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Submitted To The Graduate School

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West Virginia University

In Partial Fulfillment Of The Requirements For The Degree Of Master Of Science In Civil Engineering

By 10 Ronald Lee/Hawkins/ B.S.C.E. Captain, U.S. Air Force DC FILE COPY Morgantown West Virginia 15700 12 1978 This document has been approved for public relaces and solo; its distribution is unlimited. Su 012 200 175 78 11 15

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CHAPTER I

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INTRODUCTION

Counts of traffic volumes comprise a major effort of state highway departments. These counts are used to present a picture of traffic volumes over all sections of road in a state. The average daily traffic is tabulated in forms such as the monthly and yearly daily average, by weekday and weekend, and a peak hour percentage of the average daily traffic.

Some of the uses for these counts are (1) highway usage classification, (2) design elements in highway planning, (3) accident rates, (4) maintenance priorities, (5) vehicle miles of travel(VMT), (6) travel trends, (7) market research studies, and (8) calibrating travel forecast models.

At present these counts are obtained using permanent counters at permanent locations and portable counters moved frequently to different locations to obtain a sample of vehicular traffic for all levels of roadways. These counts are expanded to give an average count for the different classifications of roads.

Theoretically, to obtain the perfect knowledge of the volumes of vehicles travelling upon all roadways, counters would need to be set up on every section of roadway in a study area with counts taken 24 hours of every day. This undertaking is not even remotely possible at present. Hence, sampling is used to obtain traffic counts.

Using West Virginia as an example, Lancaster(16) states that 3 years were required to secure traffic volumes for all 55 counties. Now that has changed to a 5 year cycle for all secondary roads in West Virginia. Lancaster further pointed out the major inadequacies of most existing coverage counts as: (1) full coverage count data are not obtained each year, and (2) it would prove prohibitively expensive to provide the desirable annual coverage.

Aerial photography has been used in traffic studies for 50 years(13). Usually these studies have been limited to one roadway or small study area. One of the main reasons has been the data reduction problem. Simply more photographs could be taken than could be analyzed by operators in a reasonable amount of time and cost.

It appears advances in technology in the use of computers to scan photographs and identify vehicles can reduce the problem of data reduction. This fact may be the key to future expanded traffic counting programs. Purpose

The purpose of this study is to propose a method of obtaining volume counts for roadways using aerial photographs plus existing traffic counters. The study will be limited to urban areas and specific classes of

roadways. The reason for doing so is to reduce to a minimum the parameters that can affect the variation of traffic flow.

The counts to be obtained are of daily traffic. Then these counts would be used in the same manner as are the counts obtained now by pneumatic tube counters. With more locations sampled, better knowledge of traffic along <u>all</u> roads in an area in terms of accuracy and flow patterns would result.

To use the aerial photograph method, it is planned to make use of the following knowledge.

1. An aerial photograph can depict an instant of traffic flow for <u>all</u> links in a study area.

2. Urban traffic follows daily and hourly variation patterns which are generally consistent and often predictable. (11:19)

3. The percent of total traffic occurring in any given period is approximately the same along any route. (11:19)

Therefore, if the pattern of time variation of traffic is known for selected links, then the approximate variation for all similar links in the study area could be estimated. To further refine the estimates on a link-by-link basis, the photographs could provide a precise count for a specified time for every link being studied. Combining these counts into a pattern, a total count for the entire time period can be estimated.

This approach is somewhat analagous to the present counting methods. Permanent counters are installed at carefully selected locations to provide counts for all days in a year. Hence, variations of traffic flow due to time will be apparent. These counts are used to provide factors to adjust the short-term counts obtained by the portable counters.

This study will try to determine if the combined aerial photograph and tube counter approach is feasible and accurate in obtaining daily counts for links in an urban study area. If this approach is feasible, then the study will attempt to determine the smallest number of counts needed to produce volume estimates with a low percentage of error.

CHAPTER II

LITERATURE REVIEW

The literature review concentrated in four general areas. They are the following:

- 1. Traffic counting procedures,
- 2. Aerial photography in traffic studies,
- 3. Statistical approaches to traffic counts, and
- Computer processing of aerial data used in traffic studies.

The review was an attempt to ascertain the studies conducted in each of these areas and to determine if any inter-relationships existed among the areas.

Traffic Counting

In the first general area, articles by Adams(1) and Gilbert(10) reported on studies in the area of expanding short-term counts to obtain daily volumes of traffic. The Traffic Count Reports(31) show the results of the traffic counts conducted by the West Virginia Department of Highways. Two FHWA documents(5), (11) pointed out the basic objectives and uses of traffic counts. These guides form the guidelines for the nationwide counting programs.

Aerial Photography

In the second general area, the pioneering effort of Johnson(13) laid the basic framework of using cameras for aerial studies of highway traffic. The studies of Cyra(8) provided insight into the accuracy of volume and speed measurements possible along a section of freeway in studying speed and density of traffic. He brought out the fact that to be most economical, the traffic engineer must study as many facets of traffic operations as possible from the photographs taken. Jordan(14) gave a case study of the use of aerial photography in the dense urban area of New York. He pointed out the great amount of detail available from photographs. His report dealt with a study known as Project Sky Count.

Peleg, Stoch, and Etrog(21) pointed out how a relatively small team can make a comprehensive urban study in a short time by using aerial photographs. They developed mathematical relationships to determine traffic flow, traffic density, average speed, average travel times, and traffic composition. They provided information relating to flight planning, duration, and photo scale.

The parking study reported on by Syrakis and Platt (30) pointed out the tremendous savings in cost and time in using aerial photography to study on- and off-street parking in the central districts of three Ohio cities. They estimated an 85% savings in time and a 72% savings

in costs as compared to standard parking studies.

Trieterer(32) used aerial photography to obtain continuous traffic data on the general behavior of vehicles in platoons on two urban freeways in Columbus, Ohio. The knowledge obtained from aerial surveys and his research on traffic dynamics was used to develop a ramp metering system and a loop detector for density and speed measurements. 7

Wilson(36) used aerial photography to obtain measurements of 10 parameters of traffic flow in a small urban area. Among those parameters was an estimate of daily volume. The project proved that data could be collected by an aerial method and have a level of accuracy acceptable for traffic surveys.

Smollen(28) gave hope that a new traffic survey system tremendous in scope is almost here. This was used in the innovative New Orleans STAR Project. Not only traffic studies, but many other measurements related to urban life and planning were available from the use of aerial photography. In this project, recent developments in optical scanning and use of computers made the task of data reduction much easier and faster.

Ruhm(26) pointed out the advantages of aerial photography in traffic and land use studies. Likewise, the article by Moore and Wellar(18) pointed out the potential uses of airborne sensors throughout the urban environment. They stated that "...as technological advances are made, yielding better imagery outside the visible range of the electromagnetic spectrum, our ability to identify and interpret will rapidly improve."(18:43) In fact, the major obstacles of weather and darkness may be overcome in the near future to provide a full-time look at urban dynamics.

Turpin(33) gave a comprehensive overview and evaluation of the uses of aerial photography in transportation.

Sampling

For the third general area, the two Guides(5), (11) by the FHWA gave the parameters for sampling traffic flow. They provided guidelines for selection of samples to provide accurate estimates of the traffic flows.

Muranyi(19) showed the importance of systematic sampling. He pointed out the value of grouping of like types of roadways. He also did research on finding the best times to conduct a count to get an approximation of the average traffic flow.

The book by Votaw and Levinson(34) has been used as a basic reference in traffic sampling.

A publication of the West Virginia Department of Highways(27) gave a practical application of traffic counts based on Federal guidelines for a statewide system of roads.

Covault(6) gave a very practical aspect of the sampling theory in his discussion of estimating total costs of highway, bridge, and railroad crossing improvements on a statewide basis.

Computer Systems

Two traffic survey systems were studied. The system described by Raudseps(23) used a flying spot optical scanner. The operator identified ground reference points and vehicles. The machine then did the job for which it is best suited-calculation. It correlates the film coordinates to ground coordinates, keeps records, and tracks vehicles through the succession of photographs.

The system patented by Kerr(15) used two transparencies for comparison. The transparencies were made from the same aerial picture of a selected area. One transparency has all areas other than roadways made opaque by the operator. This transparency is used as the basis for comparison. The two transparencies are optically compared in order that only objects on roadways are detected as significant data. A monochromatic light beam is used as a scanning beam. A set of holographic replicas of different size vehicles is sequentially interposed in the scanning beam for each increment of roadway sample. When the filter size corresponds to vehicle size, there is more light passed through the filter than the normal intensity of light. By detecting this increase in intensity as a vehicle, the computer stores vehicle location and size in a memory. The computer then calculates traffic densities and can track vehicles on successive photographs. This system can be developed further using technology based on liquid crystals.

Treiterer(32) developed computer programs for data processing and data presentation for his study of vehicle trajectories. In his study, each vehicle was uniquely identified by the operator. The photo coordinates were stored in a computer. A computer program then produced output on vehicles, coordinates, spacing, headway, velocities, density, and volumes. The data reduction rate was about 30 minutes per photograph because of the required man-machine interaction.

Ashbaugh(2) in his thesis used a flying spot scanner to scan transparencies to find man-made objects. In this study, the transparency was represented by a 15 gray level printer program. This was then contoured using an equation representing the sum of local vertical and horizontal gradients around a point. A 5 gray level contour map was produced. The Fast Fourier Transform was used to find a correlation of contours with selected rectangular prototypes. A closed curve was traced through the contours showing a high coorelation. If the loop was closed,

then the object was assumed to be man-made. Each detected man-made object had its boundary plotted by a Calcomp plotter along with a decision as to what the object represents. Perhaps future research along this line will lead to automatic detection of vehicles on roadways because of the readily identifiable shapes of vehicles.

Summary

The literature reviewed has provided a very good background on traffic counts and aerial photography. There are many researchers genuinely enthusiastic over the promises shown by counting from the air. By reducing costs and time needed to count vehicles, present systems of traffic counting can be expanded to provide very accurate counts for all roads on shorter counting cycles.

CHAPTER III

AN APPROACH TO THE PROBLEM

To obtain traffic counts today, the agency making the counts usually uses pneumatic tube counters and/or electronic loop detectors. They use a network of roadways, such as a state, for the population of roads to be sampled. The roads are classified by a system designed to provide basic functional classes of roads. Each of these classes of roads is then sampled to obtain a representative traffic count. After sampling, an estimate can be made of the total number of vehicles that are using all roads in that class throughout the study area.

For example, the West Virginia Department of Highways obtains a count of 48-hour duration at its portable tube counter locations. There are proportionately more counters on roadways in the lower ranges of volumes in order to obtain counts of required accuracy.

The DOH also uses permanent counters installed at specified locations to give a record of all traffic passing these locations throughout the year.

Other inputs are available to the traffic counting agency. Past counts are used as trend forecasts. Seasonal counts are made to determine the variations due to time of year. These seasonal counts are especially important on routes used in recreational areas.

All these inputs result in factors that are applied to the sample counts. The end result is an estimate of Average Annual Daily Traffic(AADT) for the links of the highway or street system.

In the West Virginia Traffic Counts, the resulting traffic estimates are arranged by roads in a county. In this arrangement, the section of road, length of link, the AADT, peak hours, peak hourly volume, and peak hour percentage are arranged in columar form.

There is a yearly summation of road mileage and vehicle travel in the West Virginia Traffic Count Report also. Here, the highway system is broken down by usage and by State or Federal designation. Miles of road in the State are given for each classification. Annual vehicle-miles and daily vehicle-miles per mile for each classification are also given.

With this information, an engineer can total the miles of roadway in a particular study area, classify by usage, and then use the reported figures to obtain an estimate of vehicle-miles of travel in that area.

This information can further be used to provide estimates of air pollution and fuel usage. These latter estimates are becoming more and more important in light of today's environmental statutes and energy considerations. Priorities on maintaining or upgrading certain roads could be formed knowing the usage of these roads.

Counting by Sampling

Suppose one wanted to find volumes for the arterial streets in an urban area. The total length of this particular class of roadways in the area would first be defined. To get a count of traffic, portable counters must be set out to record the vehicles as they pass over the streets. To be truly accurate, one would divide the roadways into links of approximately equal lengths and then place a counter on each link. But, this could lead to an enormous project. Since time, money, and manpower are quite real constraints, the use of sampling is the preferred course of action.



The results of a sample survey are shown in Figure 1. A vehicle count of links E and J over a time period is shown. The links counted are chosen by statistical methods to represent all links in this class of roads. The other links in this class have no counts taken during this time period. By carefully classifying the roads into common classes, one can assume the other links of this class behaved in the same way with approximately the same numbers of vehicles using those links. This is the assumption governing the counting of traffic today. Sampling to obtain an average amount of usage and then multiplying by the total miles of that class of road is the method used to arrive at an estimate of VMT for the class for the entire study area.



In Figure 2 the ideal counting system is shown. A counter for every link is recording vehicles throughout a specified time period. Restrictions of both manpower and costs make this type of counting infeasible, however.

Counts in a Short Time Period

In Figure 3 the counting of traffic by remote sensing is shown. The count is only for short time periods simulating the traffic counts obtained by aerial photographs. From the vantage point of altitude, one can study all links of roadway in an area. An aerial photograph or series of photographs can look at only a short time span of vehicle movements. But with proper interpretation, all vehicles that are in position to be recorded can be counted.

FIGURE 3.

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REMOTE SENSING COUNTING

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To obtain a perfect count in this fashion, a system of recording would be needed that recorded continuously from beginning to end in a counting period. A system such as this using aerial photographs is not feasible either economically or technically at present. Therefore, sampling of all links by short intervals of time is proposed for use much the same way current counting practices use samples of lengths of road counted for 24 hours or 48 hours at a time.

A Combination Approach

This thesis proposes that traffic counts of an area can be obtained by using a combination of link sampling by mechanical counters and area sampling by aerial photographs.



Figure 4 shows the basic principle. If one can obtain an accurate count on several links throughout a day-long period and then combine with this accurate counts of all links in the area for short time periods, then one could build a matrix containing values for all

links throughout the day-long counting period. This matrix would be completed using the broad guidelines of the FHWA that are listed below.

Guidelines

The <u>Guide to Urban Traffic Volume Counting</u> prepared by the Federal Highway Administration gives the following findings:(11:19,20)

1. Urban traffic follows daily and hourly variation patterns which are generally consistent and often predictable. Urban traffic volume patterns exhibit relatively little weekday and seasonal variation. The per cent of total traffic occuring in any given period is approximately the same along any route.

 The more counts, even though of a very short duration, the greater the reliability of the resulting estimate. Similarly, the heavier the traffic volume at a particular location, the greater the reliability of a given sample.
The distribution of counts throughout a day is more significant than the total time during which the traffic is counted. The number of separate and independent observations is more important than the number of hours of each observation.

4. As counting locations are combined, the sampling variability resulting from short-counts diminishes.

5. Stratified sampling techniques have merit over simple random sampling in estimating VMT, since they reduce the variation within parts of the total sample.

6. Sampling <u>more locations</u>, each for a shorter period of time, will likely result in less error than sampling a few locations, each for a longer period. This implies maximizing the number of different locations sampled.

The preceding broad guidelines serve as a map for this experiment. Short counts, as representative of the counts obtained by aerial photos, over a large number of locations coupled with the knowledge of hourly and daily variations of traffic flow should provide the basis for a reliable estimate of VMT for an area.

CHAPTER IV -

ANALYTICAL TOOLS

Use of Patterns

Over the years, there have been numerous studies analyzing traffic flows and their hourly variations. Nearly every traffic study has charts of traffic flow versus hour of day or trip ends versus hour of day to show the pattern of traffic in the study area. In the <u>Transportation and Traffic Engineering Handbook</u> published by the Institute of Traffic Engineers, there are several graphs showing these patterns in the chapters on general and urban travel characteristics. While varying from city to city, urban traffic in a specific area is generally consistent, as pointed out previously. Therefore, if one can ascertain a pattern to the traffic flows being studied, then flows of traffic in the same area can be estimated. This is one premise this experiment will attempt to prove.

Muranyi(19,20) has made in-depth studies of this pattern phenomenon in both Europe and the United States. His work led to his proposals of traffic volume estimates based on factors of road classification and time variation.

Aerial Counting

While it is technically possible to obtain a full hour of photographs of a highway network at one time, the cost of such an approach would be enormous. First, there would be the cost of the film. Exposures need to be taken every few seconds to be able to follow individual vehicles. An hour's worth of film for this many exposures would require many feet of film and space to store it. The magazines of aerial cameras simply do not have this capacity.

Secondly, the space traversed by the platform used for photography has to be considered. The fixed wing aircraft covers distance quite fast. Flight patterns can be arranged to photograph the same area, but at the cost of some coverage.

The helicopter has been used in quite a few experiments. It has the ability to hover over one area or to follow the flow of traffic. It is not a steady platform and flight duration is a factor in the longer counts.

In the New Orleans STAR Project, the Goodyear blimp was used in obtaining photographs. The blimp proved to be a steady platform for photography, of fairly long endurance, and relatively economical. It does have limits on the altitude that can be reached and weather affects operations.

Satellite Observations

After studying the available literature, the use of satellites in traffic observation has to be ruled out for the present time. The main reason is resolution. The resolution available to non-military users is too poor for use in counting vehicles.

Another reason is coverage. Orbits cover a specific area on the earth's surface only for a few minutes each revolution. The earth resources satellites cover the entire earth with their orbital paths as each successive orbit shifts westward. Consequently, they pass over a specific area of the earth only once every 18 days. However, cloud cover generally reduces coverage to some multiple of 18, depending upon geographic location.

In the report(12) of remote sensor imagery used in the Tellico area of Tennessee, the researchers concluded they could not use the images that would be produced by satellites. They used photographs taken from aircraft to simulate the images that would be available from satellite observations.

Aerial Photography

For this experiment, aerial photography was chosen as the form of remote sensing that could be used in connection with traffic counting. One reason is the amount

of equipment and information available in this area. Costs are low. Another reason is that computer systems being developed use film as the method of recording the movements of vehicles.

Advanced sensors such as infrared scanners, television, or multispectral sensors have not been developed to the point where they would be a viable economic alternative to the aerial camera in recording traffic flows.

Because of the unknown areas of this research, the experiment has concentrated on using material that is familiar to most people engaged in traffic counting. Hence, aerial photographs and contemporary traffic counters are addressed in this experiment.

Simulation

In order to simulate the counts available from aerial photographs, hourly counts taken from pneumatic counters will be used. This simulates the short counts of aerial counting. While the short counts available by aerial methods are not of an hour's duration, the basic idea of obtaining a fraction of the vehicular traffic and then estimating the total count for 24 hours can be shown by using the hourly counts. From that point, it is simply an extension of the basic process to expand a count of less than an hour to an estimate of a 24 hour count.
There is further discussion of this in the section on future research.

