.05	(20)	.99	(7)	.74	(14)	.73	(8)	1.00	(37)	1.09	(24)	1.21
(15)	1.20	(15)	1.08	(15)	1.00	(32)	.78	(31)	.74	(15)	1.01	(8)	1.10	(27)	1.23
(21)	1.22	(13)	1.09	(26)	1.00	(9)	.79	(37)	.75	(32)	1.01	(33)	1.10	(37)	1.24
(20)	1.25	(9)	1.10	(38)	1.00	(8)	.80	(9)	.78	(39)	1.03	(12)	1.11	(34)	1.25
(33)	1.26	(12)	1.11	(22)	1.01	(27)	.81	(15)	.79	(31)	1.05	(39)	1.11	(33)	1.30
(39)	1.26	(38)	1.11	(13)	1.02	(26)	.84	(38)	.80	(33)	1.05	(13)	1.16	(39)	1.30

Table 7.-- Distribution of seasonal control stations by groups of similar monthly variations as determined from the mean factors in Table 4 (cont.)

April		May		June		July		August		September		October		November	
Group II - Stations 1, 4, 23, 35, and 36															
(1)	1.25	(36)	1.02	(36)	.80	(23)	.50	(35)	.49	(4)	.58	(4)	.88	(36)	1.07
(4)	1.31	(35)	1.14	(35)	.93	(35)	.50	(23)	.55	(23)	.59	(1)	1.00	(35)	1.09
(23)	1.47	(23)	1.16	(23)	.95	(36)	.63	(36)	.57	(1)	.67	(23)	1.00	(1)	1.20
(36)	1.49	(4)	1.27	(4)	1.00	(1)	.78	(1)	.60	(35)	.91	(36)	1.10	(4)	1.30
(35)	1.53	(1)	1.29	(1)	1.09	(4)	.78	(4)	.65	(36)	.92	(35)	1.20	(23)	1.33
Group III - Stations 2, 3, 16, 17, 18, 19, 28, and 30															
(18)	.98	(17)	.78	(16)	.72	(16)	.75	(16)	.80	(2)	.82	(28)	.89	(28)	.89
(17)	.99	(18)	.80	(17)	.75	(17)	.76	(2)	.83	(28)	.89	(18)	.90	(30)	.99
(28)	1.01	(16)	.87	(3)	.80	(3)	.80	(3)	.88	(18)	.90	(30)	.94	(18)	1.00
(3)	1.03	(3)	.96	(30)	.86	(19)	.82	(17)	.90	(3)	.92	(2)	.99	(19)	1.00
(19)	1.03	(28)	1.00	(18)	.87	(30)	.84	(30)	.90	(30)	.95	(3)	1.02	(17)	1.09
(30)	1.12	(30)	1.00	(2)	.90	(28)	.85	(18)	1.00	(19)	.98	(16)	1.04	(3)	1.18
(16)	1.16	(19)	1.03	(19)	.91	(2)	.91	(19)	1.00	(16)	1.00	(17)	1.09	(16)	1.20
(2)	1.19	(2)	1.06	(28)	.92	(18)	1.00	(28)	1.01	(17)	1.03	(19)	1.17	(2)	1.23

It is noted that in group II for the months of September and October; and in group III for the month of November the ranges are slightly over .30. The reasoning for the inclusion and treatment of stations which fell outside the .30 range is similar to that used in connection with grouping of continuous count stations within .20 range, as described on pages 5 and 6 in items (c) and (d).

The seasonal control stations which did not fall into any of the groups predetermined by continuous count stations are numbers: 11 and 29. The reasons why these stations did not fall into any of the predetermined groups is not always obvious. Some of them may indicate additional pattern groups. Others may reflect local and/or temporary situation such as resort areas, football games, or activities that will cause unique traffic movements. However, these types of movements are generally very limited in extent. The stations noted above which did not fall into any predetermined group were of strictly local significance and do not represent any appreciable mileage.

Table 8.--Example illustrating the application of the principle of least squares for allocating a seasonal control station to a group. (The data for station No. 8 come from table 5. The monthly group mean factors come from table 4).

	Factors Station No. 8	Mean Factors Group I	Difference between factors at Station No. 8 and Group I, d_1	d_1^2	Mean factors Group III	Difference between factors at Station #8 & Group III, d_3	d_3^2
April	1.12	1.11	.01	.0001	1.03	.09	.0081
May	.93	.97	-.04	.0016	.92	.01	.0001
June	.79	.88	-.09	.0081	.86	-.07	.0049
July	.80	.71	.09	.0081	.86	-.06	.0036
August	.73	.71	.02	.0004	.88	-.15	.0225
September	1.00	.89	.11	.0121	.96	.04	.0016
October	1.10	1.03	.07	.0049	1.03	.07	.0049
November	1.14	1.19	-.05	.0025	1.09	.05	.0025
				$\Sigma\ d_1^2 = .0378$			$\Sigma\ d_3^2 = .0482$

It should be noted that in the above example in the columns marked d_1 and d_3 the difference between the factors of station 8 and the group mean factors of group 1 and the group mean factors of group 3 are within the criterion of permissible variation of $\pm .15$. Therefore, station 8 could have been allocated to either group 1 or group 3. However, the summation of the squared values of d_1 is equal to .0378 whereas the summation of squared values of d_3 is equal to .0482. Because the summation of the squared values of d_1 is less than the summation of squared values of d_3 station No. 8 is assigned to group 1. This method of allocating seasonal control stations to the various groups is particularly useful when the data are processed on the computer.

