Research Report
UKTRP-85-30

ESTIMATION OF EQUIVALENT AXLELOADS

by

John A. Deacon
Professor of Civil Engineering
University of Kentucky

Jerry G. Pigman
Transportation Research Engineer
Kentucky Transportation Research Program
University of Kentucky

and

Jesse G. Mayes
Transportation Research Engineer
Kentucky Transportation Research Program
University of Kentucky

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16. Abstract

The primary objective of this research study was to develop a procedure for estimating equivalent axleloads for purposes of flexible-pavement design. Maximum use was made of historical data and well-accepted procedures were used in developing the prediction model. A series of computer programs was developed to summarize truck-weight and classification data such that traffic characteristics could be estimated from a matrix of data classified by geographic area, Federal highway system, volume, and extent of coal haulage. An equation was developed with the following seven parameters as independent variables; 1) annual average daily traffic volume, 2) average fraction of trucks in the traffic stream, 3) average fraction of coal trucks in the total truck population, 4) average number of axles per coal truck, 5) average number of axles per non-coal truck, 6) average number of equivalent axleloads per coal-truck axle, and 7) average number of equivalent axleloads per non-coal-truck axle. The equivalent axleload estimate was calculated from estimates of the seven traffic parameters.

The procedure for estimating equivalent axleloads was found to be a simple one that yields reproducible results while allowing great flexibility in merging site-specific data with statewide averages for roads of similar type. Location-to-location variability was recognized and a recommendation was made to incorporate site-specific data into the design estimate whenever possible.

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FRANKFORT, KENTUCKY 40622

C. LESLIE DAWSON
SECRETARY

MARTHA LAYNE COLLINS
GOVERNOR

April 4, 1986

Mr. Robert E. Johnson
Division Administrator
Federal Highway Administration
P.O. Box 536
Frankfort, Kentucky 40602

SUBJECT: Implementation Statement for UKTRP Report 85-30
"Estimation of Equivalent Axleloads"
Research Study KYHPR-84-102

Dear Mr. Johnson:

Development of a series of computer programs for processing available vehicle classification and weight data was the primary task of this study. These programs were used to generate summary statistics which describe the destructive effect on pavement performance. The primary use of these statistics will be the generation of equivalent axleload estimates for the design of flexible pavements and overlays. Additionally, the historical summaries, both for individual sites as well as for different classes of highways, are available for use in a comprehensive pavement management system. In addition to pavement analysis and design, the data generated herein can be used to support any activity, such as a revenue study, an accident investigation, or a geometric design, requiring knowledge of the numbers and types of vehicles traveling on Kentucky highways.

Sincerely,

R.K. Capito

Robert K. Capito, P.E.
State Highway Engineer

EXECUTIVE SUMMARY

Flexible pavement structures are generally designed to provide satisfactory service for a certain number of years. Initially, the pavement will have a high serviceability and then, as traffic usage increases on the pavement, the serviceability will decrease. For design purposes, it is assumed that decrease in pavement serviceability is proportional to increase in number of repetitions of equivalent axleloads. When a pavement is designed to reach a designated level of serviceability by the end of a number of years of service, the designer determines pavement layer thicknesses that will accommodate the number of repetitions of equivalent axleloads expected to be applied to that pavement during its service life. This study addressed the issue of methods to accurately estimate equivalent axleloads.

The 18,000-pound single axle is used as a reference axle. Other magnitudes of axleloads are related to the 18,000-pound axle by equivalency factors. Accurate estimations of future traffic volumes and their axleloads are necessary ingredients in the design process in order that the pavement, as designed, will provide service at the designated level for the desired time.

The primary objective of this research study was to develop a procedure for estimating equivalent axleloads for purposes of flexible-pavement design. Maximum use was made of historical data and well-accepted procedures were used in developing the prediction model. A series of computer programs was developed to summarize truck-weight and classification data such that traffic characteristics could be estimated from a matrix of data classified by geographic area, Federal highway system, volume, and extent of coal haulage. An equation was developed with the following seven parameters as independent variables; 1) annual average daily traffic volume, 2) average fraction of trucks in the traffic stream, 3) average fraction of coal trucks in the total truck population, 4) average number of axles per coal truck, 5) average number of axles per non-coal truck, 6) average number of equivalent axleloads per coal-truck axle, and 7) average number of equivalent axleloads per non-coal-truck axle. The equivalent axleload estimate was calculated from estimates of the seven traffic parameters.

The procedure for estimating equivalent axleloads was found to be a simple one that yields reproducible results while allowing great flexibility in merging site-specific data with statewide averages for roads of similar type. Location-to-location variability was recognized and a recommendation was made to incorporate site-specific data into the design estimate whenever possible.

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Donald L. Ecton, Chairman
Division of Planning, Kentucky Department of Highways

William Stutzenberger
Division of Planning, Kentucky Department of Highways

Dudley Shryock
Division of Planning, Kentucky Department of Highways

Janet Coffey
Division of Planning, Kentucky Department of Highways

Ed Rassenfoss
Division of Design, Kentucky Department of Highways

J. L. Burchett
Operations and Pavement Management Staff, Kentucky Department of Highways

Glenn Jilek
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INTRODUCTION

Prior to 1948, flexible pavement thicknesses in Kentucky were based on design curves developed by the California Department of Highways in 1942. The first set of thickness design curves developed specifically for Kentucky conditions was issued in 1948 (1). Equivalent wheel loads (EWL's) were used in this procedure to represent the destructive effects of traffic. By 1957, a need to update the 1948 curves and extend them to accommodate larger traffic loadings and volumes became apparent. Another series of field tests and analyses resulted in the 1959 Kentucky design curves which were used continuously until 1983 (2).

During that period, the design curves served reasonably well. However, instances of premature failure of newly constructed pavements were not uncommon. Speculation regarding probable cause invariably included the possibility that traffic levels had been underestimated: accuracy of the traffic estimation procedures was therefore in question. A 1968 study confirmed inadequacies of the 1959 traffic-estimation procedures and the resultant report included a recommendation for an alternate procedure designed in part to enable a more accurate reflection of the effects of local conditions on the accumulation of EWL's (3). However, as demonstrated in Appendix A, determination of the adequacy of EWL design estimates on a systemwide basis is a difficult task and convincing assessments have yet to be made. In any event, use of the 1959 traffic-estimation procedure continued until 1983, when a new flexible pavement design method was adopted which required modification of the traffic-estimation component (4, 5).

In the 1983 procedure, traffic is represented by the equivalent number of 18,000-pound single axles (EAL's) expected to accumulate in the critical lane during the design period. This parameter is significantly different from the formerly used EWL measure in three important respects:

1) distinction among the types of truck axles is necessary,

2) a different set of damage factors is required, and,

3) allocation of a portion of the bidirectional accumulations to the critical lane is necessary.

These differences were sufficiently great to mandate change in the traffic estimation procedure, thereby providing an opportunity for re-examination of the accuracy issue and for developing a procedure that better expresses the effects of site-specific, local conditions on traffic composition and weight.

The purpose of this report is to document efforts to develop an improved procedure for the estimation of equivalent axleloads for use in the design of flexible pavements in Kentucky.