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CHAPTER V

THE TESTING

This study shall test the hypothesis that traffic counts of an area can be obtained by using a combination of link sampling by mechanical counters and area sampling by aerial photographs.

First, counts of roads that are close spatially and carry the same general levels of traffic are selected. Counter records supplied by the West Virginia Department of Highways are used for data and are shown in Table 1 in the Appendix. The area used for study is the city of Morgantown, West Virginia and surrounding area. This area has a population of approximately 50,000 people.

After selecting the links for study, the hourly values of the traffic counts are arranged in a matrix form. That is, they are arranged by link and by succeeding hours. From this, a 24-hour total vehicle count for every link can be obtained.

Then, counts for certain links are removed. The hourly counts extending across every link in the study can be manipulated to form a matrix of a few columns and rows with varying numbers of missing values of hourly counts. This corresponds to pneumatic counters on certain links and aerial photographs taken at specific time intervals. From this reduced matrix, estimates of vehicle traffic for each link for a total 24-hour period will be made using the guidelines previously mentioned.

Then comparison of the estimates of vehicles of the incomplete matrix is made with the values obtained from the complete matrix of hourly counts. The number and location of hourly counts, the number of fully counted links, and the duration of counts can be changed. One objective would be to obtain an accurate count using the fewest number of links completely counted(pneumatic counters) and the fewest number of hourly counts(aerial photographic counts).



The Count

The data used was for traffic counts in the Morgantown area on April 20, 1977 as recorded by the West Virginia Department of Highways.

The following list of count stations has the West Virginia DOH station number, the street or highway, and a classification by usage.

Station	Number	Street/Highway	Classification
32		Stewart Street	Collector
3		Fayette Street	Collector
10		University Avenue	Collector
16		Willowdale Road	Collector
27		Campus Drive	Collector
1		Kirk Street(one-way)	Arterial
28		Chestnut Ridge Road	Arterial
2		North High Street	Arterial
7		Spruce Street	Arterial
6		Spruce Street	Arterial
9		Walnut Street	Arterial
33		Patteson Drive	Arterial
4		North High Street	Arterial
39		Monongahela Boulevard	Arterial
42		Monongahela Boulevard	Arterial
41		Monongahela Boulevard	Arterial

A cutoff of 5,000 vehicles per day was used as the definition of arterial versus collector. The traffic counts were a 48-hour count at each station. For this study, the 24-hour count for midnight-to-midnight on April 20, 1977 was used as the study input. Sixteen stations were used.

Use of Counts

The traffic flow was summed for each hour segment throughout the day. The hour designation for each vehicle count is the hour at the end of the timespan being counted. For example, the count for hour 6 at Station X is the number of vehicles passing Station X between 5 a.m. and 6 a.m. The hours of the day were numbered sequentially from 1 to 24.

Each station had its hourly counts totaled to produce a total daily count. The entire group of 16 stations with their 24 hours of counts formed a matrix. The counts were considered as base counts for comparisons to the estimated counts.

The West Virginia Department of Highways used the average of the two daily totals of traffic as the Average Daily Traffic(ADT) for a particular station.

In using only a one-day count as representative of daily traffic, variation from the average was expected and encountered. This study was aimed at examining the time variations for one specific day. The assumption is made that the count of vehicles used was a fair and accurate representation of the daily traffic.

By using certain stations' hourly counts as representative of variations by time over the 24-hour period, then other stations' total vehicle counts for that day were estimated. This estimation was based on using selected hours of the station counts to be estimated and multiplying these hours by factors drawn from stations selected as indicators of time and frequency variations in traffic.

Description of computer Procedures

To explain the computer program written for this study, an explanation of the mathematics used to obtain a computed count for comparison with an actual count is shown in the following example.

The counts used are for Stations 42 and 4. These counts are shown in Table 1.

Table 9.1 is the table of computed counts using Station 42 as the basis for estimating the counts at the 15 remaining stations.

The 24 hours of the day were divided into 4 six-hour segments. These segments were hours 1 - 6, 7 - 12, 13 - 18, and 19 - 24.

The hours used for each segment to provide counts for a factor of multiplication were the hours of 1, 9, 17, and 20. These hours were chosen to have one hour in each of the 4 six-hour segments. These single hours were called division hours. The computer program computed an estimated count for Station 4 in the following manner.

For Station 42, the counts for hours 1 through 6 were summed.

203 +104 + 39 + 23 + 31 +118

518 total vehicles

To obtain a factor for this segment of hourly counts, this total count was divided by the Station 42 count for hour 1, the division hour for that segment.

 $\frac{518}{203}$ = 2.552, factor for the first segment

For the remaining segments of counts, a similar procedure was used to obtain factors for each segment.

Hours 7 through 12, the factor is 4.870. Hours 13 through 18, the factor is 5.792. Hours 19 through 24, the factor is 4.230.

Since, in a remote sensing look at traffic, the counts for hours 1, 9, 17, and 20 would be known for Station 4 also, the next step in the computer program was to multiply the counts for these hours at Station 4 by the factors obtained from Station 42.

This gave an estimated total count for all six hours in each segment. These total counts for each of the segments were then summed to produce an estimated count for the station for the day.

		Station 4	Counts	Factor		
Hour	1	252	X.	2.552	=	643
Hour	9	872	X	4.870	=	4246
Hour	17	1086	X	5.792	=	6290
Hour	20	813	<u>X</u>	4.230	=	3439
			I	otal		14618

Then the computer compared the computed count of 14618 with the actual count of 14905 for Station 4 and computed the chi-square factor of 5.520.

The percentage difference was computed manually. The computed count differed from the actual count by -1.9%.

Similar procedures were used to obtain estimated counts for the other series of estimates using different stations or hours as basis to calculate the factors for the segments of hours of the day.

Chi-Square Test

Since frequency of vehicle passage is the basis of traffic counting, the initial thought of a test for the "goodness" of the estimated counts led to selection of the chi-square test. This test is a measure of the discrepancy existing between observed frequencies and expected frequencies. In this study, the counts supplied by the West Virginia DOH served as the absolute or expected frequencies of vehicles counted. The estimated frequency of vehicles for each station calculated by the computer program written for this study would serve as the actual or observed frequency.

Chi-square is given by the formula:

$$\chi^{2} = \sum_{j=1}^{k} \frac{(o_{j} - e_{j})^{2}}{e_{j}}$$

where 0_j is the observed frequency and e_j is the expected frequency.

If $X^2 = 0$, observed and expected frequencies are equal. If $X^2 > 0$, then there is a discrepancy between observed and expected frequencies.

The values for χ^2 are based on degrees of freedom. For this estimation, the number of degrees of freedom was equal to k - 1, where k = number of frequencies to be estimated.

After several computer runs, it became obvious the chi-square test was inappropriate because of the large chi-square values being computed. There simply was too

much variation in the counts of the stations to state that one street had the same frequency of traffic as another street. The variations between actual and estimated counts were much more than could be attributed to chance as shown by tables of chi-square values applicable to the degrees of freedom determined by the numbers of estimated counts. Therefore, each street did have a different frequency of traffic for each segment of hours of the day. This difference in frequencies was apparently more than would be applicable to chi-square testing with its assumption of almost normally shaped distribution of expected frequencies. How much difference in frequencies would be determined by how well the estimated counts could be matched to the actual counts.

However, the number produced by chi-square could serve as a relative indicator of the "goodness" of estimation. The chi-square number was independent of size of sample and by being squared, always a positive number. Therefore, this number is listed along with the estimated frequency totals. The number gives a quick way to determine which stations produced the greatest amounts of variation.

Comparisons Made in the Study

For this study the difference between observed and expected frequencies was tabulated by the just-mentioned

chi-square factor and by a percentage comparison of the actual and estimated counts. This percentage comparison is important because traffic count sampling is designed to obtain counts of traffic that are within a specified percentage of actual numbers of vehicles. By listing this percentage difference between actual and estimated counts, it can be ascertained how well the estimating procedure is performing to produce counts for those stations being estimated.

Using the Statistical Analysis System, a correlation matrix between hours of counts and a correlation matrix between the counting stations were calculated. The factor analysis program was also run on the groups of counts by hours and on the group of stations. Using different combinations of hours and/or stations, it can be ascertained if any relationships exist among the counts at the counting stations or among the counts by hour. It can also be seen how strong the correlation is between specific hourly counts for different stations.

Truck Factor

For this study the truck factor adjustment was disregarded. West Virginia DOH applies a truck factor(TF) for certain roadways that is statewide in application. Therefore, any factor applied in the Morgantown area did

not reflect an accurate assessment of the volume of trucks using the streets. The truck factor was applied only to the total daily count. In actual counts, the truck factor cannot be disregarded. For this study, the number of vehicles counted during each hour was not factored in any way. This was because the study was aimed at comparing variations in traffic flows.

An important benefit of aerial photographic studies is an accurate count of the numbers of trucks using the roads and streets. The truck factor obtained from aerial means is a unique and accurate figure to apply for adjustments of the traffic counts in a specific area.

CHAPTER VI -

RESULTS OF TESTS

The results of using a computer program to generate estimates of traffic volumes based on patterns of flow are shown in tables contained in the Appendix.

Since this approach has not been studied before, the objectives of the study included finding stations whose flow patterns would serve as reasonable guides to flow patterns of other streets and finding hours of the day in which counts could be used for estimation.

Two approaches were used in dividing the hours of the day into segments which had hourly counts which could define a definite pattern. One method was to divide the day into four six-hour segments. These segments included the hourly counts for hours 1 to 6, 7 to 12, 13 to 18, and 19 to 24.

The second approach was to divide the hours of the day into six segments. These segments included hourly counts for hours 1 to 6, 7 to 9, 10 to 12, 13 to 15, 16 to 18, and 19 to 24. These two approaches were used to test the theory that a day's traffic flow could be broken into segments of flow. By narrowing the segments that included the morning and evening peak hours, those peak hour volumes should have a strong effect upon predictions for the peak hour volume estimates for all roads. Since a substantial percentage of the daily traffic is concentrated in peak hour flows, it would appear logical to concentrate upon those peak hour counts.

The tests were carried out in the following order:

(a) Four Stations,

(b) Five Stations,

(c) Six Stations, and

(d) Sixteen Stations.

This order refers to the number of stations used in each series of estimations.

For the four-station tests, four stations were chosen that were geographically close. They were 1/2 to 3/4 of a mile apart.

For the five-station tests, five stations were chosen that were in the mid-range of volumes of traffic. This was to minimize the effects of stations having volumes of traffic on the extremes of the range of volumes.

Four of the stations were located in the downtown area. One was located on a major arterial near the Evansdale campus. All had heavy peak hour volumes.

In the six-station tests, stations were chosen with high volumes of traffic. The locations of these stations were widely separated.

For the sixteen-station tests, all of the counting

stations were lumped together with a resulting mixture of volumes and time patterns.

One hourly count in each of the segments of counts had to be used to obtain the factors used for estimation. During the first part of this study, these hours were chosen at random. This was done to study the effects of using different hourly counts in estimating volumes.

In the latter part of the study, a statistical analysis of the hours and stations was introduced. A computation of correlations and a factor analysis were executed for the hourly counts and counts of stations. The results of these are detailed in the section on factor analysis and in Tables 2 & 3 in the Appendix.

Vehicle Counts

Table 1 is a listing of vehicle counts by station and hour. The West Virginia DOH weekday average daily traffic(ADT) is also shown. The count of the station that is used as the base for comparison in this study is also shown. This count is compared to the ADT and percentage difference is noted. The percentage difference ranges from a -3.5% to a +6.4% for individual stations. The last two columns of the table show the sum of the counts for each hour and the ranking by volume of the hours. The table is arranged by the lowest to highest volumes for the stations.

Correlations

In Table 2, the correlations of hourly counts for the day of all stations are shown. These correlations were computed using the Statistical Analysis System program. A perfect correlation is shown by the number 1.00000. The number shown at the intersection of a row and a column shows the correlation between the count of the hour of the row and the count of the hour of the column. This number is called the R value. The closer this number is to 1.00000, the stronger is the correlation between the counts of the two hours.

For example, the correlations shown in the column under Hour 1 are the correlations between the counts for Hour 1 and the counts for all other hours in the day.

There was no strong correlation shown between hourly counts in the early morning and hourly counts throughout the rest of the day. The hourly counts for Hour 4 showed very poor correlation with most other hourly counts for other hours of the day.

For example, the correlations between the counts for Hour 4 and the counts for Hours 12 and 13 were, respectively, 0.55707 and 0.44538. This means that only approximately 20% to 30% of the variation between these hourly counts could be explained as normal deviation from a common factor.

Another feature noted in the correlation analysis

was the high correlation throughout the daytime hours of a particular hour with the hour or two hours immediately preceding or following a particular hour. For example, the correlation of the count for hour 14 with the counts for hours 13 and 15 shows a very high R value. The significance of this may lie in the fact that hourly counts may not be the best way to count traffic. In this study, traffic flows of a particular variation appear to last longer than an hour in time span.

Table 3 shows the correlations between the counts for all 16 stations used in the study. As expected, the correlations between the counts for the stations with the smaller volumes of traffic were not as strong as the correlations between the counts of stations with the larger volumes.

Four Station Tests

Tables 4.1.1 through 4.3.4 show the results of estimation in the counts of four stations. The stations used were stations 28, 16, 27, and 32.

The day was divided into six segments of hours as described earlier.

Tables 4.1.1 through 4.1.4 show the results of using two of the stations as basis for estimating the counts for the remaining two stations. The randomly selected hours used to provide factors for estimation in each

segment of hours were the hours of 2, 9, 10, 13, 17, and 19.

In Table 4.1.1, stations 27 and 32 were used to estimate the counts for stations 28 and 16.

Results: -0.6% difference in total counts 33.973 total chi-square factor In Table 4.1.2, stations 28 and 32 were used to estimate the counts for stations 16 and 27. Results: -4.8% difference in total counts 91.512 total chi-square factor In Table 4.1.3, stations 28 and 16 were used to

estimate the counts for stations 27 and 32. Results: +0.8% difference in total counts

17.996 total chi-square factor In Table 4.1.4, stations 16 and 32 were used to estimate the counts for stations 28 and 27. Results: +2.4% difference in total counts 31.560 total chi-square factor

For Tables 4.2.1 through 4.2.4, the randomly selected hours of counts used to provide factors for estimation were the hours 6, 8, 12, 15, 18, and 20. Again two stations were used to provide the basis for estimation of counts for the remaining two stations.

In Table 4.2.1, stations 16 and 27 were used to

estimate the counts for stations 28 and 32.

Results: -1.5% difference in total counts 8.291 total chi-square factor In Table 4.2.2, stations 28 and 27 were used to estimate the counts for stations 16 and 32. Results: +1.3% difference in total counts 13.905 total chi-square factor In Table 4.2.3, stations 27 and 32 were used to estimate the counts for stations 16 and 28.

Results: +1.1% difference in total counts

15.077 total chi-square factor In Table 4.2.4, stations 28 and 32 were used to estimate the counts for stations 16 and 27.

Results: +1.8% difference in total counts

16.562 total chi-square factor Comments

A direct comparison between the results of Table 4.1.1 and Table 4.2.3 shows the second series of hours produced better estimates as shown by the chisquare factor.

The same is true for a comparison between the results of Table 4.1.2 and Table 4.2.4. For these stations, the counts for the hours of 6, 8, 12, 15, 18, and 20 produced better results than the counts for the hours of 2, 9, 10, 13, 17, and 19.

Another result to note is the makeup of the

chi-square factor. This factor is a measure of "goodness" of estimation. In all preceding tables, the total chi-square factor had a large part of it composed of the chi-square factor for one station. In other words, the estimate of one station was "good" or of low variation from the true count, while the estimate of the remaining station had an estimate of a much greater variation.

For the next series of tests, the same four stations were used, stations 28, 16, 27, and 32.

Only one station was used to estimate the counts for the remaining three stations.

The hours of the day were divided into six segments to provide six groupings of hourly counts. One hour in each of these segments was chosen to provide the counts for the factors used in estimating. The counts used were the counts of hours 2, 9, 10, 13, 17, and 19.

By using the same four stations but only using one station to estimate the counts for the remaining stations, it can be determined what kind of accuracy loss can be attributed to reducing the basis of estimation from two stations to one station.

In Table 4.3.1, station 28 was used to estimate the counts for stations 16, 27, and 32.

Results: -4.2% difference in total counts

83.129 total chi-square factor In Table 4.3.2, station 16 was used to estimate the counts for stations 28, 27, and 32.

Results: +9.9% difference in total counts

263.112 total chi-square factor In Table 4.3.3, station 27 was used to estimate the

counts for stations 28, 16, and 32.

Results: +3.9% difference in total counts 86.405 total chi-square factor

In Table 4.3.4, station 32 was used to estimate the counts for stations 28, 16, and 27.

Results: -5.6% difference in total counts

105.342 total chi-square factor

In comparing the results of using two-station estimates and using one station as the estimator, the estimates were better using two stations as basis for the estimated counts. This is partially explained by the fact there were fewer stations to estimate. However, the averaging tendency of combining two stations for a basis for estimation can explain some of the reduction in errors of estimation. Station 16 seemed to be the worst station both for estimating and for use as a basis of estimation. It is in the same area as station 28, Yet, it does vary considerably from station 28 when both are estimated by other stations.

Station 16 is on a roadway connecting roadways measured by stations 28 and 32. Chestnut Ridge Road (Station 28) and Stewart Street(Station 32) carry traffic to and from centers of attraction, i.e., downtown and the Evansdale Campus. Willowdale Road(Station 16) connects these two roadways.

Therefore, even though these three stations are in close proximity to each other, the roadway connecting two main routes of travel to and from centers of attraction does not appear to be useful in predicting travel on those main routes.

Another aspect of estimation noted in the onestation tests were relationships between stations 28 and 32, and between stations 16 and 27 in predicted counts. According to the percentage differences and chi-square factors, stations 28 and 32 could be presumed to have the same flow patterns. The same holds true for stations 16 and 27. While one station of these two-station groupings predicted the other station of this grouping well, the remaining two stations had a much greater error. Five Station Tests

In the series of tests using five stations, the thrust of the effort was directed toward testing which combination of hours chosen provided the closest estimates of the true counts of traffic.

The five stations had volumes of counts located near the middle of the range of volumes for all the stations. This was to minimize any effects of stations having very large volumes of traffic or very small volumes of traffic. The stations used in this series of tests were the stations 33, 9, 6, 7, and 2.

The 24 hours of the day were divided into six segments. The segments of hourly counts were the hours of: 1 to 6, 7 to 9, 10 to 12, 13 to 15, 16 to 18, and 19 to 24. This was to have a smaller number of hourly counts clustered about the peak hours.