However, the final decision as to the allocation of a seasonal control station that could fall into more than one group should be made after examining the location of the station on the map. The contiguity of the road sections belonging to the same group determines the grouping of such a station. In such a situation, groupings of similar road sections should be maintained as much as possible.

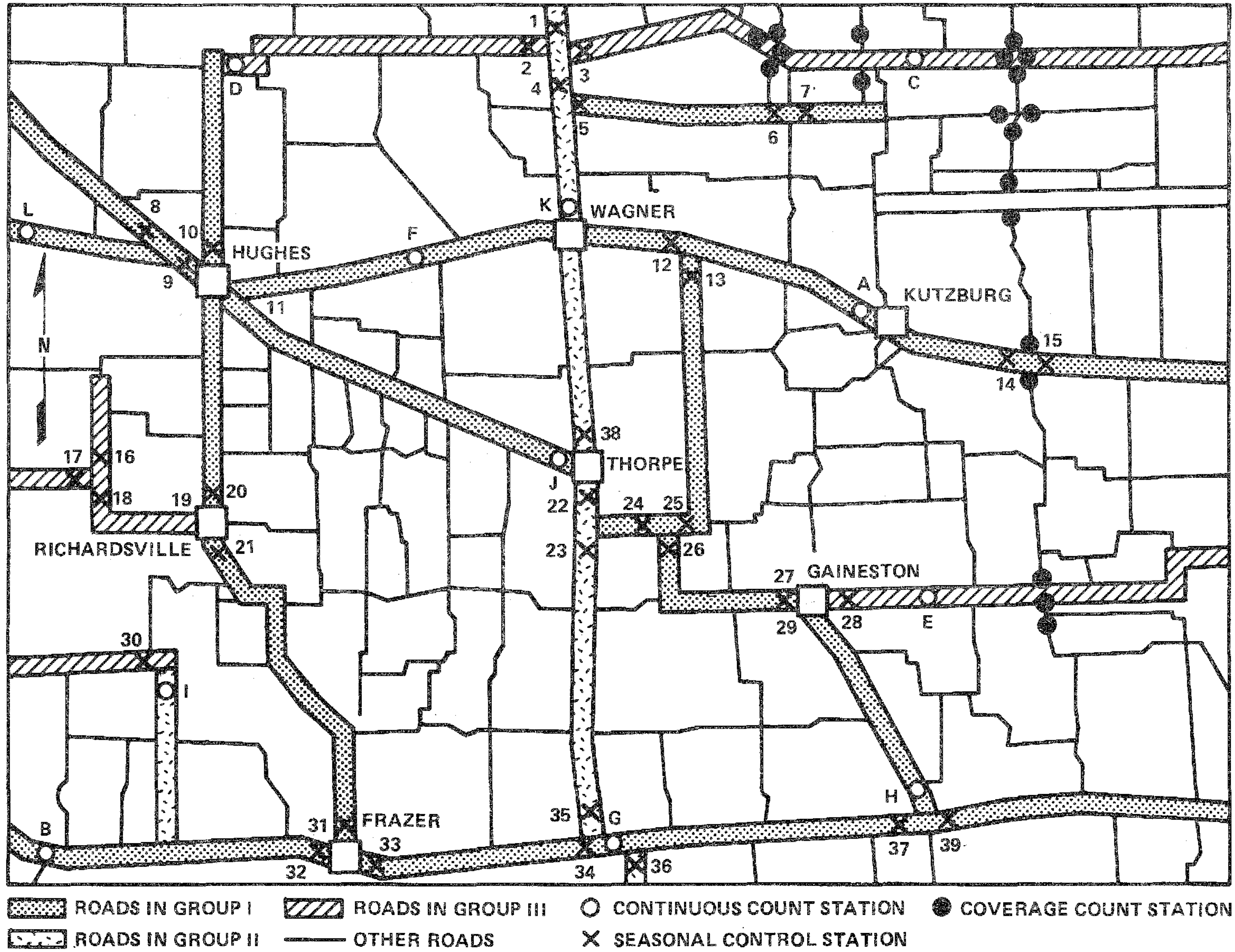


FIGURE I – GROUPING OF ROAD SECTIONS FROM CONTINUOUS AND SEASONAL CONTROL STATIONS.