CONCEPTS OF MODEL DEVELOPMENT

Available resources prohibited the development and evaluation of a number of alternate methods for estimating future EAL accumulations. Accordingly, it was necessary to initially identify criteria that could be used in structuring a suitable model. Criteria that had been identified in 1968 provided a constructive beginning (3):

1) the predictive model should consider as many of the relevant local conditions that determine the composition and weights of the traffic stream as possible,

2) the predictive model should make full use of all available vehicle classification and weight data, and

3) the predictive model should possess the qualities of simplicity, reasonableness, predictability, and accuracy.

To this set, the following four criteria were added:

1) changes from the current traffic-estimation procedure should be minimal so that those responsible for making traffic estimations would be immediately comfortable with the new procedure,

2) provision must be incorporated for the annual updating of model parameters as new vehicle classification and weight data become available,

3) the methodology should provide for the estimation of former EAL accumulations as well as the estimation of future accumulations, and

4) the predictive model should be as flexible as possible, allowing the incorporation of estimates from multiple and diverse sources.

In general, models of any type are described in terms of their dependent variable(s), the set of independent variables, and the relationships that exist between the dependent and independent variables. In developing the EAL model, attention was first directed to the selection of appropriate dependent variables. While daily or annual EAL's could have been modeled directly, one major advantage could be realized by modeling a set of more fundamental traffic parameters from which EAL's could then be derived, namely, that of obtaining maximum use of available data.

For example, consider the following five traffic parameters:

1) AADT, the annual average daily traffic volume,

2) FT, the fraction of trucks,

3) FNT, the fraction of other vehicles (non-trucks),

4) EAL/T, the number of equivalent axleloads per truck, and

5) EAL/NT, the number of equivalent axleloads per non-truck.

The average daily EAL's can be simply determined from these parameters as follows:

$$EAL = AADT\,[FT(EAL/T) + FNT(EAL/NT)] \qquad [1]$$

Now, if a model were to be developed for the direct estimation of EAL's, only data taken at the truck weigh stations could be used for its calibration--it is only at these locations that all the necessary information for calculating EAL's is available. Useless to the model calibration effort would be the very extensive collection of volume and classification data obtained at other locations. However, if models were independently developed for the five parameters of Equation 1, all available volume data (for modeling AADT), all available classification data (for modeling FT and FNT), and all weight data (for modeling EAL/T and EAL/NT) could be used.

The decision was quite clear: models would be developed for fundamental traffic parameters, and the EAL estimate would be obtained by calculation. One critical decision was that extensive effort would not be made to model or forecast traffic volumes (AADT's). This decision, endorsed by the study Advisory Committee, seemed reasonable in view of both the limited project resources and of the extensive prior efforts in Kentucky to model volumes, including development of the Kentucky statewide traffic model. Volume was thus treated no differently from other traffic parameters considered in the determination of EAL's, and volume data recorded at other than classification-station locations were not entered into the database for model calibration.

The 1959 traffic-estimation procedure had used 11 traffic parameters; volume (AADT), percentage of trucks, average number of axles per truck, and the fraction of truck axles in each of eight axleload categories (Appendix B). While this set of variables provided a reasonable point of beginning, two changes were desirable. The most important was the need to explicitly recognize the influence of coal trucks on pavement deterioration. This could easily be accomplished because coal trucks have been weighed since the very beginning of the truck weigh program and have been identified in the classification counts since 1980.

The other change involved the distribution of axleloads. Since the new procedure required different damage factors to be used with different axle types, it was impractical to continue to make direct use of axleload distributions--the analysis would become overly complex if four or five different axleload distributions were required. Without loss of precision, all information contained in the axleload distributions can be expressed in a single quantity, the number of equivalent axleloads per truck or per truck axle--a quantity much easier to use and to understand than the axleload distributions.

The above considerations led to the selection of the following seven traffic parameters as the dependent variables of the modeling effort:

1) AADT, the annual average daily traffic volume,

2) FT, the average fraction of trucks in the traffic stream,

3) FCT, the average fraction of coal trucks in the total truck population,

4) A/CT, the average number of axles per coal truck,

5) A/NCT, the average number of axles per non-coal truck,

6) EAL/CA, the average number of equivalent axleloads per coal-truck axle, and

7) EAL/NCA, the average number of equivalent axleloads per non-coal-truck axle.

The average daily EAL's can be determined from these parameters as follows:

$$EAL = AADT[(1-FT)(0.005) + (FT)(1-FCT)(A/NCT)(EAL/NCA) + (FT)(FCT)(A/CT)(EAL/CA)] \quad [2]$$

Traffic volume, composition, and weight--and, hence, the parameters used for computing equivalent axleloads--vary over an extremely wide range from one location to another. Such variations are considered in the modeling process by selecting a set of independent variables, herein termed local conditions, that are most highly correlated with the dependent variables of interest and that can reasonably be evaluated both for model-development and for forecasting purposes.

Table 1 identifies the set of variables used in the 1968 study (3): this set was considered inappropriate for direct use herein because of the complexity added by such a large number of variables and the associated difficulty of considering interaction effects and because two of the variables, "Alternate Route" and "Service Provided," required manual analysis and processing. Variables of primary candidacy for inclusion in the current study were those coded in the historical classification data file (Table 2). After examining the consistency with which these variables had been coded during prior years, the following were selected as primary independent variables reflecting the effects of site-specific, local conditions: geographic area, Federal highway system, and volume.

One critical condition, not identified by the above three variables, is the degree to which any specific roadway is used for coal haulage. Because coal-haul roads typically accumulate EAL's much more rapidly than other roads, it was considered necessary to add a variable that represented such effects. The variable ultimately selected was the percentage of coal trucks within the total truck population. Table 3 identifies the complete set of local conditions used herein and defines the various levels or categories of each.

Conceptually, the only aspect of model development remaining unspecified was the form of the relationships between the dependent and independent variables. There is, of course, no theoretical basis for developing such relationships: furthermore, the literature review failed to identify any empirical relationship that seemed worthy of testing. As a result, the decision was made to limit the analysis to cross-tabulation models--no specific mathematical relationships were needed and full interaction effects among the independent variables could be treated. Actually, the prior decision to treat the independent variables as categorical in nature and to limit the number of categories for each was made in part with this type of modeling in mind. The independent variables were ultimately used to define 46 types of highways, six for coal-haul roads and 40 for non-coal-haul roads (on which coal trucks comprised less than one percent of the total truck volume). The six coal-haul categories represent the possible combinations of two volume levels and three levels of coal-truck concentration. The 40 non-coal-haul categories represent all possible combinations of two volume levels, four geographic areas, and five highway systems.

PREPARATION OF CROSS-TABULATION TABLES

The two data sources required for developing the cross-tabulation matrices included vehicle classification counts and truck weight surveys. The classification counts serve as the dominant data source, being taken annually at several hundred sites located throughout the state. Although originally undertaken annually, the truck weight survey is now conducted biennially and only about a dozen sites are included. Although these two types of surveys have been conducted for decades, the period of this study was limited to 1969-1984, years during which the data were readily accessible by computer and in a reasonably consistent format. The one major inconsistency, that of identifying and coding the various vehicle types, was resolved by adopting the convention used for classification counts beginning in 1984 (Table 4).