Four sets of hours were used as division hours. These hourly counts provided factors for estimation for each section of hours of the day. The hourly counts were chosen randomly, but chosen so as to have one hour in each of the six segments of hourly counts throughout the day.

Tables 5.1.1 through 5.1.4 show the results of using stations 33 and 9 combined to produce estimates of counts for stations 6, 7, and 2. In Table 5.1.1, the division hours were the hours of 2, 9, 10, 13, 17, and 19.

Results: +0.8% difference in total count

12.530 total chi-square factor

In Table 5.1.2, the division hours were the hours of 6, 9, 12, 15, 18, and 19.

Results: -0.5% difference in total count 32.005 total chi-square factor

In Table 5.1.3, the division hours were the hours of 3, 8, 11, 14, 17, and 20.

Results: +4.6% difference in total count 202.891 total chi-square factor

In Table 5.1.4, the division hours were the hours of 6, 8, 12, 15, 18, and 20.

Results: +0.7% difference in total count 24.311 total chi-square factor

Tables 5.2.1 through 5.2.4 show the results of using stations 33 and 7 combined to produce estimates of counts for stations 9, 6, and 2.

In Table 5.2.1, the division hours were the hours of 2, 9, 10, 13, 17, and 19.

Results: -0.2% difference in total count 8.028 total chi-square factor In Table 5.2.2, the division hours were the hours of 6, 9, 12, 15, 18, and 19.

Results: -0.1% difference in total count 24.193 total chi-square factor

In Table 5.2.3, the division hours were the hours of 3, 8, 11, 14, 17, and 20.

Results: +1.6% difference in total count 39.201 total chi-square factor

In Table 5.2.4, the division hours were the hours of 6, 8, 12, 15, 18, and 20.

Results: -1.3% difference in total count 58.784 total chi-square factor

Tables 5.3.1 through 5.3.4 show the results of using stations 7 and 2 combined to produce estimates of counts for stations 33, 9, and 6.

In Table 5.3.1, the division hours were the hours of 2, 9, 10, 13, 17, and 19.

Results: -1.8% difference in total count 24.864 total chi-square factor

In Table 5.3.2, the division hours were the hours of 6, 9, 12, 15, 18, and 19.

Results: +0.2% difference in total count 21.793 total chi-square factor In Table 5.3.3, the division hours were the hours of 3, 8, 11, 14, 17, and 20.

Results: -3.6% difference in total counts 166.151 total chi-square factor

In Table 5.3.4, the division hours were the hours of 6, 8, 12, 15, 18, and 20.

Results: -1.8% difference in total count 54.501 total chi-square factor

Tables 5.4.1 and 5.4.2 show the results of using stations 9 and 6 combined to produce estimates of counts for stations 33, 7, and 2.

In Table 5.4.1, the division hours were the hours of 2, 9, 10, 13, 17, and 19.

Results: +1.3% difference in total count 20.630 total chi-square factor

In Table 5.4.2, the division hours were the hours of 3, 8, 11, 14, 17, and 20.

Results: -0.2% difference in total count 72.966 total chi-square factor

Due to an oversight in running the computer program, estimates using the division hours of 6, 9, 12, 15, 18, and 19; and the hours of 6, 8, 12, 15, 18, and 20 were not made. Comments

Overall, the first set of division hours, the hours of 2, 9, 10, 13, 17, and 19, gave the best estimations. This means the counts of those division hours were the counts used to calculate factors used for estimation.

In comparing the second and fourth sets of division hours, the hours of 6, 9, 12, 15, 18, and 19; and the hours of 6, 8, 12, 15, 18, and 20, the fourth set of hours gave results showing greater variation from actual counts at the stations. The difference between the two sets of hours was the changing of two of the hours used as division hours. The fourth set of division hours used hours 8 and 20 in place of hours 9 and 19 of the second set of division hours.

This is the ranking of hours by volume:

Hour	Rank
8	13
9	8
20	10
19	9

Therefore, the difference in accuracy between these two sets of division hours appears to be due to the use of higher volume hours as basis for estimation.

Again noted in this series of tests were the distribution of the chi-square factors. This factor is a measure of the "goodness" of the estimate. The greater

the error of the estimated count from the actual count, then the greater the chi-square factor.

In this series, as in the previous series of tests with four stations, the total chi-square factor was made up in large part by the chi-square factor of one station. This one large chi-square factor did not come from the same station in each series. This fact could be an indication that to predict the count at a certain location, there needs to be specific combinations of hours used to estimate the count and specific combinations of other stations to serve as a base for estimation.

Six Station Tests

Six stations were used for the next series of tests. The six stations were stations 9, 28, 33, 39, 41, and 42. The locations of these stations were widely separated. The locations were all on high volume routes. The stations were chosen because of this factor. Variations of a small number of vehicles passing the station should not affect the trends in flow patterns on these routes as much as the same number of vehicles on a lower volume route.

To form a basis for estimation, the tests using six stations were carried out in two phases. First, one station was used to estimate the counts for the remaining five stations. The results are shown in Tables 6.1.1

through 6.5.2.

The second phase combined three stations' counts to form a basis for estimation. Comparisons of accuracy of estimates could be made between the two ways of using base stations for the predicted count. The results of the second phase are shown in Tables 7.1.1 through 7.6.2. The stations used for the basis of estimation were chosen at random.

In Table 6.1.1, station 28 was used to estimate the counts of the remaining five stations. The hours used as division hours were the hours of 6, 9, 12, 15, 18, and 19.

Results: -1.3% difference in total count 81.950 total chi-square factor

In Table 6.1.2, station 28 was again used to estimate the counts of the remaining five stations. The hours used as division hours were the hours of 6, 8, 12, 15, 18, and 20.

Results: -0.04% difference in total count

98.738 total chi-square factor

In Table 6.2.1, station 33 was used to estimate the counts of the remaining five stations. The hours used as division hours were the hours of 6, 9, 12, 15, 18, and 19.

Results: +0.9% difference in total count 82.476 total chi-square factor

In Table 6.2.2, station 33 was again used to estimate the counts of the remaining five stations. The hours used as division hours were the hours of 6, 8, 12, 15, 18, and 20.

Results: +0.4% difference in total count 94.862 total chi-square factor

In Table 6.3.1, station 39 was used to estimate the counts for the remaining five stations. The hours used as division hours were the hours of 6, 9, 12, 15, 18, and 19.

Results: -0.5% difference in total count 72.716 total chi-square factor

In Table 6.3.2, station 39 was again used to estimate the counts for the remaining five stations. The hours used as division hours were the hours of 6, 8, 12, 15, 18, and 20.

Results: -2.0% difference in total count 125.316 total chi-square factor

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In Table 6.4.1, station 41 was used to estimate the counts for the remaining five stations. The hours used as division hours were the hours of 6, 9, 12, 15, 18, and 19.

Results: -0.8% difference in total count 74.951 total chi-square factor

In Table 6.4.2, station 41 was again used to estimate the counts for the remaining five stations. The hours used as division hours were the hours of 6, 8, 12, 15, 18, and 20.

Results: -1.6% difference in total count 119.079 total chi-square factor

In Table 6.5.1, station 42 was used to estimate the counts for the remaining five stations. The hours used for the division hours were the hours of 6, 9, 12, 15, 18, and 19.

Results: -2.4% difference in total count 123.291 total chi-square factor

In Table 6.5.2, station 42 was again used to estimate the counts for the remaining five stations. The hours used as division hours were the hours of 6, 8, 12, 15, 18, and 20.

Results: -1.4% difference in total count 108.424 total chi-square factor

For the first set of division hours, the counts for the hours of 6, 9, 12, 15, 18, and 19 were used. The second set of division hours used the counts for the hours of 6, 8, 12, 15, 18, and 20. These are the same two sets of division hours used in the previous five station tests.

In comparing the results of this series of estimates, a definite conclusion that using hours 9 and 19 for counts for factors gives better results than using the counts for hours 8 and 20 is not possible. The resulting estimates showed no definite pattern as far as one set of counts of division hours being able to provide counts that were closer to the actual counts.

Stations 39 and 41 gave the best results using the first set of division hours; hours 6, 9, 12, 15, 18, and 19.

Stations 28 and 33 gave the best results using the second set of division hours; hours 6, 8, 12, 15, 18, and 20.

One conclusion possible is that station 9 is not compatible with the other stations in this group. It showed the greatest variations in percentage difference from actual count and in the chi-square factor. In the total chi-square factor for the six stations on each estimate, the chi-square factor for station 9 made up the largest part of the total factor.

Therefore, to look at the impact the errors attributed to station 9 has, the estimates are shown below without the estimated count and chi-square factor of station 9.

The first set of division hours are the hours of 6, 9, 12, 15, 18, and 19.

The second set of division hours are the hours of 6, 8, 12, 15, 18, and 20.

Station 28 as estimator:

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	Computed Count	Actual Count	% Difference	Chi- Square
First set of division hours	76359	76600	-0.3	Factor 9.234
Second set of division hours	77524	76600	+1.2	15.313

Station 33 as estimator:

	Computed Count	Actual Count	% Difference	Chi- Square Factor
First set of division hours	78066	76600	+1.9	36.872
Second set of division hours	77819	76600	+1.6	24.945

Station 39 as estimator:

	Computed Count	Actual Count	% Difference	Chi- Square Factor
First set of division hours	76987	76600	+0.5	10.360
Second set of division hours	75983	76600	-0.8	9.641

Station 41 as estimator:

	Computed Count	Actual Count	% Difference	Chi- Square Factor
First set of division hours	76728	76600	+0.2	9.649
Second set of division hours	76328	76600	-0.4	4.790
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Station 42 as estimator:

	Computed Count	Actual Count	% Difference	Chi- Square Factor
First set of division hours	75504	76600	-1.4	24.348
Second set of division hours	76466	76600	-0.2	4.425

With one exception, the results of estimation were better by not using station 9. The chi-square factors were drastically reduced. And most of the percentage differences were reduced.

Station 9 was located on Walnut Street in the downtown area. The other stations were located away from the downtown area. The difference in time variation of traffic flows peculiar to station 9 can be explained by the fact that station 9 had a heavy flow of traffic throughout the day with less pronounced peak hour flows.

Therefore, the patterns of traffic flow for station 9 were different enough to state that for this study, station 9 should have been grouped with stations of like characteristics and not with the other five stations in this series of tests. Using the same six stations, now three stations will be used as the basis for estimation. The averaging of the three stations should provide a better estimation for the total count.

The 24 hours were divided into six sections. The section hours were hours 1 to 6, 7 to 9, 10 to 12, 13 to 15, 16 to 18, and 19 to 24.

The count for one hour from each section of hours described above was used to form a set of division hours. The counts for these division hours were used to provide factors for estimating the total count for each station.

In Table 7.1.1, stations 9, 28, and 41 were used to estimate the counts for the remaining three stations, The hours used as division hours were the hours of 3, 8, 11, 14, 17, and 20.

Results: -0.8% difference in total count 33.649 total chi-square factor

In Table 7.1.2, stations 9, 28, and 41 were again used to estimate the counts for the remaining three stations. The hours used as division hours were the hours of 2, 9, 10, 13, 17, and 19.

Results: +0.6% difference in total count 12.606 total chi-square factor
In Table 7.2.1, stations 33, 41, and 42 were used to estimate the counts for the remaining three stations. The hours used as division hours were the hours of 3, 8, 11, 14, 17, and 20.

Results: +1.3% difference in total count 36.390 total chi-square factor

In Table 7.2.2, stations 33, 41, and 42 were again used to estimate the counts for the remaining three stations. The hours used as division hours were the hours of 2, 9, 10, 13, 17, and 19.

Results: +0.2% difference in total counts 7.580 total chi-square factor

In Table 7.3.1, stations 28, 33, and 39 were used to estimate the counts for the remaining three stations. The hours used as division hours were the hours of 3, 8, 11, 14, 17, and 20.

Results: +0.2% difference in total counts 9.980 total chi-square factor

In Table 7.3.2, stations 28, 33, and 39 were again used to estimate the counts for the remaining three stations. The hours used as division hours were the hours of 2, 9, 10, 13, 17, and 19.

Results: -0.04% difference in total counts 12.597 total chi-square factor In Table 7.4.1, stations 9, 28, and 33 were used to estimate the counts for the three remaining stations. The hours used for division hours were the hours of 3, 8, 11, 14, 17, and 20.

Results: +0.9% difference in total counts 21.397 total chi-square factor

In Table 7.4.2, stations 9, 28, and 33 were again used to estimate the counts for the remaining three stations. The hours used as division hours were the hours of 2, 9, 10, 13, 17, and 19.

Results: +0.1% difference in total counts 12.555 total chi-square factor

In Table 7.5.1, stations 9, 28, and 39 were used to estimate the counts for the remaining three stations. The hours used as division hours were the hours of 3, 8, 11, 14, 17, and 20.

Results: -1.5% difference in total count 47.294 total chi-square factor

In Table 7.5.2, stations 9, 28, and 39 were again used to estimate the counts for the remaining three stations. The hours used as division hours were the hours of 2, 9, 10, 13, 17, and 19.

Results: -0.1% difference in total counts 13.825 total chi-square factor In Table 7.6.1, stations 9, 28, and 42 were used to estimate the counts for the remaining three stations. The hours used as division hours were the hours of 3, 8, 11, 14, 17, and 20.

24.674 total chi-square factor

Results: +0.1% difference in total counts

In Table 7.6.2, stations 9, 28, and 42 were again used to estimate the counts for the remaining three stations. The hours used as division hours were the hours of 2, 9, 10, 13, 17, and 19.

Results: -1.3% difference in total counts

27.582 total chi-square factor

Of the 12 estimates of counts, the variation for total vehicle counts was greater than 1% in only three instances. The greatest variation was a minus 1.5%. In the previous ten estimates that used only one station as a basis for estimation, five had variation for total vehicle count greater than 1%. The greatest variation was a minus 2.4%.

Averaging the three stations did produce a better estimate than using only one station as basis for estimation. However, it did not drastically improve the estimate enough to state that using three stations was justified in order to decrease errors. Using only one station as the basis for estimates gave almost the same results. Station 9 did not seem to bias the estimates as much in this series of tests. Station 33 was the station showing the greatest variations when estimated.

Overall, the second set of division hours, hours 2, 9, 10, 13, 17, and 19, showed the best results in estimation.

Sixteen Station Tests

The next series of tests were for estimating the counts for 16 stations. No means of classification was used. Every station was lumped together with a resulting mixture of volumes and time patterns.

The 24 hours of the day were divided into four 6-hour sections. The section hours were hours 1 to 6, 7 to 12, 13 to 18, and 19 to 24. The count for one hour from each of these sections was selected to provide the factors used in estimating the total counts for the stations.

In the first series of estimates as shown in Tables 8.1 through 8.6, the counts for hours 4, 9, 15, and 20 were selected as division hours to provide factors used in estimation. Only one station was used to estimate the counts for the remaining fifteen stations. In Tables 8.1 through 8.6, the hours are constant that are used for division hours. Different stations chosen at random

throughout the range of volumes were used for estimation.

In Table 8.1, station 32 was the station used for estimation.

Results: +3.0% difference in total counts 285.544 total chi-square factor

In Table 8.2, station 3 was the station used for estimation.

Results: -2.1% difference in total counts 206.144 total chi-square factor

In Table 8.3, station 16 was the station used for estimation.

Results: +5.8% difference in total counts 798.447 total chi-square factor

In Table 8.4, station 2 was the station used for estimation.

Results: -2.5% difference in total counts 301.499 total chi-square factor

In Table 8.5, station 4 was the station used for estimation.

Results: +2.5% difference in total counts 265.272 total chi-square factor In Table 8.6, station 42 was the station used for estimation.

Results: -0.8% difference in total counts 177.263 total chi-square factor

Station 42 gave the best results in this series of estimations. The high volume of this station allowed variations to be smoother in each of the four divisions of the day. A few vehicles did not have as great an influence on the time pattern of station 42 as they would have had on a location of less volume.

Station 16 produced the worst estimates. As in an earlier series of estimates, the location of station 16 has a definite effect on its time patterns of traffic flows. Station 16 did not reflect the flows of the arterial traffic to and from centers of attractions.

For the next series of estimates for 16 stations, shown in Tables 9.1 through 10.2, one station was used as the estimator and the hours used as division hours to provide estimates were varied. The 24 hours of the day were divided into 4 six-hour segments.

The station used in Tables 9.1 through 9.8 was station 42. The station used in Tables 10.1 and 10.2 was station 16. The hours used as division hours were randomly chosen and are noted with each table. Using stations 42 and 16 was to follow up the prediction characteristics of these two stations as shown in earlier estimations. Following earlier indications, station 42 should provide small errors in the estimations while station 16 should give large errors in the estimations.

Station 42 Estimates

In Table 9.1, the hours used as division hours were the hours of 1, 9, 17, and 20.

Results: -0.7% difference in total counts 408.571 total chi-square factor

In Table 9.2, the hours used as division hours were the hours of 4, 11, 18, and 21.

Results: +3.0% difference in total counts 354.614 total chi-square factor

In Table 9.3, the hours used as division hours were the hours of 2, 8, 15, and 19.

Results: -2.0% difference in total counts 383.024 total chi-square factor

In Table 9.4, the hours used as division hours were the hours of 3, 12, 13, and 20.

Results: -1.1% difference in total counts 694.593 total chi-square factor

In Table 9.5, the hours used as division hours were the hours of 5, 7, 16, and 24.

Results: -0.5% difference in total counts 2068.607 total chi-square factor

In Table 9.6, the hours used as division hours were the hours of 1, 9, 14, and 23.

Results: +1.7% difference in total counts 422.573 total chi-square factor

In Table 9.7, the hours used as division hours were the hours of 6, 10, 17, and 22.

Results: +6.0% difference in total counts 1129.446 total chi-square factor

In Table 9.8, the hours used as division hours were the hours of 5, 8, 13, and 19.

Results: -5.6% difference in total counts 985.577 total chi-square factor

Station 16 Estimates

In Table 10.1, the hours used as division hours were the hours of 5, 8, 13, and 19.

Results: +4.9% difference in total counts 940.977 total chi-square factor

In Table 10.2, the hours used as division hours were the hours of 1, 9, 17, and 20.

Results of Table 10.2

+1.0% difference in total counts 367.160 total chi-square factor

The best hours for estimation using station 42 seemed to be the groups of hours 1, 9, 17, and 20; and hours 1, 9, 14, and 23. The counts for hours 4, 11, 18, and 21 gave a lower chi-square factor. However, the percentage difference was 3 percent for the total count and one station varied from the actual count by over 10%.

Estimates using the counts for hours 5, 7, 16, and 24 had the lowest percentage difference for the total count. The chi-square factor was over 2000 for the total estimate with several stations being over 10% in variation from the actual counts.

Station 16 was used to see if a prediction made from a station shown to be a bad basis for estimation from a previous series of estimations would produce the same results. The counts for the hours containing the peak hours, hours 1, 9, 17, and 20, gave the best estimation. Total count variation was 1% with only three stations varying from actual counts by more than 10%. Therefore, even by using station 16, the estimations of counts using the counts for these particular hours proved to be fairly accurate.

In comparing the estimations given by using the two

stations, it is evident the results are almost the same. (Tables 9.1 and 10.2, Tables 9.8 and 10.1) Indications concerning station 16 given by earlier estimations were not borne out by this test.

Sixteen Station Tests Three Stations Used for Estimation

Next, three stations were used as basis for estimation. The counts for three stations were averaged and used to predict the counts for the remaining 13 stations.

The 24 hours of the day were divided into 4 six-hour segments. For this series of estimations, Tables 11.1 through 11.5, the hours of 4, 9, 15, and 20 were used as division hours. These were chosen at random so as to provide one division hour in each six-hour segment.

By using three stations, consistently close estimations should be made for the total counts. The averaging effect of the three stations should provide a time pattern of flows closer to the average flows of all 16 stations. The stations were chosen at random throughout the range of volumes for all 16 stations.

In Table 11.1, stations 33, 27, and 4 were used for estimation.

Results: +0.9% difference in total count 153.529 total chi-square factor In Table 11.2, stations 28, 2, and 42 were used for estimation.

Results: -1.6% difference in total counts

185.794 total chi-square factor

In Table 11.3, stations 3, 7, and 33 were used for estimation.

Results: -2.2% difference in total counts

229.995 total chi-square factor

In Table 11.4, stations 32, 1, and 28 were used for estimation.

Results: -1.7% difference in total counts 161.903 total chi-square factor

In Table 11.5, stations 3, 10, and 39 were used for estimation.

Results: -2.1% difference in total counts 217.072 total chi-square factor

In this series of estimations, the value of using more than one station to serve as basis for estimation was shown. Total variation was well within 5% for the total counts. Variation on any one station was well within 10% of the actual counts. The chi-square factor was lower as expected. Part of this was due to two less chi-square factors being added to form the total chi-square factor. But mainly it was due to the use of three stations as a basis for estimation. There were large variations on only one station which would produce a large chi-square factor. This was station 41. It consistently showed the highest chi-square factor. Its location was next to station 42. Yet station 42 showed no large variations when estimated. Therefore, these two stations had very different traffic flow patterns.

Sixteen Station Tests Eight Stations Used for Estimation

In the next series of estimations, eight stations were used as the basis for estimation of counts. The stations used and hours used as division hours will vary. This series was designed to see if any improvement in accuracy of estimates could be made by using a higher number of stations as basis for estimation.

The stations are arranged in ascending order by volume. In Tables 12.1 through 12.6, the counts for every other station were used as the basis of estimation.

In Tables 13.1 through 13.4, the counts for the four lowest and four highest stations by volume were used as the basis of estimation.

In Tables 14.1 through 14.3, the counts of the eight highest stations by volume were used as the basis for estimation. In Tables 15.1 through 15.4, the counts of two stations located in the lower range of volumes plus the counts of six stations located in the mid-range of volumes were used as the basis for estimation.

The 24 hours of the day were divided into 4 sixhour segments. The counts for one hour of each of these segments were chosen at random to use as division hours to provide a factor for each segment for use in estimation.

In Tables 12.1 through 12.6, the stations chosen to provide counts used as the basis for estimation were the stations 32, 10, 27, 28, 7, 9, 4, and 41.

In Table 12.1, the hours used as division hours were the hours of 4, 9, 15, and 20.

Results: +1.7% difference in total counts

152.580 total chi-square factor

In Table 12.2, the hours used as division hours were the hours of 1, 9, 17, and 20.

Results: -0.5% difference in total counts

120.352 total chi-square factor

In Table 12.3, the hours used as division hours were the hours of 5, 8, 13, and 19.

Results: +1.5% difference in total counts 295.738 total chi-square factor

In Table 12.4, the hours used as division hours were the hours of 6, 7, 17, and 20.

Results: -0.6% difference in total counts 1006.184 total chi-square factor

In Table 12.5, the hours used as division hours were the hours of 2, 7, 14, and 21.

Results: +1.2% difference in total counts 551.682 total chi-square factor

In Table 12.6, the hours used as division hours were the hours of 6, 9, 14, and 19.

Results: +1.8% difference in total counts 190.363 total chi-square factor

In Tables 13.1 through 13.4, the stations chosen to provide counts used as the basis for estimation were stations 32, 3, 10, 16, 4, 39, 41, and 42.

In Table 13.1, the hours used as division hours were the hours of 1, 9, 17, and 20.

Results: -0.9% difference in total counts 243.799 total chi-square factor

In Table 13.2, the hours used as division hours were the hours of 5, 8, 13, and 19.

Results: -1.6% difference in total counts 147.991 total chi-square factor In Table 13.3, the hours used as division hours were the hours of 1, 8, 13, and 20.

Results: -0.6% difference in total counts 114.013 total chi-square factor

In Table 13.4, the hours used as division hours were the hours of 6, 9, 14, and 19.

Results: +0.2% difference in total counts 28.836 total chi-square factor

In Tables 14.1 through 14.3, the stations chosen to provide counts used as the basis for estimation were the stations 7, 6, 9, 33, 4, 39, 41, and 42.

In Table 14.1, the hours used as division hours were the hours of 4, 9, 15, and 20.

Results: +0.4% difference in total counts

58.988 total chi-square factor

In Table 14.2, the hours used as division hours were the hours of 6, 9, 14, and 19.

Results: -0.7% difference in total counts

103.055 total chi-square factor

In Table 14.3, the hours used as division hours were the hours of 6, 9, 15, and 19.

Results: +0.3% difference in total counts 42.670 total chi-square factor In Tables 15.1 through 15.4, the stations chosen to provide counts used as the basis for estimation were the stations 3, 27, 28, 2, 7, 6, 9, and 33.

In Table 15.1, the hours used as division hours were the hours of 4, 9, 15, and 20.

Results: -0.007% difference in total counts 115.591 total chi-square factor

In Table 15.2, the hours used as division hours were the hours of 6, 9, 14, and 19.

Results: +0.5% difference in total counts 197.234 total chi-square factor

In Table 15.3, the hours used as division hours were the hours of 6, 9, 15, and 19.

Results: +2.1% difference in total counts 259.055 total chi-square factor

In Table 15.4, the hours used as division hours were the hours of 5, 8, 13, and 19.

Results: +2.4% difference in total counts

612.429 total chi-square factor

In this series of tests, the best estimates of counts were those using the eight highest volume stations as the basis for estimation. The series using the four lowest volume stations plus the four highest volume stations also gave good results. In using different hours for hours of division, the groups of hours using the hour 9 seemed to have good estimates. Hour 9 is the morning peak hour.

In using alternate stations as basis for estimation, the counts for the group of hours 1, 9, 17, and 20 gave the best results. This group of hourly counts contained the counts for both morning and evening peak hours of traffic.

In the group of stations using mostly middle-volume stations as basis for estimation, the counts for the hours of 4, 9, 15, and 20 gave the best estimates.

The results of using eight stations as basis for estimation as opposed to using three stations as basis for estimation did not show that much improvement in terms of percentage difference of total counts or in the total chi-square factor.

Using over twice as many stations for basis of estimation did not improve the accuracy of estimation twice as much.

Therefore, more than one station in a grouping of like stations should be used to provide the base for estimation of traffic counts. This study showed that three stations combined gave fairly accurate estimates of counts for the other thirteen stations. It is not believed that more stations produced a commensurate increase in accuracy.

Factor Analysis

The Factor Analysis program of the Statistical Analysis System was used to find if a common factor was present in the counts by hour to explain variations in volumes. The result is a matrix for each hour evaluated. The number 1.00000 shows a perfect correlation of the hourly volume with the volume predicted by using a common factor. If the variations in volume by hour vary from the volumes explained by this common factor, then a progressively lower number is shown in the matrix.

The computer program also has the ability to "rotate" the common factors to explain the most variation possible as shown by the volumes of the hours. Therefore, if the volumes of traffic counts shown by the counts in this study have common factors which can explain most of the variation shown, then the computer program will "rotate" the factors running throughout the counts and calculate the amount of variation that can be explained by that factor.

Using all 16 stations and 24 hours of counts, the Factor Analysis produced the results shown in Table 16. The higher volumes showed the strongest correlation with the first factor. Hour 4 showed the lowest correlations and the program rotated to a common factor along the variations in counts that occurred during hour 4. During hour 4, the traffic in the area dropped almost to zero, and any vehicle had a more pronounced effect upon the pattern of time variation.

To see how much this one hour of traffic counts, hour 4, can affect the rest of the counts in the estimation efforts, the Factor Analysis program was used on the counts for the odd hours, i.e., hours 1, 3, etc., and then the counts for the even hours, i.e., hours 2, 4, etc. throughout the day. The results are shown in Tables 16.1 and 16.2.

As can be inferred, the counts for hour 4 are the cause of most of the variations in the estimates of the traffic counts. Because of its low volumes, hour 4 does not behave in the same way as other hours in the pattern of traffic flows. One could conclude the counts for hours 2 and 3 behave in much the same way.

Therefore, the very early morning hours, with their low volumes of traffic, should not be used in estimating traffic for day-long periods.

The Factor Analysis program was also used on the counts of the stations to see if common factors were present in their volumes of traffic. All 16 stations were used with all 24 hours of counts. The results are shown in Table 17. As expected, the higher volume stations showed a higher correlation to the factor found by the computer program. Station 16, which showed itself to be weak in estimation, has a low correlation number.

From the numbers given in this table, one can conclude the stations behaved in approximately the same patterns throughout the day with regard to traffic time patterns.

Summary in Rankings of Stations

Table 18 shows the summation of the four station tests shown in Tables 4.3.1 through 4.3.4. In this series, one station provided the hourly counts used as a basis for prediction of the total counts for the remaining three stations.

As is evident, the ranking given by using the criteria for accuracy in estimation varies closely with the ranking based on correlations from the factor analysis matrix.

Table 19 shows the summation of the sixteen station tests shown in Tables 8.1 through 8.6. The table shows the stations used, their ranking among the six stations from the correlations of the factor analysis, and the rankings among the six stations based upon the accuracy of estimated counts. The rankings based on the correlations of the factor analysis correspond closely with the rankings based on accuracy of estimation.

Based upon these two observations, there would seem to be a relationship based on correlations shown in factor analysis that could be used when choosing locations for use in estimating counts of traffic. Initial evidence shown in this study points to further use of a factor analysis or statistical analysis of traffic count stations to choose locations that can provide accurate estimates for all roadways in an area.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

Conclusions

The hypothesis tested was that variations in traffic flow along selected roadways in an area could be used to predict traffic flows of other roadways in the area. The results of using this method of estimating traffic show the hypothesis to be essentially correct.

The study was concerned with providing estimates of daily traffic based upon different combinations of hours and count locations. The experiment focused on providing indications of suitability in combining certain hours or count locations to get reasonably accurate estimates of counts. Some conclusions on using certain hours and count locations are discussed below.

The very early morning hours with their low percentage of daily traffic gave poor predictions. These hours should not be used to provide factors for estimation.

The afternoon hours carried the greatest volume of traffic. When combined with the morning peak hour, the afternoon hours gave the best predictions.

The peak hours of traffic should definitely be used when determining estimation factors by the method used in this thesis. The streets used in this study were chosen at random to provide the West Virginia Department of Highways with statistically acceptable estimates of traffic flow. That the estimates obtained in the experiment are very close to the actual counts is very significant. The conclusion reached is that variations by time have a basic pattern extending across all volume classes of roadways.

This conclusion is further supported by the correlations shown between the hourly counts or between count locations. There were very high R values in most instances.

This leads to another conclusion concerning counting locations. Stations that were in close physical proximity to each other seemed to be varying closely in time patterns. This reinforces the theory that routes in different parts of the city behave in distinct patterns.

To predict the total vehicle miles of travel(VMT) of an area, one can draw a conclusion from the differences between total estimated count and actual count. When all the stations' counts were totalled and compared to the total actual count for all those stations, the percentage difference was very small. This averaging tendency would also apply to those roadways grouped together for estimation. By dividing those roadways into roughly equal lengths, the averaging effect of the group of roadways should produce an estimate of VMT that is

reasonably accurate.

Areas for Future Research

This research was an initial attempt to discern traffic flow patterns for use in traffic volume predictions. The traffic counts used were supplied as a part of the West Virginia Department of Highways annual traffic counts. The locations were statistically selected to provide a reasonable estimate of the total vehicle miles of travel(VMT). Therefore, this experiment was limited to locations that were stations in the DOH count. To obtain a more thorough evaluation of the prediction process, an experiment using locations selected by means other than random choice would be appropriate. These locations could be chosen in terms of physical proximity, volumes of traffic, or by functional classification.

Experiments on the variations of traffic by time have been carried out in the past. The hourly count has been the basic unit for counting. Perhaps experiments can be carried out using a greater or lesser time period. Perhaps two or even three hours grouped together would provide a better factor on which to base an estimation.

Since the early morning hours contained such a small percentage of traffic flow, future experiments would be better suited to obtain their traffic counts during the daylight hours when most traffic occurs. Those experiments should prove that errors caused by variations in traffic in the early morning hours would be minor.

One future experiment of great importance would be to use aerial sensors to obtain traffic counts of an area that has numerous counting stations in it. Counting by aerial means has been shown to be accurate in several experiments. By isolating a specific region, installing traffic counters at locations on the roadways to serve as basis for estimation and comparison, and using an aerial means of counting traffic, the concept advanced in this thesis can be evaluated. It is suggested an area containing several roads of varying volumes be used. In this this way, patterns of flow could be discerned for different types of roadways.

Also, by obtaining aerial photographs of an area and obtaining counts of traffic flows for a period of less than one hour duration, the experiment can determine a minimum time needed to provide a 24-hour count within specified accuracy limits.

Counts taken from aerial photos would record the traffic for only a brief timespan. Implicit in using a series of these counts is the assumption these counts represent smoothly varying rates of flow. If in fact the photos captured the flows in a period when the traffic was not varying smoothly but was flowing in spurts.

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Administration Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Metalogical Met		Anna Sana Sana Sana Sana Sana Sana Sana			A second		END DATE FILMED 2 -79					× ô	

then a certain amount of "noise" would be introduced in the pattern of traffic flow. This "noise" in the pattern of flow would introduce errors. Therefore, studies of this nature would need to determine the number of counts needed to reduce to an acceptable level the errors caused by this "noise" on the flow patterns.

In observing the ranking by volume of the hourly counts, the afternoon hours contained the largest amounts of daily traffic. Perhaps this pattern was unique only to this particular area. Perhaps the traffic engineer needs to discern the flow pattern unique to an area before he can use the method of estimation proposed by this thesis. This would be done in order to determine the hours of the day best suited for use in providing the factors used for estimation.

In this experiment, stations were used that were located in the Central Business District(CBD) of Morgantown and at varying distances from the CBD. To determine if there are certain factors, based upon distance from the CBD, that could be used in the estimation process, an experiment using the CBD and rings of distance around the CBD is recommended.

The use of factor analysis in further studies is recommended. Future studies could concentrate on obtaining predictions of traffic counts based on stations showing high correlation with a common factor explaining the variation of traffic counts throughout the day. Future studies could concentrate on determining if predicted traffic counts accuracies do in fact vary with the selection of "good" hours or stations as shown by factor analysis.

Further studies are recommended in other cities having varied population and topographic characteristics. These studies could investigate relationships among distances traveled, size of population, corridors of travel, etc.

Another possible area of study is the use of factor analysis in the present counting methods. At present, roadways are chosen at random to provide statistically sufficient samples for use in determining VMT for different types of roads. Perhaps factor analysis could provide a basis for choosing fewer roadways to obtain a count that would be as accurate as the present methods.

APPENDIX -

<u>Stations</u> refers to the counting stations as numbered by the West Virginia Department of Highways. In Tables 4.1.1 through 15.4, the station numbers listed in the headings are those stations used as basis for estimation in that table.