The cross-tabulation matrices, showing the average values of the seven traffic parameters for each of the 46 road types, are designed to be updated annually as additional classification data become available. The following sequence of five computer programs is used to construct the annual tables:

1) CLASSUM - Estimates annual average daily volumes (or fractions) of the various vehicle types from the short-term classification count at each individual classification station.

2) CLASEDIT - Edits tape output from CLASSUM.

3) LOADOMTR - Computes statewide average axleload distributions for the various vehicle and axle types.

4) EALCAL - Using output from the prior three programs, estimates the seven traffic parameters at each individual classification station and develops the cross-tabulation matrices showing average values of the parameters for each of the 46 road types.

5) SMOOTH - By means of time-series analysis, smooths data from the cross-tabulation matrices to assure year-to-year consistency and to increase reliability of the estimates.

Documentation of the first four of these programs has been previously published (6). Documentation of the fifth is included herein as Appendix C. Additional details regarding preparation of the cross-tabulation matrices follow.

Appendix D summarizes important changes to previously documented programs (6). Appendix E is a brief explanation of application of the five programs used to produce data for the EAL estimating procedure.

CLASSIFICATION DATA

Records documenting each classification count contain information necessary to determine five of the seven required traffic parameters, namely, the annual average daily traffic volume, the average fraction of trucks in the traffic stream, the average fraction of trucks that haul coal, the average number of axles per non-coal truck, and the average number of axles per coal truck. Additionally, information is provided with which to determine descriptors of local conditions (Table 3) at the site: geographic area is determined from the county code, the Federal highway system is coded directly, the volume category is selected from the AADT, and the coal-haul category is selected from the average percentage (or fraction) of trucks that haul coal.

While the AADT is recorded directly within the "raw" classification data, the other parameters, representing annual average conditions, must be estimated from a small sample, usually from eight to a maximum of 96 hours in duration, in which hourly volumes are recorded by direction and by vehicle type. Because of temporal variations in traffic flow, computation of these parameters without adjustment from the short-term counts may result in poor approximations of the annual averages. The primary purpose of the first computer program, CLASSUM, is to make reasonable approximations of annual average conditions on the basis of short-term counts. Additionally, an error file is produced which may be edited and used as input to the CLASEDIT program to correct the CLASSUM tape output.

As developed and applied herein, two sets of adjustment factors are used in CLASSUM, one to estimate missing hourly volumes for counts of durations less than 24 hours and the second to estimate daily volumes for seasons during which counts were not taken. It was implicitly assumed that each day in a given season is similar to all other days in that season and that there are no day-of-the-week effects. Possible long-term effects are effectively treated by developing a completely new set of adjustment factors from each annual database.

The purpose of the hourly adjustment is to expand counts of less than 24-hours duration to the full 24 hours. Multiplicative adjustment factors are used to estimate the uncounted hourly volumes from those counted in the field. An independent estimate of each uncounted hourly volume is obtained from each of the counted hours; results are averaged to obtain the final estimate. The daily volume estimates are obtained by appropriate summation. A separate set of adjustment factors is used for each combination of 14 vehicle types, four seasons, and two road types (Interstates and US-numbered highways comprise one category and all other highways the other).

When counts have not been made during each of the four seasons, multiplicative seasonal adjustment factors are used to estimate the missing quantitites. As before, an independent estimate is made on the basis of each of the seasons in which a count was taken and the results averaged to obtain the final estimate. A separate set of adjustment factors is used for each combination of the 14 vehicle types and the two road types.

Following completion of the previously described process, daily totals for each of the four seasons are averaged to obtain the desired estimates, the volume of each of the 14 vehicle types on the average day of the year. These volumes are later converted to fractions for use in the EAL-computation routine.

Validation of this adjustment process is a challenging task because no satisfactory set of classification data is available with which to compute actual--as opposed to estimated--annual average fractions by vehicle type. Accurate estimates of total volume are available, however, at the ATR stations, and comparisons can be made readily between the actual AADT's and those estimated by the above process at these locations.

Twenty-four ATR stations at which classification data had been obtained annually from 1969 to 1971 and again from 1976 to 1984 were identified. For each station and year, an error statistic was computed as follows:

$$\text{Error} = 100 \frac{\text{Estimated AADT} - \text{Actual AADT}}{\text{Actual AADT}} \qquad [3]$$

For the more than 250 data points, the error averaged -0.6 percent, indicating an overall tendency to slightly underestimate the total daily volume. However, the average error is sufficiently close to zero to suggest that the adjustment procedure is not biasing the estimates. The standard deviation of the error was determined to be about 17 percent. Assuming the error is distributed normally, this means that approximately 68 percent of the estimates would be expected to be within ± 17 percent of the actual volume.

Available data also permitted a cursory examination of the possible effect of length of the field count on the accuracy of the estimation. Lack of a definitive trend between count duration and estimation accuracy (Table 5) prohibited any conclusion regarding the relative contributions of sample size and of the adjustment procedure on the accuracy of the estimates.

An additional analysis was made to determine the possible effect of volume level on accuracy of AADT estimates. Contradictions within the data also prohibited a firm conclusion relative to volume effects (Table 6).

Estimates of percentage of trucks in the traffic stream at these 24 ATR stations were also examined using a procedure similar to that used with volumes. Comparisons were limited to the eight years of continuous estimates, 1976-1984. Since the true truck percentages were unknown, best approximations were required. In this case, the approximations were based on the linear equation of least-squares fit to the nine original estimates for each station. The error statistic for each station and year was then computed as follows:

$$\text{Error} = 100 \frac{\text{Estimated \% Trucks} - \text{Least Squares \% Trucks}}{\text{Least Squares \% Trucks}} \qquad [4]$$

The average error for the 215 valid truck-percentage estimates was zero, a necessary result of the procedure for approximating the true truck percentages. The standard deviation of the error was 17 percent, the same as was observed for the AADT estimates. Substitution of the true truck percentages--if known, for their least-squares approximations would result in an even larger variation in the error.

Considerable judgement is required in assessing the adequacy of the adjustment process on the basis of the above analysis. Admittedly, errors in the AADT and truck-percentage estimates were larger than desired. However, they stem not only from possible deficiences in the adjustment process but also from randomness of the sampled data: the limit that could theoretically be reached by a more effective adjustment procedure has yet to be established. Although it is clear that alternate adjustment procedures should be investigated in any future study, the adjustment procedure being used almost certainly is providing better estimates of the annual vehicle-type fractions than would have been obtained if no adjustments had been made.

WEIGHT DATA

The basic weight data file contains, for each vehicle that has been weighed, various descriptive information together with the weight of each individual axle and the spacings between axles. For convenience in future processing and storage, this information is summarized by the computer program, LOADOMTR, in the form of axleload distributions. Because of the limited number of locations at which trucks have been weighed, all data are aggregated in an attempt to reproduce statewide average conditions.

Separate axleload distributions are computed for coal and for non-coal trucks. Additionally, distributions are computed for each truck type and each of six types (configurations) of axles including steering axles, other single axles, tandem axles, tridem axles, quad axles, and a representation such as had been used with the 1959 design procedure that considered all axles as singles. All available rural data were used to determine the axleload distributions for coal trucks, but only data from the permanent rural weigh stations were used for non-coal trucks.