<u>Division Hours</u> refers to the counts of the hours chosen to provide factors for use in estimating the total count at a counting station. In Tables 4.1.1 through 15.4, the hours listed in the headings are the hours used as division hours. Table 1

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Vehicle Counts by Hour and by Station

Statio	n 32	3	10	16	27	1	28	2
Hours								
1 2 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 2 2 2 2 2 2 2 2 2 2 2 2 2	29 16 6 9 7 14 86 200 208 141 128 133 152 165 194 227 306 288 230 158 120 122 114 67	42 30 17 11 6 55 154 228 250 217 211 226 264 287 232 190 140 124 86 9	27 25 15 2 13 57 142 231 170 194 234 187 194 234 185 294 3300 173 211 154 201 83 66	36 20 13 5 202 283 212 137 186 243 229 360 397 434 260 216 171 174 143 67	75 57 25 12 20 20 20 239 225 190 292 272 280 313 346 334 378 307 284 225 258 258 192 258	88 32 14 11 16 122 347 388 426 387 396 308 375 389 3375 389 3375 389 3375 389 375 389 375 389 375 389 375 389 375 370 216 185 154 111	67 32 10 12 5 216 424 412 296 361 325 420 536 502 502 502 502 502 502 502 502 502 502	101 63 35 24 24 38 119 380 492 656 603 686 598 641 524 620 535 421 280 535 176 139
Total	3120	3456	3557	4410	4782	5779	6239	8385
DOH Weekday ADT %	3232	3434	3475	4453	4679	5611	6214	7998
DIII.	-2-2	+0.0	+2-4	-1.0	+2.9	+2.0	+0.4	+4.0

Table 1 Continued

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Vehicle Counts by Hour and by Station

Station	7	6	9	33	4	39	42	41
Hours			•					
1 2 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 6 7 8 9 0 11 12 3 4 5 16 7 8 9 0 11 12 3 4 5 16 7 8 9 0 11 12 3 14 5 16 7 8 9 0 11 12 3 14 5 16 7 8 9 0 11 12 3 14 5 16 7 8 9 0 11 12 3 14 5 16 7 8 9 0 11 12 3 14 5 16 7 8 9 0 11 1 2 3 14 5 16 17 11 12 2 3 14 5 17 8 9 0 11 12 3 14 5 15 1 12 11 12 13 14 15 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 11	213 129 48 51 22 37 164 550 6307 5559 6031 529 5052 595 5052 595 5052 595 5052 595 5052 595 5052 595 5052 5983 287	144 91 53 23 23 209 454 491 625 723 709 703 794 550 517 352 413 303	178 167 77 66 28 70 403 652 743 658 678 677 647 666 661 767 720 598 600 547 439 451 333	146 89 32 18 15 60 392 648 772 690 589 734 763 675 782 788 770 761 767 771 629 508 397	252 179 82 52 34 77 300 697 872 881 864 939 869 869 868 945 1086 1043 781 813 669 721 474	210 136 54 34 52 120 568 1085 1145 979 1006 1114 1051 1134 1072 1147 1090 1115 1090 855 704 474	203 104 39 23 31 118 556 1104 1266 1070 1013 1156 1393 1217 1373 1509 1436 1389 1249 1157 923 667 496	245 113 48 25 52 152 641 1097 1026 922 1043 1125 1403 1273 1461 1813 1680 1528 1315 1156 906 667 505
24	234	223	278	345	402	364	402	409
Total	9442	10324	11104	12141	14905	17721	19894	20605
DOH Weekday ADT	9184	9702	11017	12189	14566	17472	20114	20201
% Diff.	+2.8	+6.4	+0.8	-0.4	+2.3	+1.4	-1.1	+2.0

Table 1 Continued

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Vehicle Count by Hour and by Station

Hours	Sum of Hour Count	Rank by Volume
1	2056	19
2	1283	20
4	390	. 23
5	331	24
6	862	22
7	4165	17
0	9279	13
10	8729	12
11	8764	11
12	9502	6
13	9830	27
15	10474	4
16	11096	2
17	11579	1
18	10489	3
19	8802	10
21	6716	14
22	6015	15
23	4385	16
24	5469	18

Table 2

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Correlation of Hourly Counts

Hour	.s 1	2	3	4	5
Hour	.8				
1 2 3 4 5 6 7 8 9 0 1 1 2 3 4 5 6 7 8 9 0 1 1 2 3 4 5 6 7 8 9 0 1 1 2 1 3 4 5 6 7 8 9 0 2 1 2 2 3 2 4	1.00000 0.92131 0.85180 0.76834 0.87180 0.80821 0.76736 0.86650 0.87187 0.92219 0.93633 0.90562 0.86147 0.90115 0.86078 0.81715 0.86078 0.81715 0.84065 0.83510 0.86111 0.89067 0.86814 0.92960 0.93119 0.93470	0.92131 1.00000 0.96882 0.91710 0.76995 0.65919 0.63939 0.71555 0.75654 0.81059 0.81793 0.78032 0.69280 0.74537 0.68420 0.63363 0.65441 0.64841 0.64841 0.68626 0.72545 0.71962 0.82961 0.84674	0.85180 0.96882 1.00000 0.92405 0.73211 0.57921 0.54309 0.60824 0.65695 0.74672 0.77125 0.72770 0.62234 0.68901 0.61940 0.56621 0.59074 0.57085 0.58479 0.62339 0.61612 0.74715 0.76020	0.76834 0.91710 0.92405 1.00000 0.58681 0.40019 0.39767 0.48331 0.51814 0.61623 0.63975 0.55707 0.44538 0.52669 0.43345 0.37853 0.40586 0.36996 0.42296 0.42296 0.45923 0.43610 0.60297 0.58565 0.60175	0.87149 0.76995 0.73211 0.58681 1.00000 0.90945 0.84243 0.89422 0.86096 0.88105 0.92610 0.91811 0.88732 0.91455 0.89565 0.85199 0.87559 0.86401 0.88442 0.88733 0.86905 0.87771 0.87057 0.87057
Tabl	e 2 Contin	nued			
Corr	elation of	f Hourly Co	ounts		
Hour	s 6	7	8	9	10
HOUT	8	0 76776	0 96650	0 97497	0 02210
123456789	0.80821 0.65919 0.57921 0.40019 0.90945 1.00000 0.96841 0.96320 0.92181	0.76736 0.63939 0.54309 0.39767 0.84243 0.96841 1.00000 0.96393 0.92599	0.86650 0.71555 0.60824 0.48331 0.89422 0.96320 0.96393 1.00000 0.97916	0.87187 0.75654 0.65695 0.51814 0.86096 0.92181 0.92599 0.97916 1.00000	0.92219 0.81059 0.74672 0.61623 0.88105 0.85396 0.83020 0.92597 0.95989
10	0.85396	0.83020	0.92597	0.95989	1.00000

Table 2 ContinuedCorrelation of Hourly Counts							
Hou: Hou:	rs 6 rs	7	8	9	10		
11 12 13 14 15 16 17 18 19 20 21 22 23 24	0.88040 0.90894 0.95105 0.93237 0.95935 0.96842 0.96403 0.96412 0.96814 0.94227 0.95310 0.88991 0.91192 0.88261	0.84611 0.87501 0.91844 0.89563 0.92178 0.92984 0.91986 0.91722 0.95212 0.92410 0.94064 0.86108 0.90198 0.87357	0.93150 0.94463 0.96467 0.95621 0.96279 0.93842 0.94848 0.95003 0.98456 0.97889 0.97615 0.91507 0.94305 0.91922	0.94076 0.96091 0.96095 0.95185 0.95111 0.90929 0.92244 0.93580 0.96508 0.97696 0.97848 0.93925 0.95006 0.94090	0.98426 0.98653 0.94726 0.96555 0.93909 0.86475 0.89303 0.89556 0.91759 0.95052 0.92931 0.93273 0.93349 0.92968		
Tabl Hour Hour	le 2 Contin rs 11 rs	nuedCorro 12	elation of 13	Hourly Cou 14	ints 15		
123456789011234567890122234	0.92219 0.81793 0.77125 0.63975 0.92610 0.88040 0.84611 0.93150 0.94076 0.98426 1.00000 0.98616 0.95537 0.98133 0.95162 0.88983 0.91763 0.90471 0.92582 0.94711 0.92582 0.94711 0.92165 0.93098 0.93187 0.91700	0.90562 0.78032 0.72770 0.55707 0.91811 0.90894 0.87501 0.94463 0.96091 0.98653 0.98616 1.00000 0.97478 0.98717 0.97318 0.98717 0.97318 0.91157 0.93443 0.93522 0.94796 0.96752 0.94796 0.95328 0.94818 0.95063 0.93656	0.86147 0.69280 0.62234 0.44538 0.88732 0.95105 0.91844 0.96467 0.96095 0.94726 0.95537 0.97478 1.00000 0.99117 0.99647 0.97084 0.97813 0.97855 0.98319 0.97855 0.98319 0.97973 0.97305 0.92297 0.94015	0.90115 0.74537 0.68901 0.52669 0.91455 0.93237 0.89563 0.95621 0.95185 0.96555 0.98133 0.98717 0.99117 1.00000 0.98982 0.95176 0.96660 0.96660 0.96660 0.96932 0.97207 0.95609 0.93189 0.94746 0.92909	0.86078 0.68420 0.56621 0.43345 0.89565 0.95935 0.92178 0.96279 0.95111 0.93909 0.95162 0.97318 0.99647 0.98982 1.00000 0.97733 0.98661 0.98464 0.98073 0.97550 0.96947 0.92146 0.94091 0.91996		

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Hou	rs 16	17	. 18	19	20
Hour 1 2 3 4 5 6 7 8 9 10 11 2 3 4 5 6 7 8 9 10 11 2 3 4 5 6 7 8 9 10 11 2 3 4 5 6 7 8 9 10 11 12 3 4 5 6 7 8 9 10 11 12 13 4 5 6 7 8 9 10 11 12 13 14 5 6 7 8 9 10 11 12 13 14 5 6 7 8 9 10 11 12 13 14 5 16 7 8 9 10 11 12 13 14 5 16 7 8 9 10 11 12 13 14 5 16 7 8 9 10 11 12 13 14 5 16 7 8 9 10 11 12 13 14 5 16 7 8 9 20 1 22 23 23 23 23 23 23 23 23 23	0.81715 0.63363 0.56621 0.37853 0.85199 0.96842 0.92984 0.93842 0.90929 0.86475 0.88983 0.91157 0.97084 0.95176 0.97733 1.00000 0.99201 0.98722 0.96646 0.93943 0.94597 0.87915 0.90922	0.84065 0.65441 0.59074 0.40586 0.87559 0.96403 0.91986 0.94848 0.92244 0.89303 0.91763 0.93443 0.97813 0.96660 0.98661 0.99201 1.00000 0.99180 0.96823 0.94923 0.95090 0.89695 0.92057	0.83510 0.64841 0.57058 0.36996 0.86401 0.96412 0.91722 0.95003 0.93580 0.89556 0.90471 0.93522 0.97855 0.96000 0.98464 0.98722 0.99180 1.00000 0.97725 0.96319 0.97012 0.91364 0.93306	0.86111 0.68626 0.58479 0.42296 0.88442 0.96814 0.95212 0.98456 0.96508 0.91759 0.92582 0.94796 0.98319 0.96932 0.98073 0.96646 0.96823 0.97725 1.00000 0.99016 0.98947 0.92734 0.95525	0.89067 0.72545 0.62339 0.45923 0.88733 0.94227 0.92410 0.97899 0.97696 0.95052 0.94711 0.96752 0.97973 0.97550 0.93943 0.96319 0.99016 1.00000 0.99296 0.94993 0.96405
24	0.89204	0.09002	0.9100/	U.93013	0.95117
Tabl	e 2 Conti	nuedCorro	elation of	Hourly Cou	nts
Hour	rs 21 rs	22	23	24	
1 2 3 4 5 6 7 8 9 10 11	0.86814 0.71962 0.61612 0.43610 0.86905 0.95310 0.94064 0.97615 0.97848 0.92931 0.92165 0.95328	0.92960 0.85671 0.78984 0.60297 0.87771 0.88991 0.86108 0.91507 0.93925 0.93273 0.93098 0.94818	0.93119 0.82961 0.74715 0.58565 0.87057 0.91192 0.90198 0.94305 0.95006 0.93349 0.93187 0.95063	0.93470 0.84674 0.76020 0.60175 0.83773 0.88261 0.87357 0.91922 0.94090 0.92968 0.91700 0.93656	

Table 2 Continued -- Correlation of Hourly Counts

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Table	2 Contin	uedCorre	lation of	Hourly Counts
Hours Hours	21	22	23	24
13 0 14 0 15 0 16 0 17 0 18 0 19 0 20 0 21 1 22 0 23 0 24 0	.97305 .95609 .96947 .94597 .95090 .97012 .98947 .99296 .00000 .95566 .96944 .95913	0.92297 0.93189 0.92146 0.87915 0.89695 0.91364 0.92734 0.94993 0.95566 1.00000 0.98397 0.97943	0.94015 0.94746 0.94091 0.90922 0.92057 0.93306 0.95525 0.96405 0.96944 0.98397 1.00000 0.99229	0.92405 0.92909 0.91996 0.89204 0.89882 0.91667 0.93613 0.95117 0.95913 0.97943 0.99229 1.00000

Table 3--Correlation of Stations

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Sta	tions 32	3	10	16	27
Sta	tions				
32	1.00000	0.89492	0.92790	0.94072	0.91657
3	0.89492	1.00000	0.95019	0.87254	0.91442
10	0.92790	0.95019	1.00000	0.91390	0.94954
16	0.94072	0.87254	0.91390	1.00000	0.88646
27	0.91657	0.91442	0.94954	0.88646	1.00000
1	0.86231	0.96305	0.88692	0.82063	0.87918
28	0.97434	0.92102	0.93693	0.96649	0.89288
2	0.79006	0.95722	0.88008	0.78712	0.85122
7	0.83160	0.95407	0.86948	0.78460	0.88308
6	0.83911	0.97046	0.91135	0.85283	0.90415
9	0.87765	0.96290	0.90203	0.87011	0.88746
33	0.90108	0.94241	0.92307	0.87678	0.94585
4	0.90762	0.98109	0.96476	0.88096	0.96178
39	0.89549	0.95168	0.90965	0.87497	0.91605
42	0.92573	0.96525	0.94700	0.91600	0.93941
41	0.93395	0.94795	0.94819	0.95619	0.93729
Tabl	Le 3 Contin	nuedCorre	elation of	Stations	
---------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------	---------
Stat	tions 1	28	2	7	6
Stat	tions				
32	0.86231	0.97434	0.79006	0.83160	0.83911
3	0.96305	0.92102	0.95722	0.95407	0.97046
10	0.88692	0.93693	0.88008	0.86948	0.91135
27	0.87918	0.89288	0.85122	0.88308	0.90415
1	1.00000	0.88095	0.96264	0.98205	0.94892
28	0.88095	1.00000	0.83402	0.84424	0.87064
2	0.96264	0.83402	1.00000	0.94523	0.97621
6	0.98205	0.84424	0.94525	1.00000	1 00000
q	0.96476	0.91467	0.93236	0.95879	0.94642
33	0.94925	0.91237	0.89962	0.94627	0.92208
4	0.96002	0.91629	0.94446	0.95663	0.96511
39	0.96852	0.91328	0.92118	0.96376	0.93590
42	0.94/4/	0.95215	0.88435	0.88707	0.93312
Tabl	le 3 Contir	uedCorre	ation of	Stations	
Stat	tions 9	33	4	39	
Stat	tions				
32					
-	0.87765	0.90108	0.90762	0.89549	
3	0.87765	0.90108	0.90762	0.89549	
3 10	0.87765 0.96290 0.90203	0.90108 0.94241 0.92307 0.87678	0.90762 0.98109 0.96476	0.89549 0.95168 0.90965 0.87497	
3 10 16 27	0.87765 0.96290 0.90203 0.87011 0.88746	0.90108 0.94241 0.92307 0.87678 0.94585	0.90762 0.98109 0.96476 0.88096 0.96178	0.89549 0.95168 0.90965 0.87497 0.91605	
3 10 16 27 1	0.87765 0.96290 0.90203 0.87011 0.88746 0.96476	0.90108 0.94241 0.92307 0.87678 0.94585 0.94925	0.90762 0.98109 0.96476 0.88096 0.96178 0.96002	0.89549 0.95168 0.90965 0.87497 0.91605 0.96852	
3 10 16 27 1 28	0.87765 0.96290 0.90203 0.87011 0.88746 0.96476 0.91467	0.90108 0.94241 0.92307 0.87678 0.94585 0.94925 0.91237	0.90762 0.98109 0.96476 0.88096 0.96178 0.96002 0.91629	0.89549 0.95168 0.90965 0.87497 0.91605 0.96852 0.91328	
3 10 16 27 1 28 2	0.87765 0.96290 0.90203 0.87011 0.88746 0.96476 0.91467 0.93236	0.90108 0.94241 0.92307 0.87678 0.94585 0.94925 0.91237 0.89962	0.90762 0.98109 0.96476 0.88096 0.96178 0.96002 0.91629 0.94446	0.89549 0.95168 0.90965 0.87497 0.91605 0.96852 0.91328 0.92118	
3 10 16 27 1 28 2 7 6	0.87765 0.96290 0.90203 0.87011 0.88746 0.96476 0.91467 0.93236 0.95879 0.94624	0.90108 0.94241 0.92307 0.87678 0.94585 0.94925 0.91237 0.89962 0.94627 0.92208	0.90762 0.98109 0.96476 0.88096 0.96178 0.96002 0.91629 0.94446 0.95663 0.96511	0.89549 0.95168 0.90965 0.87497 0.91605 0.96852 0.91328 0.92118 0.96376 0.93590	
3 10 16 27 1 28 2 7 6 9	0.87765 0.96290 0.90203 0.87011 0.88746 0.96476 0.91467 0.93236 0.95879 0.94624 1.00000	0.90108 0.94241 0.92307 0.87678 0.94585 0.94925 0.91237 0.89962 0.94627 0.92208 0.96435	0.90762 0.98109 0.96476 0.88096 0.96178 0.96002 0.91629 0.94446 0.95663 0.96511 0.96190	0.89549 0.95168 0.90965 0.87497 0.91605 0.96852 0.91328 0.92118 0.96376 0.93590 0.97664	
3 10 16 27 1 28 2 7 6 9 33	0.87765 0.96290 0.90203 0.87011 0.88746 0.96476 0.91467 0.93236 0.95879 0.94624 1.00000 0.96435	0.90108 0.94241 0.92307 0.87678 0.94585 0.94925 0.91237 0.89962 0.94627 0.92208 0.96435 1.00000	0.90762 0.98109 0.96476 0.88096 0.96178 0.96002 0.91629 0.94446 0.95663 0.96511 0.96190 0.96820	0.89549 0.95168 0.90965 0.87497 0.91605 0.96852 0.91328 0.92118 0.96376 0.93590 0.97664 0.98904	
3 10 16 27 1 28 2 7 6 9 33 4 30	0.87765 0.96290 0.90203 0.87011 0.88746 0.96476 0.91467 0.93236 0.95879 0.94624 1.00000 0.96435 0.96190	0.90108 0.94241 0.92307 0.87678 0.94585 0.94925 0.91237 0.89962 0.94627 0.92208 0.96435 1.00000 0.96820	0.90762 0.98109 0.96476 0.88096 0.96178 0.96002 0.91629 0.94446 0.95663 0.96511 0.96190 0.96820 1.00000 0.96370	0.89549 0.95168 0.90965 0.87497 0.91605 0.96852 0.91328 0.92118 0.96376 0.93590 0.97664 0.98904 0.96370 1.00000	
3 10 16 27 1 28 2 7 6 9 33 4 39 42	0.87765 0.96290 0.90203 0.87011 0.88746 0.96476 0.91467 0.93236 0.95879 0.94624 1.00000 0.96435 0.96190 0.97664 0.96618	0.90108 0.94241 0.92307 0.87678 0.94585 0.94925 0.91237 0.89962 0.94627 0.92208 0.96435 1.00000 0.96820 0.98904 0.98190	0.90762 0.98109 0.96476 0.88096 0.96178 0.96002 0.91629 0.94446 0.95663 0.96511 0.96190 0.96820 1.00000 0.96370 0.96917	0.89549 0.95168 0.90965 0.87497 0.91605 0.96852 0.91328 0.92118 0.96376 0.93590 0.97664 0.98904 0.96370 1.00000 0.98254	

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Table 3 Cont	tinuedCorre	elation of	Stations	
Stations	42	41		
Stations				
32	0.92573	0.93395		
3	0.96525	0.94795		
10	0.94700	0.94819		
16	0.91600	0.95619		
27	0.93941	0.93729		
. 1	0.94747	0.90013		
28	0.95213	0.96493		
2	0.92119	0.88435		
7	0.93498	0.88707		
6	0.94438	0.93312		
9	0.96618	0.93139		
33	0.98190	0.94606		
4	0.96917	0.94709		
39	0.98254	0.94355		
42	1.00000	0.98275		
41	0.98275	1.00000		

Table 4.1.1

Stations 27 & 32

Hours 2, 9, 10, 13, 17, & 19 % Chi-Square Difference Factor Computed Count Station Actual Count +3.7 8.578 28 6470 6239 4075 4782 4410 4782 -7.5 25.395 16 27 32 0 0 3120 0 0 3120 18551 -0.6 33.973 Total 18447

Table 4.1.2	Stations	28 & 32	• • • • •	
Hours 2, 9,	10, 13, 17,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
28 16 27 32 Total	6239 3874 4428 <u>3120</u> 17661	6239 4410 4782 <u>3120</u> 18551	$ \begin{array}{r} 0 \\ -12.2 \\ -7.4 \\ 0 \\ -4.8 \end{array} $	0 65.243 26.268 0 91.512
Table 4.1.3	Stations	28 & 16		
Hours 2, 9,	10, 13, 17,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
28 16 27 32 Total	6239 4410 4704 <u>3348</u> 18701	6239 4410 4782 <u>3120</u> 18551	0 0 -1.6 <u>+7.3</u> +0.8	0 0 1.263 <u>16.733</u> 17.996
Table 4.1.4	Stations	16 & 32		
Hours 2, 9,	10, 13, 17,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
28 16 27 32	6683 4410 4788	6239 4410 4782	+7.1 0 +0.1	31.553 0 0.007

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Table 4.2.1	Stations	16 & 27	• • • •	
Hours 6, 8,	12, 15, 18,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
28 16 27 32 Total	6042 4410 4782 <u>3039</u> 18237	6239 4410 4782 <u>3120</u> 18551	-3.2 0 <u>-2.6</u> -1.5	6.205 0 2.087 8.291
Table 4.2.2	Stations	28 & 27		
Hours 6, 8,	12, 15, 18,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
28 16 27 32 Total	6239 4657 4782 <u>3108</u> 18786	6239 4410 4782 <u>3120</u> 18551	0 +5.6 0 -0.4 +1.3	0 13.858 0 0.046 13.905
Table 4.2.3	Stations	27 & 32		
Hours 6, 8,	12, 15, 18,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
28 16 27 32 Total	6187 4664 4782 <u>3120</u> 18753	6239 4410 4782 <u>3120</u> 18551	-0.8 +5.8 0 	0.440 14.638 0 0 15.077

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Table 4.2.4	Stations	28 & 32	•	
Hours 6, 8,	12, 15, 18,	& 20		
Station	Computed	Actual	%	Chi-Square
	Count	Count	Difference	Factor
28	6239	6239	0	0
16	4669	4410	+5.9	15.240
27	4862	4782	+1.7	1.322
32	<u>3120</u>	<u>3120</u>	_0	0
Total	18890	18551	+1.8	16.562
Table 4.3.1	Station	28		
Hours 2, 9,	10, 13, 17,	& 19		
Station	Computed	Actual	%	Chi-Square
	Count	Count	Difference	Factor
28	6239	6239	0	0
16	3897	4410	-11.6	59.662
27	4458	4782	-6.8	22.012
32	<u>3187</u>	<u>3120</u>	+2.1	1.455
Total	17781	18551	-4.2	83.129
Table 4.3.2	Station	16		
Hours 2, 9,	10, 13, 17,	& 19		
Station	Computed	Actual	%	Chi-Square
	Count	Count	Difference	Factor
28	7187	6239	+15.2	143.944
16	4410	4410	0	0
27	5159	4782	+7.9	29.740
32	<u>3648</u>	<u>3120</u>	<u>+16.9</u>	89.428
Total	20404	18551	+9.9	263.112

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Table 4.3.3	Station	27	• • • • •	
Hours 2, 9,	10, 13, 17,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
28 16 27 32 Total	6751 4275 4782 <u>3475</u> 19283	6239 4410 4782 <u>3120</u> 18551	+8.2 -3.1 0 <u>+11.4</u> +3.9	41.961 4.124 0 40.320 86.405
Table 4.3.4	Station	32		
Hours 2, 9,	10, 13, 17,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
28 16 27 32 Total	6149 3846 4391 <u>3120</u> 17506	6239 4410 4782 <u>3120</u> 18551	-1.4 -12.8 -8.2 0 -5.6	1.302 72.025 32.015 0 105.342
Table 5.1.1	Stations	33 & 9		
Hours 2, 9,	10, 13, 17,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
33 9 6 7 2 Total	12141 11104 10269 9605 <u>8666</u> 51785	12141 11104 10324 9442 8385 51396	0 -0.5 +1.7 <u>+3.4</u> +0.8	0 0.295 2.814 <u>9.421</u> 12.530

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Table 5.1.2	Stations	33 & 9		
Hours 6, 9,	12, 15, 18,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
33 9 6 7 2 Total	12141 11104 10180 9022 <u>8693</u> 51140	12141 11104 10324 9442 8385 51396	0 -1.4 -4.5 <u>+3.7</u> -0.5	0 2.012 18.650 <u>11.342</u> 32.005
Table 5.1.3	Stations	33 & 9	•	
Hours 3, 8,	11, 14, 17,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
33 9 6 7 2 Total	12141 11104 11158 10431 <u>8903</u> 53737	12141 11104 10324 9442 8385 51396	0 +8.1 +10.5 +6.2 +4.6	0 0 67.442 103.491 <u>31.958</u> 202.891
Table 5.1.4	Stations	33 & 9		
Hours 6, 8,	12, 15, 18,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
33 9 6 7 2 Notal	12141 11104 10209 9479 <u>8823</u> 51756	12141 11104 10324 9442 <u>8385</u> 51396	0 -1.1 +0.4 +5.2 +0.7	0 1.270 0.143 <u>22.897</u> 24.311

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Table 5.2.1	Stations	33 & 7		
Hours 2, 9,	10, 13, 17,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
33 9 6 7 2 Total	12141 10976 10172 9442 <u>8575</u> 51306	12141 11104 10324 9442 8385 51396	0 -1.2 -1.5 0 +2.3 -0.2	0 1.477 2.244 0 4.307 8.028
Table 5.2.2	Stations	33 & 7		
Hours 6, 9,	12, 15, 18,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
33 9 6 7 2 Total	12141 10794 10214 9442 <u>8732</u> 51323	12141 11104 10324 9442 <u>8385</u> 51396	$0 \\ -2.8 \\ -1.1 \\ 0 \\ +4.1 \\ -0.1$	0 8.663 1.170 0 <u>14.360</u> 24.193
Table 5.2.3	Stations	33 & 7		
Hours 3, 8,	11, 14, 17,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
33 9 6 7 2 Total	12141 11096 10882 9442 <u>8661</u> 52222	12141 11104 10324 9442 8385 51396	0 -0.1 +5.4 0 +3.3 +1.6	0 0.005 30.139 <u>9.057</u> 39.201

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Table 5.2.4	Stations	33 & 7	• • • • •	
Hours 6, 8,	12, 15, 18,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
33 9 6 7 2 Total	12141 10443 10032 9442 <u>8691</u> 50749	12141 11104 10324 9442 <u>8385</u> 51396	0 -5.9 -2.8 0 <u>+3.6</u> -1.3	0 39.331 8.279 0 <u>11.174</u> 58.784
Table 5.3.1	Stations	7 & 2		
Hours 2, 9,	10, 13, 17,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
33 9 6 7 2 Total	11851 10793 10015 9442 <u>8385</u> 50486	12141 11104 10324 9442 <u>8385</u> 51396	-2.4 -2.8 -3.0 0 -1.8	6.905 8.698 9.262 0 0 24.864
Table 5.3.2 Hours 6, 9,	Stations 12, 15, 18,	7&2 &19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
33 9 6 7 2 Total	12567 10836 10261 9442 8385 51491	12141 11104 10324 9442 8385 51396	+3.5 +2.4 -0.6 0 +0.2	14.961 6.446 0.386 0 21.793

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Table 5.3.3	Stations	7 & 2	ę	
Hours 3, 8,	11, 14, 17,	& 20		
Station .	Computed Count	Actual Count	% Difference	Chi-Square Factor
33 9 6 7 2 Total	10866 10505 10328 9442 <u>8385</u> 49526	12141 11104 10324 9442 <u>8385</u> 51396	-10.5 -5.4 +0.01 0 -3.6	133.797 32.352 0.002 0 0 166.151
Table 5.3.4	Stations	7 & 2		
Hours 6, 8,	12, 15, 18,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
33 9 6 7 2 Total	12247 10412 9996 9442 8385 50482	12141 11104 10324 9442 8385 51396	+0.9 -6.2 -3.2 0 0 -1.8	0.930 43.152 10.420 0 0 54.501
Table 5.4.1	Stations	9 & 6		
Hours 2, 9,	10, 13, 17,	& 19		
Station '	Computed Count	Actual Count	% Difference	Chi-Square Factor
33 . 9 6 7 2 Total	12224 11104 10324 9662 <u>8739</u> 52053	12141 11104 10324 9442 8385 51396	+0.7 0 +2.3 +4.2 +1.3	0.565 0 5.126 <u>14.940</u> 20.630

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Table 5.4.2	Station			
Hours 3, 8,	11, 14, 17,	, & 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
33 9 6 7 2 Total	11427 11104 10324 9975 <u>8475</u> 51305	12141 11104 10324 9442 8385 51396	-5.9 0 +5.6 +1.1 -0.2	41.940 0 30.060 <u>0.965</u> 72.966
Table 6.1.1	Station	28		·
Hours 6, 9,	12, 15, 18,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 .33 39 41 42 Total	10205 6239 11895 17577 20522 20126 86564	11104 6239 12141 17721 20605 <u>19894</u> 87704	-8.1 0 -2.0 -0.8 -0.4 +1.2 -1.3	72.716 0 5.001 1.178 0.337 <u>2.717</u> 81.950
Table 6.1.2	Station	28		
Hours 6, 8,	12, 15, 18,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 33 39 41 42 Total	10142 6239 12136 18083 20900 <u>20166</u> 87666	11104 6239 12141 17721 20605 <u>19894</u> 87704	-8.7 0 -0.04 +2.0 +1.4 +1.4 -0.04	83.425 0 0.002 7.381 4.213 <u>3.716</u> 98.738

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Table 6.2.1	Station	33		
Hours 6, 9,	12, 15, 18,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 33 39 41 42 Total	10392 6341 12141 17971 21068 <u>20545</u> 88458	11104 6239 12141 17721 20605 <u>19894</u> 87704	-6.4 +1.6 0 +1.4 +2.2 +3.3 +0.9	45.604 1.681 0 3.522 10.391 <u>21.278</u> 82.476
Table 6.2.2	Station	33		
Hours 6, 8,	12, 15, 18,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 33 39 41 42 Total	10223 6281 12141 18181 20992 20224 88042	11104 6239 12141 17721 20605 <u>29894</u> 87704	-7.9 +0.7 0 +2.6 +1.9 <u>+1.7</u> +0.4	69.917 0.286 0 11.928 7.269 <u>5.462</u> 94.862
Table $6.3.1$	Station	30		
Hours 6. 9.	12, 15, 18,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 33 39 41 42 Total	10272 6266 11988 17721 20731 20281 87259	11104 6239 12141 17721 20605 <u>19894</u> 87704	-7.5 +0.4 -1.3 0 +0.6 <u>+1.9</u> -0.5	62.356 0.120 1.933 0 0.772 <u>7.534</u> 72.716

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Table 6.3.2	Station	39	-	
Hours 6, 8,	12, 15, 18,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 33 39 41 42 Total	9971 6130 11862 17721 20506 <u>19764</u> 85954	11104 6239 12141 17721 20605 <u>19894</u> 87704	-10.2 -1.7 -2.3 0 -0.5 -0.7 -2.0	$ \begin{array}{r} 115.675 \\ 1.901 \\ 6.419 \\ 0 \\ 0.475 \\ 0.846 \\ 125.316 \\ \end{array} $
Table 6.4.1	Station	41		
Hours 6, 9,	12, 15, 18,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 33 39 41 42 Total	10252 6288 11953 17642 20605 20240 86980	11104 6239 12141 17721 20605 <u>19894</u> 87704	-7.7 +0.8 -1.5 -0.4 0 +1.7 -0.8	65.302 0.384 2.903 0.349 0 <u>6.013</u> 74.951
Table 6.4.2	Station	41		
Hours 6, 8,	12, 15, 18,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 33 39 41 42 Total	9977 6175 11921 17763 20605 <u>19864</u> 86305	11104 6239 12141 17721 20605 <u>19894</u> 87704	-10.1 -1.0 -1.8 +0.2 0 -0.2 -1.6	114.289 0.667 3.981 0.098 0 0.045 119.079

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Table 6.5.1	Station	42	-	
Hours 6, 9,	12, 15, 18,	& 19		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 33 39 41 42 Total	10056 6154 11753 17354 20349 <u>19894</u> 85560	11104 6239 12141 17721 20605 <u>19894</u> 87704	$ \begin{array}{r} -9.4 \\ -1.4 \\ -3.2 \\ -2.1 \\ -1.2 \\ 0 \\ -2.4 \\ \end{array} $	98.943 1.156 12.423 7.596 3.173 0 123.291
Table 6.5.2	Station	42		
Hours 6, 8,	12, 15, 18,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 33 39 41 42 Total	10029 6182 11942 17825 20623 <u>19894</u> 86495	11104 6239 12141 17721 20605 <u>19894</u> 87704	-9.7 -0.9 -1.6 +0.6 +0.1 0 -1.4	103.999 0.528 3.271 0.611 0.015 0 108.424
Table 7.1.1	Stations	9, 28, 8	k 41	
Hours 3, 8,	11, 14, 17,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 33 39 41 42 Total	11104 6239 11603 17925 20605 <u>19509</u> 86985	11104 6239 12141 17721 20605 <u>19894</u> 87704	0 0 -4.4 +1.2 0 -1.9 -0.8	0 0 23.847 2.349 0 <u>7.453</u> 33.649

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Stations 9, 28, & 41 Table 7.1.2 Hours 2, 9, 10, 13, 17, & 19 % Chi-Square Station Computed Actual Count Count Difference Factor 11104 11104 0 0 9 28 6239 0 0 6239 33 39 12125 0.022 12141 -0.1 +0.2 0.066 17755 17721 41 20605 20605 0 0 +2.5 12.517 42 20393 19894 88221 12.606 87704 +0.6 Total Stations 33, 41, & 42 Table 7.2.1 Hours 3, 8, 11, 14, 17, & 20 Computed Actual % Chi-Square Station Count Count Difference Factor 9 28 11526 11104 +3.8 16.070 2.340 6360 6239 +1.9 33 12141 12141 0 0 39 41 +3.2 18285 17.980 17721 20605 20605 0 0 42 0 0 19894 19894 Total 88811 87704 +1.3 36.390 Table 7.2.2 Stations 33, 41, & 42 Hours 2, 9, 10, 13, 17, & 19 Station Computed Actual % Chi-Square

	Count	Count	Difference	Factor	
9	11124	11104	+0.2	0.037	
28	6454	6239	+3.4	7.384	
33	12141	12141	0	0	
39	17668	17721	-0.3	0.158	
41	20605	20605	0	0	
42	<u>19894</u>	19894	0	0	
Total	87886	87704	+0.2	7.580	

Table 7.3.1	Stations	28, 33,	& 39				
Hours 3, 8,	11, 14, 17,	& 20					
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor			
9 28 33 39 41 42 Total	11378 6239 12141 17721 20736 19676 87891	11104 6239 12141 17721 20605 <u>19894</u> 87704	+2.5 0 0 +0.6 -1.1 +0.2	6.765 0 0 0.834 <u>2.382</u> 9.980			
Table 7.3.2	Stations	28, 33,	& 39				
Hours 2, 9,	10, 13, 17,	& 19					
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor			
9 28 33 39 41 42	11033 6239 12141 17721 20271 20260	11104 6239 12141 17721 20605 <u>19894</u>	-0.6 0 0 -1.6 +1.8	0.451 0 0 5.425 6.720			
Total	87665	87704	-0.04	12.597			
Table 7.4.1 Stations 9, 28, & 33 Hours 3, 8, 11, 14, 17, & 20							
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor			
9 28 33 39 41 42 Total	11104 6239 12141 18271 20903 <u>19870</u> 88528	11104 6239 12141 17721 20605 <u>19894</u> 87704	$0 \\ 0 \\ +3.1 \\ +1.4 \\ -0.1 \\ +0.9$	0 0 17.048 4.320 0.029 21.397			

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Table	7 4 2	Stations	0 28 8	. 33	
Table	1.4.2	Stations	9, 20, 0		
Hours	2, 9,	10, 13, 17,	& 19	•	
Static	n	Computed Count	Actual Count	% Difference	Chi-Squar e Factor
9 28 33 39 41 42 Total		11104 6239 12141 17662 20347 <u>20320</u> 87813	11104 6239 12141 17721 20605 <u>19894</u> 87704	$ \begin{array}{c} 0 \\ 0 \\ -0.3 \\ -1.3 \\ +2.1 \\ +0.1 \end{array} $	0 0 0.197 3.226 9.132 12.555
Table	7.5.1	Stations	9, 28, &	39	
Hours	3, 8,	11, 14, 17,	& 20		
Statio	n	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 33 39 41 42 Total		11104 6239 11522 17721 20395 <u>19374</u> 86355	11104 6239 12141 17721 20605 <u>19894</u> 87704	0 -5.1 -1.0 -2.6 -1.5	0 31.566 0 2.135 <u>13.592</u> 47.294
Table	7.5.2	Stations	9, 28, &	39	
Hours	2, 9,	10, 13, 17,	& 19		
Statio	n	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 33 39 41 42 Total		11104 6239 12049 17721 20262 <u>20278</u> 87653	11104 6239 12141 17721 20605 <u>19894</u> 87704	0 -0.8 0 -1.7 <u>+1.9</u> -0.1	0 0.700 5.712 <u>7.414</u> 13.825