COMPUTATIONS

Classification data and weight data are merged to provide estimates of the seven traffic parameters at each classification-station location by a computer program, named EALCAL. Actually, the AADT is transferred directly from the previously generated output file of CLASSUM (as edited by CLASEDIT), and the average fraction of trucks in the traffic stream and the average fraction of coal trucks in the total truck population are obtained by simple computation.

The average number of axles per truck (for both coal-hauling and non-coal-hauling vehicles) can not be determined easily because several of the vehicle classes (Table 4) are open ended with respect to their numbers of axles: for example, a Class 14 vehicle--defined as a multi-trailer truck with seven or more axles--could have seven, eight, or even more axles. To determine the required estimates, the average number of axles for each vehicle class was first computed from average statewide weigh station data. When fewer than 10 of a given type of vehicle had been weighed, default entries, computed from the entire population of trucks weighed during 1969-1982, were substituted (Table 7). The final estimates were determined using weighting factors proportional to the fractions of the various truck types at the location in question.

Determination of the average number of equivalent axleloads per axle--again for both coal-hauling and non-coal-hauling trucks--required a similar integration of classification and weight data. The average EAL's per axle for each vehicle type was developed using the axleload distributions previously derived by the program, LOADOMTR, and the damage factors of Table 8. Representation of EAL's per axle for the average truck required weighting using the fractions of total axles associated with the various truck types counted at the particular classification-station location. Also calculated for each classification-station location were the annual bidirectional EAL accumulation and its three individual components representing the contributions of four-tired vehicles, non-coal trucks, and coal trucks.

The main thrust of this effort was development of cross-tabulation matrices representing the influence of the four local conditions (geographical area, Federal-aid class, volume level, and coal-haulage level) on the traffic parameters of interest. Each classification-station site was located in the appropriate cell of a 46-cell matrix--each cell representing a pertinent combination of the local-condition categories--and its parameters were merged with those from other similar locations to determine the final averages.

While the aforedescribed computation process was simple in concept, its execution was complicated by the following four specific problems:

1) in selected instances, the weight data were not sufficiently extensive to yield reliable estimates of representative axleload distributions;

2) buses had not been weighed in Kentucky and, hence, their axleload distributions could not be developed from the main database;

3) the vehicle classification counts identified the total number of coal trucks but not their types; and

4) considerable year-to-year variation was evidenced in the 46-cell matrices, necessitating the development of a smoothing procedure in order to achieve consistent, reliable estimates.

A description of activities undertaken to resolve each of these deficiencies follows.

Default Axleload Distributions

Even a cursory examination of statewide average axleload distributions reveals there are often quite large year-to-year variations and that, for certain truck types, very few (or none) are weighed in any specific year. These revelations raise two rather serious questions, namely,

1) how many axles of a given type must be weighed to obtain sufficiently reliable estimates of average EAL accumulations, and

2) if the sample size is insufficient, what procedures can be undertaken to obtain sufficiently reliable, default axleload distributions?

To address these questions, weight data for three truck types were examined, the six-tired, single-unit truck (Vehicle Code 6), the four-axle, single-trailer truck (Vehicle Code 9), and the five-axle, single-trailer truck (Vehicle Code 10). These truck types were selected for examination both because of their prevalence in the traffic stream and because of their comparatively large contributions to EAL accumulations. The original plan was to examine both non-coal-hauling and coal-hauling trucks. After the analysis of non-coal-hauling trucks had been completed, however, it was decided that little or no additional knowledge could be gained by continuing the analysis and the extension to include coal-hauling trucks was abandoned.

For simplicity, the number of EAL's per axle was selected to be the variable of concern. This variable is an accurate reflection of the effects of a specific axleload distribution on EAL accumulations and is much more convenient to analyze than the entire distribution of axleloads. In each case, the sample size was set at 1,000. Beginning with the 1982 weight data and proceeding to prior years as necessary to obtain the 1,000 measurements, EAL's were computed for each axle of a given type (for each of the three truck types).

Table 9 includes summary statistics for 10 truck-type/axle-type combinations (including, in addition to the three trucks of primary interest, a category in which a distinction based on truck type has not been made). The large coefficients of variation (ranging from 39 to 340 percent) demonstrate rather conclusively the large variability in EAL's per axle and, by inference, the large variation in axleload distributions. For each truck type/axle type, the frequency distribution of EAL's per axle is skewed to the larger side. A Chi-squared test conclusively demonstrated that none of the distributions could be assumed to be normal.

Sufficient data were available to determine the sample size necessary to obtain reliable estimates of the average number of EAL's per axle. Such determinations require selection of an allowable risk that the estimate will deviate from the true average by some preselected error. Figure 1 shows results for a risk of 20 percent: similar analyses were conducted for smaller levels of risk, but the sample sizes for such low risks were intolerably large.

Analytical results, depicted by Figure 1, do not yield a definitive selection of sample size. However, a size of 200 axles would restrict expected errors to no more than 30 percent of the true mean for each of the axle types that were examined. Two hundred is also a reasonable sample size for the most prevalent axle types encountered at the weigh stations.

If 200 axles of a given truck type/axle type are not weighed during a given year, a substitute or default axleload distribution was considered to be necessary. One possible substitute is an axleload distribution for the specific type of axle but determined for all trucks (without regard for truck type). Summary statistics for a sample of such distributions are shown in Table 9 ("All Types").

A statistical test was performed to ascertain if the average number of EAL's per axle for each truck-type/axle-type combination was significantly different from the average number of EAL's per axle for the corresponding axle type but with all truck types contributing to the sample. In only two of the cases (Vehicle Type 6/Axle Type 2 and Vehicle Type 10/Axle Type 3) was there justification for the assumption that the two sample averages could reasonably have been obtained from the same population. Accordingly, this alternate axleload distribution can not be considered to be a very reliable substitute.

Another alternative is to extend the analysis back through time, accumulating a larger sample size as additional years are added to the database. In essence, this represents the previously used Kentucky procedure in which axleload distributions reflected average conditions over the most recent three-year period during which weight data had been obtained. The deficiency of this procedure is that axleload distributions do change through time as a result of such factors as changing legal weight limits, changing vehicle technology, et cetera. Unfortunately, there is no accurate way to determine the maximum number of years that can reasonably be accumulated into a consistent database.

As a compromise solution, a sample size of at least 200 weighed axles is sought for each truck-type/axle-type combination. If current-year weight data do not yield a sufficient sample size, a backward search is initiated until the required size is reached. However, if 200 axles have not been weighed within eight calendar years (this means four weighing seasons when weight studies are performed every second year), an alternate distribution is used. The alternate is the distribution for a given axle type when all truck types are grouped together. Again a backward searching procedure is used until 200 axles have been weighed. In this case, however, the dataset is exhausted (no time limitation) if necessary to obtain the largest possible sample size.

Axleload Distributions for Buses

Estimates of the contributions of buses to EAL accumulations require bus weight data. Unfortunately, most states, including Kentucky, do not routinely collect such data, and a search of the literature failed to locate useful information about the weights of buses in service. During 1977-1982, however, a limited number of buses were weighed in four states--1,477 in Florida, 461 in Iowa, 178 in Nevada, and 48 in Texas. This database, generously made available by the Highway Statistics Division of the Federal Highway Administration, was used to develop an approximation of the weight distribution of buses traveling in Kentucky.