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Table 7.6.1	Stations	9, 28, 8	k 42	
Hours 3, 8,	11, 14, 17,	& 20		
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 33 39 41 42 Total	11104 6239 11698 18091 20730 <u>19894</u> 87756	11104 6239 12141 17721 20605 <u>19894</u> 87704	0 0 -3.6 +2.1 +0.6 0 +0.1	0 0 16.188 7.721 0.764 0 24.674
Table 7.6.2	Stations	9, 28, 8	42	
Hours 2, 9,	10, 13, 17,	& 19		
Stations	Computed Count	Actual Count	% Difference	Chi-Square Factor
9 28 33 39 41 42 Total	11104 6239 11881 17398 20029 <u>19894</u> 86545	11104 6239 12141 17721 20605 <u>19894</u> 87704	0 0 -2.1 -1.8 -2.8 0 -1.3	0 0 5.582 5.882 16.118 0 27.582
Table 8.1	Station 3	52		
Hours 4, 9,	15, & 20			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2	3120 3608 3847 4539 4744 6340 6332 8897 Continue	3120 3608 3557 4410 4782 5779 6239 8385	0 +4.4 +8.2 +2.9 -0.8 +9.7 +1.5 +6.1	0 6.696 23.635 3.755 0.297 54.542 1.387 31.315
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Table 8.1 Co	ntinued		· · · · · · · ·	
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
7 6 9 33 4 39 42 41	9825 10226 11141 12814 14886 18619 21026 20610	9442 10324 11104 12141 14905 17721 19894 20605	+4.1 -0.9 +0.3 +5.5 -0.1 +5.1 +5.7 +0.02	15.548 0.923 0.121 37.328 0.025 45.525 64.447 0.001
Total	160574	133004	+3.0	207.744
Table 8.2	Station	3		
Hours 4, 9,	15, & 20			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7	3001 3456 3651 4274 4467 6027 6077 8477	3120 3456 3557 4410 4782 5779 6239	-3.8 0 +2.6 -3.1 -3.1 +4.3 -2.6	4.568 0 2.486 4.176 20.796 10.665 4.221 1.006
6 9 33 4 39 42 41	9349 9672 10787 12150 14193 17706 19979 19381	9442 10324 11104 12141 14905 17721 19894 20605	-1.0 -6.3 -2.9 +0.1 -4.8 -0.1 +0.4 -5.9	0.911 41.173 9.022 0.007 34.008 0.013 0.367 72.725

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Table 8.3	Station	16	· · · · · · · · ·	
Hours 4, 9,	15, & 20			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3289 3787 3844 4410 4807 6502 6531 9080 10561 10400 12320 13051 15586 19138 21232 20333 164871	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	+5.4+9.6+8.10+0.5+12.5+4.7+8.3+11.9+0.7+10.9+7.5+4.6+8.0+6.7-1.3+5.8	9.125 31.698 23.195 0 0.135 90.387 13.637 57.548 132.613 0.566 133.236 68.260 31.148 113.380 89.943 <u>3.579</u> 798.447
Table 8.4	Station	2		
Hours 4, 9,	15, & 20			1/ - ···
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Totol	3031 3475 3627 4144 4398 6029 6099 8385 9379 9478 10986 12131 14189 17727 19891 18960	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605	$\begin{array}{r} -2.9 \\ +0.5 \\ +2.0 \\ -6.0 \\ -8.0 \\ +4.3 \\ -2.2 \\ 0 \\ -0.7 \\ -8.2 \\ -1.1 \\ -0.1 \\ -4.8 \\ +0.03 \\ -0.02 \\ -8.0 \\ -2.5 \end{array}$	2.538 0.105 1.391 15.987 30.828 10.831 3.138 0 0.423 69.313 1.263 0.009 34.401 0.002 0.001 131.271 301 499
Total	121929	199004	-2.5	101.433

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Table 8.5	Station	4	• • • • • •	
Hours 4, 9,	15, & 20			
Station	Computed Count	Actual Count	% Difference	Chi-Sq uare Factor
 32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3147 3626 3803 4413 4679 6320 6340 8825 9900 10083 11403 12738 14905 18575 20853 20162 159772	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	+0.9 +4.9 +6.9 +6.9 +0.1 -2.2 +9.4 +1.6 +5.2 +4.9 -2.3 +2.7 +4.9 -2.3 +2.7 +4.9 0 +4.8 +4.8 -2.1 +2.5	$\begin{array}{r} 0.237\\ 8.409\\ 17.057\\ 0.002\\ 2.234\\ 50.585\\ 1.640\\ 23.064\\ 22.172\\ 5.625\\ 8.032\\ 29.382\\ 0\\ 41.134\\ 46.189\\ 9.511\\ 265.272 \end{array}$
Table 8.6	Station 4	42		
Hours 4, 9,	15, & 20			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
 32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3059 3531 3607 4239 4531 6059 6111 8600 9826 9903 11422 12163 14581 17821 19894 19299 154646	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	-1.9 + 2.2 + 1.4 - 3.9 - 5.2 + 4.8 - 2.1 + 2.6 + 4.1 + 2.9 + 0.2 - 2.2 + 0.2 - 2.2 + 0.6 - 6.3 - 0.8	1.190 1.615 0.706 6.604 13.132 13.529 2.632 5.516 15.640 17.150 9.129 0.040 7.054 0.568 0 82.759 177.263

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Table 9.1	Station	42	• • • •	
Hours 1, 9,	17, & 20			•
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39	3528 3683 4032 4552 4491 6042 7070 8025 9232 9544 10556 11853 14618 17365	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721	+13.1+6.6+13.4+3.2-6.1+4.6+13.3-4.3-2.2-7.6-4.9-2.4-1.9-2.0	53.223 14.960 63.522 4.542 17.711 11.977 110.650 15.431 4.688 58.933 27.025 6.838 5.520 7.136
42	19894 	19894 20605	0 8	0 <u>6.416</u>
Total	154726	155864	-0.7	408.571
Table 9.2	Station	42		
Hours 4, 11,	18, & 21			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42	3342 3901 3693 4211 4888 5964 6303 8898 10202 10803 11521 11882 16222 17948	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721	+7.1 +12.9 +3.8 -4.5 +2.2 +3.2 +1.0 +6.1 +8.0 +4.6 +3.8 -2.1 +8.8 +1.3	15.858 57.219 5.163 8.975 2.361 5.905 0.664 31.434 61.112 22.232 15.663 5.534 116.330 2.914
41	19894 20864	19894 20605	+1.3	3.250

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Hours 2, 8, 15, & 19 Station Computed Actual Count Difference Factor 32 3273 3120 +4.9 7.495 3 3131 3456 -9.4 30.616 10 3140 3557 -11.7 48.881 16 4879 4410 +10.6 49.970 27 4522 4782 -5.4 14.134 1. 5715 5779 -1.1 0.704 28 6655 6239 +4.3 11.373 2 7812 8385 -6.8 39.217 7 9375 9442 -0.7 0.478 6 9681 10324 -6.2 40.089 9 10828 11104 -2.5 6.873 33 11804 12141 -2.8 9.342 4 13568 14905 -9.0 119.866 39 17974 17721 +1.4 3.625 42 19894 19894 0 0 0 41 20691 20605 +0.4 0.362 42 19894 19894 0 0 0 41 20691 20605 +0.4 0.362 Total 152792 155864 -2.0 383.024 Table 9.4 Station 42 Hours 3, 12, 13, & 20 Station Computed Actual M Chi-Square Factor 32 2365 3120 -24.2 182.779 3 3447 3456 -0.3 0.026 10 3523 3557 -1.0 0.316 16 3750 4410 -15.0 98.921 27 4715 4782 -1.4 0.950 1 5702 5779 -1.3 1.031 28 5157 6239 -17.3 187.683 2 9475 8385 -15.0 141.570 7 9568 9442 +1.5 1.663 2 9475 8385 -15.0 141.570 7 9568 9442 +1.5 1.663 2 9475 8385 -15.0 141.570 7 9568 9442 +1.5 1.663 2 9475 8385 -15.0 141.570 7 9568 9442 +1.5 1.663 4 14724 14905 -1.2 2.194 39 10985 10324 +6.4 42.328 9 10810 11104 -2.6 7.790 33 12156 12141 +0.1 0.019 34 4724 14905 -1.2 2.194 39 17968 17721 +1.4 3.437 42 19894 19894 0 0 41 19904 20605 -3.4 23.871 50 51 150 44.593	Table 9.3	Station	42	·	
StationComputed CountActual Count% DifferenceChi-Square Factor3232733120 $+4.9$ 7.495331313456 -9.4 30.6161031403557 -11.7 48.8811648794410 $+10.6$ 49.9702745224782 -5.4 14.13157155779 -1.1 0.704 2865056239 $+4.3$ 11.373 278128385 -6.8 39.217793759442 -0.7 0.478 6968110324 -6.2 40.08991082811104 -2.5 6.873 331180412141 -2.8 9.342 41356814905 -9.0 119.866391797417721 $+1.4$ 3.625 412069120605 $+0.4$ 0.362 Total152792155864 -2.0 383.0247563120 -24.2 182.779334473456 -0.3 0.026 1035233557 -1.0 0.316 1637504410 -15.0 98.912747154782 -1.4 0.950 157025779 -1.3 1.603 223653120 -24.2 182.779334473456 -0.3 0.026 1035233557 -1.0	Hours 2, 8,	15, & 19			
32 3273 3120 $+4.9$ 7.495 3 3131 3456 -9.4 30.616 10 3140 3557 -11.7 48.881 16 4879 4410 $+10.6$ 49.970 27 4522 4782 -5.4 14.134 1 5715 5779 -1.1 0.704 28 6505 6239 44.3 11.373 2 7812 8385 -6.8 39.217 7 9375 9442 -0.7 0.478 6 9681 10324 -6.2 40.089 9 10828 11104 -2.5 6.873 33 11804 12141 -2.8 9.342 4 13568 14905 -9.0 119.866 39 17974 17721 $+1.4$ 3.625 42 19894 19894 0 0 41 20691 20605 $+0.4$ 0.362 $7o$ tal 152792 155864 -2.0 383.024 Table 9.4Station 42 410 -15.0 98.921 7 4715 4782 -1.4 0.950 1 5702 5779 -1.3 1.031 2 9475 8385 -13.0 141.570 7 9568 9442 $+1.5$ 1.680 6 10985 10324 $+6.4$ 42.328 9 10810 11104 -2.6 7.790 33 <	Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
Table 9.4Station 42Hours 3, 12, 13, & 20StationComputed CountActual Count% DifferenceChi-Square Factor3223653120 -24.2 182.779334473456 -0.3 0.026 1035233557 -1.0 0.316 1637504410 -15.0 98.9212747154782 -1.4 0.950 157025779 -1.3 1.031 2851576239 -17.3 187.683294758385 -13.0 141.570795689442 $+1.5$ 1.680 61098510324 -6.4 42.32891081011104 -2.6 7.790 331215612141 $+0.1$ 0.019 41472414905 -1.2 2.194 391796817721 $+1.4$ 3.437 42198941989400411990420605 -3.4 23.871 Total154143155864 -1.1 694.593	32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3273 3131 3140 4879 4522 5715 6505 7812 9375 9681 10828 11804 13568 17974 19894 20691 152792	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	+4.9-9.4-11.7+10.6-5.4-1.1+4.3-6.8-0.7-6.2-2.5-2.8-9.0+1.40+0.4-2.0	7.495 30.616 48.881 49.970 14.134 0.704 11.373 39.217 0.478 40.089 6.873 9.342 119.866 3.625 0 0.362 383.024
Hours 3, 12, 13, & 20StationComputed CountActual Count% DifferenceChi-Square Factor3223653120 -24.2 182.779334473456 -0.3 0.026 1035233557 -1.0 0.316 1637504410 -15.0 98.9212747154782 -1.4 0.950 157025779 -1.3 1.031 2851576239 -17.3 187.683294758385 -13.0 141.570795689442 $+1.5$ 1.680 61098510324 $+6.4$ 42.32891081011104 -2.6 7.790 331215612141 $+0.1$ 0.019 41472414905 -1.2 2.194 391796817721 $+1.4$ 3.437 42198941989400411990420605 -3.4 23.871Total154143155864 -1.1 694.593	Table 9.4	Station	42		
StationComputed CountActual Count% DifferenceChi-Square Factor3223653120 -24.2 182.779334473456 -0.3 0.026 1035233557 -1.0 0.316 1637504410 -15.0 98.9212747154782 -1.4 0.950 157025779 -1.3 1.031 2851576239 -17.3 187.683294758385 -13.0 141.570795689442 $+1.5$ 1.680 61098510324 $+6.4$ 42.32891081011104 -2.6 7.790 331215612141 $+0.1$ 0.019 41472414905 -1.2 2.194 391796817721 $+1.4$ 3.437 42198941989400411990420605 -3.4 23.871Total154143155864 -1.1 694.593	Hours 3, 12,	13, & 20			
32 2365 3120 -24.2 182.779 3 3447 3456 -0.3 0.026 10 3523 3557 -1.0 0.316 16 3750 4410 -15.0 98.921 27 4715 4782 -1.4 0.950 1 5702 5779 -1.3 1.031 28 5157 6239 -17.3 187.683 2 9475 8385 -13.0 141.570 7 9568 9442 $+1.5$ 1.680 6 10985 10324 $+6.4$ 42.328 9 10810 11104 -2.6 7.790 33 12156 12141 $+0.1$ 0.019 4 14724 14905 -1.2 2.194 39 17968 17721 $+1.4$ 3.437 42 19894 19894 0 0 41 19904 20605 -3.4 23.871 Total 154143 155864 -1.1 694.593	Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
	32 3 10 16 27 1 28 2 7 6 9 33 4 39 42	2365 3447 3523 3750 4715 5702 5157 9475 9568 10985 10810 12156 14724 17968 19894	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894	-24.2 -0.3 -1.0 -15.0 -1.4 -1.3 -17.3 -13.0 +1.5 +6.4 -2.6 +0.1 -1.2 +1.4 0	182.779 0.026 0.316 98.921 0.950 1.031 187.683 141.570 1.680 42.328 7.790 0.019 2.194 3.437 0

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Table 9.9	Station	42		
Hours 5, 7,	16, & 24			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3137 3005 3073 5411 4878 4723 7000 6301 7917 9291 12548 13140 14328 17507 19894 22948 155101	3120 3456 3557 4410 4782 5779 6239 8385 9442 10342 11104 12141 14905 17721 19894 20605 155864	$+0.5 \\ -13.0 \\ -13.6 \\ +22.7 \\ +2.0 \\ -18.3 \\ +12.2 \\ -24.9 \\ -16.2 \\ -10.2 \\ +13.0 \\ +8.2 \\ -3.9 \\ -1.2 \\ 0 \\ +11.4 \\ -0.5$	$\begin{array}{r} 0.096\\ 58.807\\ 65.957\\ 227.059\\ 1.924\\ 192.874\\ 92.834\\ 518.056\\ 246.186\\ 103.316\\ 187.830\\ 82.266\\ 22.359\\ 2.590\\ 0\\ 266.452\\ 2068.607\end{array}$
Table 9.6	Station	42		
Hours 1, 9,	14, & 23			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41	3339 3501 3284 4100 5163 6196 6056 8450 10194 11024 11910 12662 15498 17971 19894 19304	3120 3456 3557 4410 4782 5779 6239 8385 9442 10342 11104 12141 14905 17721 19894 20605	+7.0 +1.3 -7.7 -7.0 +8.0 +7.2 -2.9 +0.8 +8.0 +6.6 +7.3 +4.3 +4.0 +1.4 0 -6.3	15.419 0.590 20.972 21.764 30.388 30.125 5.370 0.497 59.897 47.461 58.433 22.363 23.611 3.530 0 82.151
Total	158546	155864	+1.7	422.573

Table 9.5 Station 42

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Hours 6, 10,	17, & 22			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3451 3803 4555 4751 5238 6245 6736 9408 10116 11410 11578 12426 16994 17976 19894 20604 165275	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	+13.5+10.0+28.1+7.7+9.5+8.1+8.0+12.2+7.1+10.5+4.3+2.3+14.0+1.400.0+6.0	56.887 34.760 280.205 26.349 43.483 37.603 39.539 124.906 48.080 114.242 20.207 6.689 292.823 3.673 0 0.000 1129.446
Table 9.8	Station	42		
Hours 5, 8,	13, & 19			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41	3043 2972 2885 4133 4133 5222 6041 7586 8979 9308 10323 11430 12709 17996 19894 20524	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605	$\begin{array}{r} -2.5 \\ -14.0 \\ -18.9 \\ -6.3 \\ -9.6 \\ -9.6 \\ -3.2 \\ -9.5 \\ -4.9 \\ -9.8 \\ -7.0 \\ -5.9 \\ -14.7 \\ +1.6 \\ 0 \\ -0.4 \\ \end{array}$	$\begin{array}{r} 1.922 \\ 67.687 \\ 127.087 \\ 17.341 \\ 88.025 \\ 53.652 \\ 6.300 \\ 76.074 \\ 22.744 \\ 100.030 \\ 54.967 \\ 41.622 \\ 323.549 \\ 4.259 \\ 0 \\ 0.317 \\ 0.05 \\ 57.57 \\ \end{array}$
Total	147178	155864	-5.6	985.577

Table 9.7 Station 42

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Table 10.1	Station	16		
Hours 5, 8,	13, & 19			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3214 3359 3369 4410 4618 5641 6547 8706 9819 10660 11264 12758 14189 19668 22384 22960 163566	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	$+3.0 \\ -2.8 \\ -5.3 \\ 0 \\ -3.4 \\ -2.4 \\ +4.9 \\ +3.8 \\ +4.0 \\ +3.3 \\ +1.4 \\ +5.1 \\ -4.8 \\ +11.0 \\ +12.5 \\ +11.4 \\ +4.9 \end{bmatrix}$	2.807 2.735 9.983 0 5.622 3.280 15.195 12.314 15.032 10.967 2.314 31.390 34.419 213.932 311.769 269.219 940.977
Table 10.2	Station	16		
Hours 1, 9,	17, & 20			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3498 3727 4019 4410 4569 6252 6996 8133 9624 9531 10952 12314 14924 18009 20353 20182	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	+12.1+7.8+13.00-4.5+8.2+12.1-3.0+1.9-7.7-1.4+1.4+0.1+1.6+2.3-2.1+1.0	45.702 21.198 59.888 0 9.447 38.691 91.742 7.584 3.498 60.904 2.084 2.468 0.023 4.675 10.577 8.679 367.160

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Table 11.1	Stations	33, 27,	& 4-	
Hours 4, 9,	15, & 20			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3100 3574 3726 4330 4782 6210 6232 8692 9811 9951 11315 12141 14905 18259 20460 19791 157279	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	$\begin{array}{r} -0.6 \\ +3.4 \\ +4.8 \\ -1.8 \\ 0 \\ +7.5 \\ -0.1 \\ +3.7 \\ +3.9 \\ -3.6 \\ +1.9 \\ 0 \\ 0 \\ +3.0 \\ +2.8 \\ -4.0 \\ +0.9 \end{array}$	$\begin{array}{c} 0.128 \\ 4.029 \\ 8.030 \\ 1.451 \\ 0 \\ 32.144 \\ 0.008 \\ 11.240 \\ 14.421 \\ 13.476 \\ 4.009 \\ 0 \\ 0 \\ 16.333 \\ 16.103 \\ 32.157 \\ 153.529 \end{array}$
Table 11.2	Stations	28, 2, &	42	
Hours 4, 9,	15, & 20			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Totol	3032 3493 3624 4227 4484 6042 6239 8385 9583 9736 11121 12154 14372 17766 19894 19253	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605	$ \begin{array}{r} -2.8 \\ +1.1 \\ +1.9 \\ -4.1 \\ -6.2 \\ +4.6 \\ 0 \\ 0 \\ +1.5 \\ -5.7 \\ +0.1 \\ +0.1 \\ -3.6 \\ +0.3 \\ 0 \\ \underline{-6.6} \\ -1.6 \end{array} $	2.482 0.396 1.262 7.594 18.570 11.969 0 2.106 33.489 0.026 0.014 19.060 0.114 0 88.712 185.794
TOtal	133403	133004	-1.0	103.194

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Table	11.	.3	Stations	3.	7.	&	33

Hours 4, 9, 15, & 20

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Stations	Computed Count	Actual Count	% Difference	Chi-Square Factor
32	3012	3120	-3.5	3.738
3	3456	3456	0	0
10	3634	3557	+2.2	1.667
16	4213	4410	-4.5	8.800
27	4452	4782	-6.9	22.772
1	6031	5779	+4.4	10.989
28	6072	6239	-2.7	4.470
2	8436	8385	+0.6	0.310
7	9442	9442	0	Ō
6	9614	10324	-6.9	48.828
9	10908	11104	-1.8	3.460
33	12141	12141	0	0
4	14225	14905	-4.6	31.023
39	17726	17721	0.0	0.001
42	19920	19894	+0.1	0.034
41	19214	20605	-6.8	93.903
Total	152496	155864	-2.2	229.995

Table 11.4 Stations 32, 1, & 28

Hours 4, 9, 15, & 20

Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32	3120	3120	0	0
3	3474	3456	+0.5	0.094
10	3643	3557	+2.4	2.079
16	4268	4410	-3.2	4.572
27	4487	4782	-6.2	18.198
1	5779	5779	0	0
28	6239	6239	0	0
2	8506	8385	+1.4	1.746
7	9467	9442	+0.3	0.066
6	9731	10324	-5.7	34.061
9	10929	11104	-1.6	2.758
33	12165	12141	+0.2	0.047
4	14289	14905	-4.1	25.458
39	17747	17721	+0.1	0.038
42	19973	19894	+0.4	0.314
41	19383	20605	-5.9	72.472
Total	153200	155864	-1.7	161,903

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Table 11.5 Stations 3, 10, & 39

Hours 4, 9, 15, & 20

Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32	3015	3120	-3.4	3.534
3	3456	3456	0	0
10	3557	3557	0	0
16	4204	4410	-4.7	9.623
27	4463	4782	-6.7	21.280
1	6006	5779	+3.9	8.702
28	6053	6239	-3.0	5.545
2	8466	8385	+1.0	0.782
7	9556	9442	+1.2	1.376
6	9699	10324	-6.1	37.837
9	11084	11104	-0.2	0.036
33	12079	12141	-0.5	0.317
4	14307	14905	-4:0	23.992
39	17721	17721	0	0
42	19785	19894	-0.5	0.597
41	19145	20605	-7.1	103.451
Total	152596	155864	-2.1	217.072

Table 12.1 Stations 32, 10, 27, 28, 7, 9, 4, & 41

Hours 4, 9, 15, & 20

Station	Computed	Actual	%	Chi-Square
	Count	Count	Difference	Factor
32	· 3120	3120	0	0
3	3599	3456	+4.1	5.929
10	3557	3557	0	0
16	4391	4410	-0.4	0.080
27	4782	4782	0	0
1	6265	5779	+8.4	40.887
28	6239	6239	0	0
2	8774	8385	+4.6	18.090
7	· 9442	9442	0	0
6	10017	10324	-3.0	9.105
9	11104	11104	0	0
33	12624	12141	+4.0	19.180
4	14905	14905	0	0
39	18413	17721	+3.9	27.003
42	20696	19894	+4.0	32.305
41	20605	20605	0	0
Total	158533	155864	+1.7	152.580

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Square 545 0 949 189 0 638
Square 545 0 949 0 189 0 638
0 545 0 949 0 189 0 638
767 0026 0338 400 00 352
8 41
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0 318 0 006 0 471 0 185
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Table 12.4	Stations	32, 10,	27, 28, 7, 9	, 4, & 41
Hours 6, 7,	17, & 20			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41	3120 3052 3557 5867 4782 5347 6239 6815 9442 9227 11104 12490 14905 18368 20046 20605	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605	$ \begin{array}{r} 0 \\ -11.7 \\ 0 \\ +33.0 \\ 0 \\ -7.5 \\ 0 \\ -18.7 \\ 0 \\ -10.6 \\ 0 \\ +2.9 \\ 0 \\ +3.7 \\ +0.8 \\ 0 \\ \end{array} $	$\begin{array}{r} 0\\47.294\\0\\481.322\\0\\32.258\\0\\293.847\\0\\116.630\\0\\10.035\\0\\23.636\\1.163\\0\end{array}$
Total	154966	155864	-0.6	1006.184
Table 12.5	Stations	32, 10,	27, 28, 7, 9,	, 4, & 41
Hours 2, 7,	14, & 21			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41	3120 3019 3557 4984 4782 5378 6239 7350 9442 10146 11104 13201 14905 19328 20599 20605	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605	$ \begin{array}{r} 0 \\ -12.6 \\ 0 \\ +13.0 \\ 0 \\ -6.9 \\ 0 \\ -12.3 \\ 0 \\ -1.7 \\ 0 \\ +8.7 \\ 0 \\ +9.1 \\ +3.5 \\ 0 \\ \end{array} $	$ \begin{array}{r} 0 \\ 55.209 \\ 0 \\ 74.653 \\ 0 \\ 27.774 \\ 0 \\ 127.647 \\ 0 \\ 3.052 \\ 92.598 \\ 0 \\ 145.773 \\ 24.976 \\ 0 \\ \hline 551.682 \\ \end{array} $
TOTAL	12/129	100004	+1.2	1002

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Table 12.6 Stations 32, 10, 27, 28, 7, 9, 4, & 41 Hours 6, 9, 14, & 19 % Chi-Square Station Computed Actual Count Difference Factor Count 0.383 +1.0 -8.0 28.311 +5.3 16.116 2.703 +1.8 2.796 +1.6 33 4 3.551 +1.7 42 62.781 +5.9 +6.1 73.722 +1.8 190.363 Total Table 13.1 Stations 32, 3, 10, 16, 4, 39, 41, & 42 Hours 1, 9, 17, & 20 Station Computed Actual % Chi-Square Count Count Difference Factor -6.3 18.776 +4.9 13.796 +12.2 92.768 17.582 -4.6 -1.7 2.887 -8.2 70.152 -4.6 23.359 -1.9 4.479 42 -0.9 243.799 Total

Table 13.2	Stations	32, 3,	10, 16, 4, 39	9, 41, & 42
Hours 5, 8,	13, 19			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3120 3456 3557 4410 4311 5422 6289 7915 9331 9727 10716 11939 14905 17721 19894 20605 153318	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	0 0 -9.8 -6.2 +0.8 -5.6 -1.2 -5.8 -3.5 -1.7 0 0 0 0 -1.6	0 0 0 46.423 22.027 0.409 26.395 1.303 34.533 13.536 3.365 0 0 0 0 0 147.991
Table 13.3	Stations	32, 3,	10, 16, 4, 39	, 41, & 42
Hours 1, 8,	13, 20			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3120 3456 3557 4410 4349 5796 6229 8113 9885 9782 10716 12337 14905 17721 19894 20605 154875	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	0 0 -9.1 +0.3 -0.2 -3.2 +4.7 -5.2 -3.5 +1.6 0 0 0 0 -0.6	0 0 0 39.238 0.048 0.017 8.821 20.783 28.414 13.525 3.167 0 0 0 0 114.013

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Table 13.4	Stations	32, 3, 1	0, 16, 4, 39	, 41, & 42
Hours 6, 9,	14, & 19			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3120 3456 3557 4410 4583 6022 6078 8443 9564 10390 11307 12153 14905 17721 19894 20605 156208	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	$ \begin{array}{c} 0 \\ 0 \\ -4.2 \\ +4.2 \\ -2.6 \\ +0.7 \\ +1.3 \\ +0.6 \\ +1.8 \\ +0.1 \\ 0 \\ 0 \\ 0 \\ 0 \\ -0 \\ +0.2 \\ \end{array} $	0 0 0 8.304 10.214 4.179 0.408 1.584 0.427 3.709 0.012 0 0 0 0 28.836
Table 14.1	Stations	7, 6, 9,	33, 4, 39,	41, & 42
Hours 4, 9,	15, & 20			
Station	Computed	Actual	%	Chi-Square
	count	count	Difference	Factor

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Table 14.2	Stations	7, 6, 9,	33, 4, 39,	41, & 42
Hours 6, 9,	14, & 19			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41	3230 3418 3243 3951 4541 5948 6056 8308 9442 10324 11104 12141 14905 17721 19894 20605	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605	+3.5 -1.1 -8.8 -10.4 -5.0 +2.9 -2.9 -0.9 0 0 0 0 0 0 0	3.907 0.417 27.785 47.763 12.176 4.926 5.368 0.714 0 0 0 0 0 0
Total	154831	155864	-0.7	103.055
Table 14.3	Stations	7, 6, 9,	33, 4, 39,	41, & 42
Hours 6, 9,	15, & 19			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41	3328 3417 3571 4633 4609 5857 6477 8314 9442 10324 11104 12141 14905 17721 19894 20605	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605	$ \begin{array}{r} +6.7 \\ -1.1 \\ +0.4 \\ +5.1 \\ -3.6 \\ +1.3 \\ +3.8 \\ -0.8 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0$	$ \begin{array}{r} 13.891\\ 0.449\\ 0.059\\ 11.295\\ 6.258\\ 1.064\\ 9.054\\ 0.600\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ $
Total	156342	155864	+0.3	42.670

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Table 15.1	Stations	3, 27,	28, 2, 7, 6,	9, & 33
Hours 4, 9,	15, & 20			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3079 3456 3722 4300 4782 6174 6239 8385 9442 10324 11104 12141 14524 18147 20393 19641 155853	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	$ \begin{array}{r} -1.3\\ 0\\ +4.6\\ -2.5\\ 0\\ +6.8\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ -2.6\\ +2.4\\ +2.5\\ -4.7\\ -0.007 \end{array} $	$\begin{array}{c} 0.533 \\ 0 \\ 7.679 \\ 2.727 \\ 0 \\ 27.056 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ $
Table 15.2	Stations	3, 27,	28, 2, 7, 6,	9, & 33
Hours 6, 9,	14, & 19			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3272 3456 3273 4033 4782 5978 6239 8385 9442 10324 11104 12141 14183 18610 20870 20497 156589	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	+4.9 -8.0 -8.5 0 +3.4 0 0 0 -4.8 +5.0 +4.9 -0.5 +0.5	7.409 0 22.749 32.149 0 6.860 0 0 0 0 0 0 0 34.982 44.598 47.924 0.562 197.234

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Table 15.3	Stations	3, 27,	28, 2, 7, 6,	9, & 33
Hours 6, 9,	15, & 19			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3388 3456 3619 4734 4782 5933 6239 8385 9442 10324 11104 12141 14343 18743 21380 21178 159191	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	+8.6 0 +1.7 +7.3 0 +2.7 0 0 0 0 0 -3.8 +5.8 -7.5 +2.8 +2.1	$22.994 \\ 0 \\ 1.078 \\ 23.758 \\ 0 \\ 4.088 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 $
Table 15.4	Stations	3, 27,	28, 2, 7, 6,	9, & 33
Hours 5, 8,	13, & 19			
Station	Computed Count	Actual Count	% Difference	Chi-Square Factor
32 3 10 16 27 1 28 2 7 6 9 33 4 39 42 41 Total	3313 3456 3111 4494 4782 5671 6239 8385 9442 10324 11104 12141 13782 19546 21539 22256 159585	3120 3456 3557 4410 4782 5779 6239 8385 9442 10324 11104 12141 14905 17721 19894 20605 155864	+6.2 0 -12.5 +1.9 0 -1.9 0 0 0 0 0 -7.5 +10.3 +8.3 +8.0 +2.4	$ \begin{array}{r} 11.997\\0\\55.957\\1.607\\0\\2.014\\0\\0\\0\\0\\0\\84.660\\187.912\\136.065\\132.218\\612.429\end{array} $

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Table 16

Rotated Factor Matrix for 24 Hours of Counts

Percent

71.75 28.25

Rotated Factor Matrix

	1	2	
Hour			
12345678901123456789012234 11123456789012234	0.67045 0.42779 0.32767 0.12265 0.77514 0.93255 0.91278 0.91546 0.88137 0.80087 0.80416 0.85602 0.93224 0.88944 0.93718 0.94211 0.93784 0.95159 0.94543 0.91956 0.92679 0.79700 0.83398 0.80457	$\begin{array}{c} -0.71003 \\ -0.89506 \\ -0.92417 \\ -0.96975 \\ -0.50519 \\ -0.27733 \\ -0.25919 \\ -0.35726 \\ -0.41742 \\ -0.54343 \\ -0.55621 \\ -0.48129 \\ -0.33910 \\ -0.42793 \\ -0.32850 \\ -0.25569 \\ -0.28916 \\ -0.26667 \\ -0.31008 \\ -0.36823 \\ -0.36823 \\ -0.34640 \\ -0.56011 \\ -0.51554 \\ -0.54222 \end{array}$	
Facto	r	Variance	
1 2		16.48183 6.48866	

Table 16.1				
Factor Matrix	for Odd He	ours		
	Factor Ma	atrix		
	1			
Hour				
1	0.92560			
3	0.72546			
27	0.92150			
9	0.97221			
11	0.97290			
13	0.98137			
15	0.98117			
10	0.97970			
21.	0.97871			
23	0.97667			
Only 1 factor	retained.	No rotation	will be made	
Table 16.2				
Factor Matrix	for Even H	lours		
	Rotated H	Mactor Matrix		
	1	2		
nour				
2	0.47162	-0.87332		
6	0.94180	-0.23268		
8	0.92146	-0.32914		
10	0.82691	-0.50521		
12	0.88162	-0.43261		
14	0.95525	-0.20550		
18	0.96788	-0.21384		
20	0.93467	-0.32776		
22	0.82929	-0.51344		
24	0.03197	-0.90972		
Factor	Variance	Percent		
1	8.37822	72.54		
2	3.17122	27.46		

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Table 17

Factor Matrix for 16 Stations

Factor Matri	x
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	1
Station	
32	0.93486
3	0.98283
10	0.96125
16	0.92056
27	0.95123
1	0.96530
28	0.95285
2	0.94006
7	0.95352
6	0.96488
9	0.97439
33	0.97767
4	0.98928
39	0.98013
42	0.99100
41	0.97572

Only 1 factor retained. No rotation will be made.

Table 18

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Number of Street, or other

Relationships Between Factor Analysis and Estimate Accuracies, Four Station Tests, Tables 4.3.1 to 4.3.4

Station	Correlation From Table 17	Rank Among Stations	% Difference	Rank Among Stations
28	0.95285	1	-4.2	2
16	0.92056	4	+9.9	4
27	0.95123	2	+3.9	1
32	0.93486	3	-5.6	3
		•		
Station	Total Chi Square Fac	- tor	Rank Among Stations	
28	83.129		1	
16	263.112		4	
27	86.405		2	
32	105.342		. 3 .	

Table 19

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Relationships Between Factor Analysis and Estimate Accuracies, Sixteen Station Tests, Tables 8.1 to 8.6 Station Correlation From Rank Among % Factor Analysis Stations Difference Rank Among Stations +3.0 52 0.93486 32 3 16 2 4 2 53642 -2.1 0.98283 6 0.92056 +5.8 -2.5 0.94006 3,4 0.98928 1 -0.8 1 0.99100 Station Total Chi-Rank Among Square Factor Stations 32 285.544 4 206.144 798.447 301.499 265.272 3 16 26531 2 4

177.263

Algebraic Representation of the Estimation Process

Terms

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This process was described on pages 30, 31, and 32 using the counts for station 42 to estimate the count for station 4.

 $H_{x} = Hourly Count, Hour x, Station y$ $EC_{x} = Estimated Count for Station x$ Factors for the segments of hours of the day $F_{1} = Factor 1 \qquad F_{2} = Factor 2$ $F_{3} = Factor 3 \qquad F_{4} = Factor 4$ $F_{1} = \frac{1^{H}42 + 2^{H}42 + 3^{H}42 + 4^{H}42 + 5^{H}42 + 6^{H}42}{1^{H}42}$ $F_{2} = \frac{7^{H}42 + 8^{H}42 + 9^{H}42 + 10^{H}42 + 11^{H}42 + 12^{H}42}{9^{H}42}$ $F_{3} = \frac{13^{H}42 + 14^{H}42 + 15^{H}42 + 16^{H}42 + 17^{H}42 + 18^{H}42}{17^{H}42}$ $F_{4} = \frac{19^{H}42 + 20^{H}42 + 21^{H}42 + 22^{H}42 + 23^{H}42 + 24^{H}42}{20^{H}42}$

$$EC_4 = (F_1 \cdot _1^{H_4}) + (F_2 \cdot _9^{H_4}) + (F_3 \cdot _{17}^{H_4}) + (F_4 \cdot _{20}^{H_4})$$

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ABSTRACT

The highway agencies of the federal and state governments require traffic counts of selected roadways be taken every year. This information is used to provide statistics for Vehicle Miles of Travel(VMT) and usage for each type of roadway.

Presently, the bulk of these data is collected by use of portable and permanent traffic recorders. The permanent recorders are used to provide factors on time variations of traffic flows throughout the year. The portable recorders are moved to statistically selected locations to provide a sampling of all volumes of roads and streets.

In this study, estimates of traffic counts were obtained using the variations of traffic flow at selected locations. This was based on the assumption that the per cent of total traffic occurring in any given period is approximately the same along any route in an area.

The results were obtained by a predictive computer program. The variations in time of certain flows at specific locations were used to provide factors for estimating the traffic counts for other locations in the same general area.

The results showed this method of estimation was feasible. The estimated daily count for individual

locations was usually within 10% of actual volumes.

The hours chosen to provide counts to represent the traffic flow variations had a great effect upon the estimates. The higher volume hours seemed to provide better basis for estimates.

The location of the counting station also had a marked bearing upon the estimates. However, most of the counts of the stations showed very similar patterns in traffic volumes over a daily period.

This study showed the feasibility of estimating traffic counts by using the counts of a few stations in the same localized area. The hypothesis that traffic follows daily and hourly patterns which can be predicted has been substantiated by this study.

This method of estimation can be used with aerial counting of traffic to provide estimates of traffic for all roads in an area. This would be of great importance in obtaining yearly counts of the roadways in a large area.

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