Actually needed were axleload distributions for two categories of buses, school buses and other buses. Such a two-part classification of bus types had not been used in the four-state database. The most acceptable accommodation seemed to be to treat all buses as one type for the purpose of determining axleload distributions and to reflect the difference between school and other buses by varying the number of axles on the two bus types. The number of axles on school buses was set at 2, the typical number, and on other buses, at 2.7, an approximate average from the four-state data.

The data format prevented the identification of tandem or other multiaxle units, requiring instead that all axles be considered as single units. Such treatment was considered acceptable since very few tridem and quad axles are used on buses and since the loads on the two single axles of a bus tandem set often deviate substantially from one another. It was possible, however, to distinguish between steering and other single axles, a factor of some significance due to the especially destructive impact of the single-tired steering axle.

Detailed examination of the weight data revealed that Florida buses were apparently much more lightly loaded than those in the other states and raised the issue of what weights would likely be most representative of Kentucky conditions. The issue was resolved by a somewhat arbitrary decision to compute axleload distributions separately for each state and to use the arithmetic averages to represent Kentucky conditions. The resulting axleload distributions are tabulated as Table 10.

Estimation of Coal Trucks by Truck Type

Since the beginning of the truck weight program, trucks hauling coal have routinely been weighed, together with those hauling all other types of commodities: a reasonable database has thus been developed for the loaded weights of coal trucks by truck type. However, only since 1980 have routine efforts been made to separately identify coal trucks during vehicle classification surveys. Unfortunately, the count of coal trucks is not recorded by truck type, making impossible the direct merger of classification and weight data and necessitating the development of an empirical algorithm for estimating the number of coal trucks by type.

The task can be described in the following way. For each classification count, the number of trucks of the ith truck type (V_i) and the total number of coal trucks (VC) are known. The objective is to estimate, for each truck type, the number of coal trucks (C_i) and the number of non-coal trucks (NC_i) subject to the following three constraints: $C_i \leq V_i$ (the number of coal trucks of the ith type can not exceed the total number of trucks of the ith type); Sum (C_i) = VC (the sum of coal trucks of all types must equal the count of the total number of coal trucks); and $C_i + NC_i = V_i$ (the number of coal and non-coal trucks of the ith type must sum to the count of all trucks of the ith type).

The algorithm used to obtain the necessary estimates entailed the following multistage process:

1) Make a first estimate of the number of coal trucks of type i by applying fractions by type based on <u>weight</u> data to the total number of coal trucks (VC) subject to the constraint that $C_i \leq V_i$.

2) If all coal trucks are not allocated to a truck type in Step 1, distribute the remainder based on the frequency with which the individual types had been weighed but again subject to the constraint that $C_i \leq V_i$.

3) If all coal trucks are not allocated to a truck type in Step 2, distribute the remainder based on the unfilled "capacity" of each truck-type category, that is, ($V_i - C_i$).

Unfortunately, testing the algorithm was impossible because necessary data were unavailable. However, the basic assumption that the distribution of coal trucks by type at classification stations is similar to that at weigh stations seems to be quite reasonable. The error anticipated because the algorithm does not account for locational effects is likely to have insignificant effect on EAL estimations.

Smoothing

The current study verified earlier findings (3) of considerable year-to-year variation in the relevant traffic parameters at a given location. Although the data of Table 11 are typical of results that may be expected, even more pronounced variability is not uncommon. Year-to-year variations are caused not only by long-term changes in the traffic pattern but more significantly by random variations thought to be due primarily to sampling procedures.

Averages of data collected at a group of stations would normally be expected to exhibit less year-to-year random fluctuations than those at individual stations. However, when composition of the group varies through time, as happens with the 46-cell cross-tabulation matrices, random fluctuations can be expected to be quite large. Table 12 documents the fluctuation for one parameter (annual number of EAL's) for a cell representative of a road class that exhibited reasonably stable traffic patterns through time.

Because of the magnitude of annual fluctuations in the cross-tabulated traffic parameters, a procedure was needed that would provide more consistent year-to-year estimates, hopefully enhancing their reliability as well. An auxiliary benefit of such procedures would be the capability for providing estimates by interpolation and extrapolation--a necessary capability for dealing with periods for which classification data are unavailable.

Three smoothing procedures were examined: the first was a five-year moving average, and the second two involved the least-squares calibration of simple equations to the time-series data. The following two relationships were examined:

$$P = a_0 + a_1 Y \qquad [5]$$

and

$$P = a_0 (a_1)^Y \qquad [6]$$

in which P is the cell average for the parameter of interest, Y is the year, and the a's are calibration constants. In each of the three cases, each cell average was weighted by the number of stations contributing to the average. For the least-squares calibration, additional weighting gave added emphasis to more recent data. The earliest of the available data were assigned a weighting of one, the next earliest, two, and continuing to increment the weighting by one for each succeeding year. A maximum of 15 years of data was used for each calibration. No calibrations were attempted when data were available for fewer than four years in any 10-year period. Extrapolations were not made beyond two years from the first or last year of available data.

The five-year moving average was eliminated as an acceptable smoothing procedure primarily because it failed to adequately attenuate annual fluctuations. The two least-squares equations performed equally well: both provided reasonable estimates of the traffic parameters and neither enjoyed an ascertainable advantage in accuracy. The linear procedure (Equation 5) was adopted in accordance with the preference of the study Advisory Committee.

The benefits of using a smoothing procedure, in terms of eliminating year-to-year variability, can be shown by comparing single-year averages (weighted by number of stations) within each cell with data generated by the smoothing procedure. To demonstrate the year-to-year variability in each cell, yearly averages for the 15-year period from 1970 through 1984 for each of the 46 cells are presented in Appendix F. Included are cross-tabulation matrices for each of the seven traffic parameters used in the EAL prediction procedure (Figures F-1 through F-7). Results from the linear smoothing procedure are presented in Appendix G, with 1984 as the last year of input data. Included in Appendix G are cross-tabulation matrices that show the results of linear smoothing for each of the seven traffic parameters (Figures G-1 through G-7). It is apparent when comparing the sets of data that year-to-year variations are present within yearly cell averages; however, this variation is eliminated when the linear smoothing procedure is applied over time. It should be noted that data presented in Appendix G are for 1970 through 1984 with 1984 data weighted 15 times more than 1970 data. This is suggested as the best estimate for 1984. A best estimate for a specific year could be obtained by using smoothed data with that specific year as the last year of the smoothing procedure.

To further demonstrate the results of the smoothing procedure, a series of graphs was prepared to show averaged data for two road-type categories from 1972 through 1984 as compared to smoothed data for these same two categories. These graphical representations for each traffic parameter are presented in Appendix H.

HISTORICAL TRENDS

Much of the analysis contained in this research effort has relied on historical trends to provide insights into the relevant traffic parameters. Previous presentations have included data that compare averaged traffic parameters with data produced from the linear smoothing procedure. Averaged data showed considerable year-to-year variation that was eliminated by the linear smoothing procedure. These two extremes may not represent best values of traffic parameters to demonstrate historical trends and an alternative presentation for historical trends was selected. Five-year moving averages are somewhat of a compromise between the two extremes, even though they may not be most appropriate for traffic estimates and pavement design considerations.

Rather than show individual traffic parameters, the data selected for use in presentation of historical trends were total bidirectional EAL's. Presented in Appendix I is a series of graphs that shows variation of total bidirectional EAL's over the time period 1971 through 1982 for each of the Federal-aid categories and volume groups. All four geographical areas are shown on each graph for Federal-aid category and volume group. Coal-haul roads, where data were taken for 1980 through 1984, were considered separately in this analysis. For coal-hauling roads, the patterns of bidirectional EAL's were clearly a decreasing trend over the five-year period of available data. Annual changes for the coal-haul road categories ranged from -5.0 percent for low volume roads with coal trucks comprising more that 20 percent of the truck volume to -18.1 percent for high volume roads with coal trucks comprising 5 to 20 percent of the truck volume.

In general, the results show that bidirectional EAL's have increased consistently over the time period of analysis on the interstates (Figure I-1). It is interesting to note that for high-volume interstates, the south-central geographic area has the highest bidirectional EAL's and the western area has the lowest average EAL's. On low-volume primary routes, the historical trends have shown a fairly flat pattern for all geographic areas except western Kentucky where the total EAL's peaked in the mid 1970's (Figure I-2). Bidirectional EAL's have generally declined since the mid 1970's on high-volume primary routes throughout the state (Figure I-3).

Total EAL's on low-volume Federal-aid-urban routes have shown a steady decline over the analysis period (Figure I-4). High-volume Federal-aid-urban routes showed a mid-1970's peak similar to the pattern for high-volume primary routes (Figure I-5). Federal-aid-secondary routes have experienced general increases in total EAL's over the analysis period (Figure I-6 and I-7). Non-Federal-aid routes have shown little change, with the exception of eastern Kentucky where there was a steady increase up to 1978 and then a decline through 1982 (Figures I-8 and I-9). As noted previously, the analysis of historical trends does not include coal-haul roads and this exclusion of coal routes for 1980 through 1984 may have been a factor in the decline experienced in some areas.

SIGNIFICANCE OF TRAFFIC PARAMETERS

The influence of individual traffic parameters is important when considering the variance in these parameters that is acceptable. As noted previously, the independent variables selected for inclusion in the model to predict future EAL accumulations are;

1) AADT, the average daily traffic volume

2) FT, the average fraction of trucks in the traffic stream,

3) FCT, the average fraction of coal trucks in the total truck population,

4) A/CT, the average number of axles per coal truck,

5) A/NCT, the average number of axles per non-coal truck,

6) EAL/CA, the average number of equivalent axleloads per coal-truck axle, and

7) EAL/NCA, the average number of equivalent axleloads per non-coal-truck axle.

The form of the model previously shown as Equation 2 indicates an equation that has separate components for four-tired vehicles, non-coal trucks, and coal trucks.

It can be seen from the form of Equation 2 that a change in AADT results in a directly proportional change in the EAL's. For example, a 50-percent increase in AADT would result in a 50-percent increase in the EAL prediction. This analysis can be carried further to show the impact on flexible pavement thickness relative to the variance in EAL predictions. For the case of a design-lane prediction of 10,000 EAL's the total pavement thickness would be 9.6 inches based on thickness design curves for pavements having 33-percent asphaltic concrete and a CBR of 5 (7). If the assumption is made that variance in parameters may cause an increase in the EAL prediction of 50 percent, then the total thickness requirement would be 10.8 inches. This is an increase in total thickness of 1.2 inches or 12.5 percent. Additional examples of changes in EAL predictions as compared to changes in required thicknesses are presented in Table 13. Generally, the indication is that the magnitude of changes in total pavement thickness is not nearly as great as the magnitude of changes in design EAL's. It should also be recognized that variations in the lower range of EAL predictions produce greater percentage changes in the total pavement thickness than variations in the higher range.

It was noted that changes in total EAL's are directly proportional to changes in the total AADT; however, the form of Equation 2 indicates that changes in other variables would not result in proportional changes in EAL's. The predominance of the influence of trucks suggests that variance in percent trucks is very nearly proportional to changes in EAL's. Other variables such as the number of axles per truck and EAL's per axle can also have a major impact on total EAL's depending upon the proportions of non-coal and coal trucks in the traffic stream.

An analysis of significance of parameters should also consider the impact of pavement thickness requirements upon life-cycle costs. It has been shown that major variations in total EAL's result in relatively little change in total pavement thickness, especially in the higher ranges of total EAL's. This small change in pavement thickness requirement is difficult to interpret from the standpoint of how much effect it has upon pavement life and total costs. Premature deterioration of the pavement may result from underdesign and the cost of repair or resurfacing would likely be much greater than an additional inch of pavement during construction. This is a consideration when attempting to assess the impact of minor changes in pavement thickness requirements.

PROPOSED DESIGN METHODOLOGY

The traffic parameter necessary for the design of flexible pavements in Kentucky is the total number of equivalent axleloads expected to accumulate in the critical lane during the design period. Year-to-year changes in the rapidity with which EAL's accumulate should logically be incorporated into the design estimate. Unfortunately, however, the analysis of historical data revealed no identifiable patterns that could be readily reflected in the design process. Accordingly, the proposed design procedure is based on the simple premise that, at a given location, the EAL's will accumulate linearly over time. The design estimate can therefore be simply represented by the product of the design period (in years) and the <u>annual</u> accumulation of EAL's at the midyear of the project design life.

The thrust of the design requirement, then, is to estimate the annual midyear accumulation of EAL's in the critical lane. The common approach to this task is to consider it as a two-step process, the first involving an estimate of the total bidirectional accumulations of EAL's and the second involving the distribution or allocation of this bidirectional total to the several lanes.

BIDIRECTIONAL DESIGN EAL's

The individual contributions of three generic types of vehicles to the accumulation of EAL's are recognized in the design process. These types include four-tired vehicles, coal-hauling trucks, and other trucks (a category that includes buses and that has been herein termed non-coal-hauling trucks). Using the seven traffic parameters identified earlier, daily EAL's are computed as previously shown in Equation 2 and again shown below:

$$\text{Daily EAL's} = AADT[(1-FT)(0.005) + (FT)(1-FCT)(A/NCT)(EAL/NCA) + (FT)(FCT)(A/CT)(EAL/CA)]$$

in which AADT is the annual average daily traffic volume, FT is the average fraction of trucks in the traffic stream, FCT is the average fraction of coal trucks in the total truck population, A/NCT is the average number of axles per non-coal truck, EAL/NCA is the average number of equivalent axleloads per non-coal-truck axle, A/CT is the average number of axles per coal truck, and EAL/CA is the average number of equivalent axleloads per coal-truck axle.

To obtain the required project midyear estimate of each of the seven parameters, an increment is added to each base-year estimate. The base year is normally the year during which the estimate is made but could alternatively be another recent year during which traffic data had been collected at the location in question. In estimating traffic parameters for the base year, preference should always be given to actual data collected at the site under investigation or alternatively at a nearby one known to have similar traffic characteristics. When actual measurements are unavailable, the location is classified into one of the 46 road types, and the parameter estimates are extracted from the most recent cross-tabulation matrix (illustrated by Appendix G). If reliable site-specific volume data is available, as is often the case, only the remaining six parameters need be extracted from the matrix. If reliable site-specific classification data are also available, the matrix will be needed to provide estimates of only two parameters, namely, EAL/NCA and EAL/CA.

In the absence of a special study and forecast, the additive increment--to be applied to each base-year estimate to produce the project midyear estimate for that parameter--is a product of the base-year estimate, the annual percentage change expressed as a fraction of the base-year estimate, and the number of years between the base year and the project midyear. The annual changes, like the base-year estimates themselves, have been estimated from historical data and tabulated as a function of the 46 road types (see Appendix G). The annual change, determined in this manner, tends to be somewhat erratic when the historical data are limited. To avoid making unreasonable estimates in such a case, excessive annual changes must be avoided: five percent of the base-year condition is a recommended maximum limit. As a conservative measure, it is further recommended that no change be recognized when a negative or declining pattern is shown by the cross-tabulation matrix.

A simple worksheet has been prepared to aid in the computations (Figure 2). The upper portion of this worksheet identifies the route and records relevant dates, and the lower portion provides ordered space for the computations. The middle portion, where estimates of the traffic parameters at the project midyear point are made, warrants some brief explanation. Here, the first column provides space for the base-year estimates, whether derived from field measurements, special studies, or the cross-tabulation matrix. The second column, titled "Site-Specific Adjustment", is used only where base-year data were obtained from the cross-tabulation matrix and is to be adjusted based on field measurements taken at the site several years earlier. This column contains, for the earlier year, the ratio of the site-specific field data to the cross-tabulation average for the appropriate road type. This ratio is applied to the unadjusted base-year estimate of the first column to obtain the adjusted base-year estimate of the third column. The fourth column, labeled "Increment", is simply the difference between the project midyear estimate and the adjusted base-year estimate. In the absence of a special investigation, the increment is determined by taking the product of the adjusted base-year estimate, the annual change expressed as a fraction of the base-year estimate and extracted from the cross-tabulation matrix, and the number of years between the base year and the project midyear.

LANE DISTRIBUTION

Since the 1940's, the traffic parameter used in the design of flexible pavements in Kentucky has been a bidirectional expression of equivalent loading (1, 2). When the new design procedure (4, 5) was adopted in 1983, very little in-state information was available to determine what portion of the bidirectional EAL's on multilane highways should be assigned to the critical or design lane. As a result, information was sought about the design practices used by others, a logical point of beginning being the AASHTO guide for pavement design (8).

AASHTO provides the following guidance for allocating bidirectional EAL's to the critical lane:

> "The equivalent axle loads derived from many prediction procedures represent the totals for all lanes for both directions of travel. This traffic must be distributed by direction and by lanes for design purposes. Directional distribution is usually made by assigning 50 percent of the traffic to each direction, unless special conditions warrant some other distribution. In regard to lane distribution, 100 percent of the traffic in each direction is usually assigned to all lanes in that direction for purpose of structural design. Some states have developed lane-distribution factors for facilities with more than one lane in a given direction. These factors vary from 80 to 100 percent of the one-direction traffic for design of all lanes when there is a total of four lanes in both directions, and from 60 to 80 percent of the one-direction traffic to one or more of the outer lanes and lesser values to inner lanes when there are six or more lanes in both directions. If there is doubt as to which factor to apply, it is suggested that the highest (most conservative) range be used."

The two major trade associations, the Asphalt Institute (AI) and the Portland Cement Association (PCA), offer more definitive and more useful recommendations. Both express lane distribution factors in terms of the proportion of trucks in the design lane: presumably the proportion of EAL's is identical. The AI factors (Table 14), to be applied to bidirectional truck volumes, are sensitive only to the number of lanes (9). The PCA, on the other hand, recommends factors to be applied to unidirectional volumes that reflect both number-of-lane and traffic-volume influences (10). The PCA recommendations are as follow:

$FT = 1.579 - 0.0838 \ln(ADT)$ for 2 lanes in one direction and ADT of 1,000 to 40,000 [7]

$FT = 1.438 - 0.0819 \ln(ADT)$ for 3 lanes in one direction and ADT of 3,000 to 80,000 [8] in which FT is the fraction of unidirectional trucks in the right or outer lane and ADT is the unidirectional average daily traffic volume. Both the AI and the PCA recognize the possibility of directional imbalances and both recommend design for the most critical loading condition.

Very little information was found in the open literature about how the individual states approached the matter of directional and lane distributions of EAL's on multilane facilities. As a result, a survey of state practices was conducted that queried each state regarding its standard practice in converting from "two-directional equivalent 18 kip axleloads (EAL's) to design lane EAL's." Of the 37 responses to the survey, nine (Arkansas, Kansas, Maine, Mississippi, Missouri, New York, Oklahoma, South Dakota and Vermont) did not provide useful information, typically because design-lane equivalencies were not required in the pavement design process.

Regarding directional distribution, the prevailing design practice among the remaining states involves an even distribution of EAL's in each direction of a bidirectional roadway. However, those states commenting on the directional split of EAL's pointed out unusual situations of unequal split and indicated that, when encountered and recognized, the pavement design would be adjusted to reflect that condition.

There is less unanimity among the states regarding their practices in apportioning the unidirectional load equivalencies to individual lanes (Table 15). While there are a few states that assign all unidirectional EAL's to a single critical lane--some even for six- or eight-lane facilities--most distribute them among the several lanes, with a smaller assignment to the critical or design lane as the number of lanes increases. For four-lane facilities, 90 percent is the most frequent allocation to the critical lane. For six-lane facilities, 80 percent is typically allocated. When a difference is recognized between rural and urban conditions, the flow is typically considered to be more dispersed in urban areas, perhaps reflecting combined effects of larger volumes and more frequent ramp termini. When explicit recognition is taken of volume effects, greater dispersion across the lanes is considered to accompany larger traffic volumes.

Very little research, which may have formed the basis for the aforedescribed state practices, has been reported in the open literature. Early work by Taragin (11) documented the concentration of trucks within the outside lanes of lightly-traveled four-lane divided highways and demonstrated the diversion to inner lanes as volume increased. Later studies (12, 13) confirmed the significance of traffic volume in determining the lanes in which trucks travel, and one (12) identified the influence of the percentage of trucks on truck lane usage for one highway category, namely, six-lane urban highways. Unfortunately, each of these investigations was plagued not only by sample-size restrictions but also by a failure to adjust the sample observations to conditions representative of annual averages.

Collection of field data by automatic weighing or vehicle classification equipment is a promising future technique for learning more about lane-distribution characteristics (14, 15, 16). Meanwhile, another possibility is to calculate lane-distribution factors using a simple model, calibrated with the limited field data that is available. The approach tested herein involved the following steps:

1) Select the annual average daily traffic volume (AADT). The AADT, treated parametrically in this analysis, was varied to a maximum of 60,000 vpd for four-lane highways and 90,000 vpd for six-lane highways.

2) Select the annual average fraction of trucks (FT). FT was also treated parametrically, varying within the range of 0.10 to 0.30 (10 to 30 percent).

3) Estimate the 8,760 bidirectional hourly traffic volumes (HV_i). In examining 1977 data from 45 Kentucky ATR stations (17), an hourly volume distribution representative of average statewide conditions was developed (Table 16). This distribution was employed herein to estimate the hourly volumes.

4) Estimate the 8,760 bidirectional hourly truck volumes (HT_i). Very little quantitative information is known about the hourly distribution of truck volumes. As a first approximation, however, the following model was used:

$$HT_i/HV_i = FT^a e^{b(1-FT)(HV_i/AADT)} \quad [9]$$

in which a and b are constants and e is the base of the natural logarithms. Equation 9, although appearing unnecessarily complex, has several of the necessary attributes including the following:

a) the fraction of the hourly volume classified as trucks (HT_i/HV_i) diminishes as the hourly volume increases,

b) the fraction of the hourly volume classified as trucks (HT_i/HV_i) satisfies the boundary conditions--that is, it assumes a value of one when all vehicles are trucks (FT = 1) and a value of zero when no trucks are present (FT = 0), and

c) its constants can be calibrated to "fit" available data subject to the following constraint:

$$\text{Sum } [HT_i] = AADT\ (FT)\ (365) \quad [10]$$

Values of 1/2 for a and -16.4 for b provide a reasonable fit of Equation 9 to very limited data collected in 1973 on I 75 in Grant County (18).

5) Estimate the 8,760 hourly truck volumes in the design lane. Each hourly truck volume in the design lane was found by applying to the estimate of the total hourly truck volume a multiplicative factor developed by Pigman and Mayes (18). Making a first-approximation assumption that the total hourly volume (HV) is evenly proportioned in two directions, the multiplicative factor is given by:

$$FTDL = (99.42 - 0.008\ HV)/200 \quad \text{for 4-lane roadways} \quad [11]$$

$$FTDL = (85.43 - 0.01\ HV)/200 \quad \text{for 6-lane roadways} \qquad [12]$$

in which FTDL is the fraction of the bidirectional hourly truck volume in the design lane.

6) Compute the lane distribution factor by dividing the annual design-lane truck volumes by the total annual truck volumes.

7) Develop a simplified relationship between the lane distribution factor and annual average daily traffic volume, percentage of trucks, and number of lanes. The lane distribution factors were adequately represented by the following:

$$L = 0.497 - (1.84 + 1.42\ FT)\ (AADT)\ (10^{-6}) \quad \text{for 4-lane roadways} \qquad [13]$$

$$L = 0.427 - (2.308 + 1.75\ FT)\ (AADT)\ (10^{-6}) \quad \text{for 6-lane roadways} \qquad [14]$$

in which L is the fraction of annual, bidirectional truck volumes anticipated in the design lane, AADT is the annual average daily traffic volume (bidirectional), and FT is the annual fraction of trucks in the traffic stream.

To assess the reasonableness of Equations 13 and 14, comparisons were made with the volume-based, lane distribution factors of others (Table 17). Because general accord among the several procedures was found--at least for the mid-range volumes--Equations 13 and 14 are recommended for use in Kentucky. They reflect important volume and traffic composition effects on lane distribution and are as intuitively appealing as alternate choices. However, in recognition of the extremely limited amount of information used in the development of Equations 13 and 14, particularly in the large-volume range, minimum bidirectional lane distribution fractions of 0.375 and 0.25 are recommended for four-lane and six-lane roadways, respectively. Arbitrarily selected, these minimums represent concentrations in the critical lanes that are 50 percent greater than a uniform dispersion across all available lanes.

SUMMARY

The aforedescribed design process is considered to be a simple one that yields reproducible estimates while allowing great flexibility in merging site-specific data with statewide averages for roads of similar type. Maximum use is made of available historical vehicle classification and weight data, and computerization enables annual updating of the cross-tabulation matrices and other data of potential interest.

VALIDATION OF PROPOSED METHODOLOGY

In comparison with possible alternate design methodologies, the one proposed herein is not considered to involve great risk. Evolving from a long-standing and well-accepted procedure, the recommended design process uses familiar traffic parameters, requires no untested mathematical models, and exploits the available traffic database to the maximum possible extent. Remaining to be determined, however, is the accuracy with which estimates of design EAL's can be made. Two paramount questions involve 1) the extent to which the local-condition categories capture the variability in those traffic characteristics that influence EAL accumulations and 2) the extent to which changes through time can be accurately modeled.

Tables 18 and 19 offer some preliminary insight into the first of these two questions. Road type, as defined by the local-condition categories used herein, is a major factor explaining the different rates at which highways accumulate equivalent axleloads. Unfortunately, however, road type does not account for all of the observed differences. In fact, the coefficient of variation of EAL's for a set of highways classified in the same road-type category is typically within the range of 70 to 100 percent, indicating a standard deviation approaching the mean in magnitude. While a portion of this large variability is likely due to a variety of sampling errors, the fact remains that, even among roads of the same type, EAL's can be expected to accumulate at differing rates. Accurate design estimates can thus be expected to require the merger of site-specific data, particularly traffic volume in the base year, with data extracted from the cross-tabulation matrices.

Ultimately, the most acceptable way for validating the design methodology is a comparison of design estimates with actual accumulations of EAL's. Sufficient data are at hand to permit a first-order approximation of such an approach.

Forty-eight sites were selected from the database, for each of which it was possible to make a reasonable estimate of the historical accumulation of EAL's over a recent although short period of time. The specific criterion used for site selection was that classification data had to be available for at least five of the 10 years between 1975 and 1984. Annual EAL's for any missing years were estimated from a linear equation, fit to the available data by the least-squares procedure. Of the 48 sites, 21 were located on coal-haul roads and 27 on non-coal-haul roads. The lack of specific data on coal haulage before 1980 necessitated different treatments for coal-haul and non-coal-haul categories.

For non-coal-haul roads, the hypothetical base year was selected to be 1975. Using data collected during 1969-1975, "design" estimates were made for the nine-year period, 1976-1984. For coal-haul roads, 1979 was chosen as the base year and 1980-1984, as the design period. Designs for coal-haul roads were based on linear relationships calibrated to the 1980-1984 data and extrapolated backward in time to 1979.

Actually, four different design estimates were made for each site, reflecting in part the primary options available to the designer. In the first, all parameter estimates were extracted from the applicable cross-tabulation matrix. In the remaining three, substitutions were made based on the type of data and/or analysis most likely to be available to the designer. One assumed that the site-specific, base-year volume (AADT) was known. The second assumed that both the site-specific, base-year volume and the percentage of trucks were known. Finally, the third assumed that an independent estimate had been made for the midyear volume. The design estimates, together with the historical EAL accumulations, are shown for each of the 48 sites on Table 20. Figure 3 is a graphic portrayal of the relationship between actual EAL's and those estimated without refinement from the cross-tabulation matrix.

To characterize the accuracy of the design procedure, the deviation of each design estimate from its most likely actual value was expressed as an error term and computed as follows:

$$\text{Error} = 100 \; \frac{\text{Design EAL} - \text{Actual EAL}}{\text{Actual EAL}} \qquad [15]$$

When summarized for the sites in question, high accuracy is indicated both by a mean error and a standard deviation of the error that approach zero. These summary variables are tabulated as Table 21.

Generally confirmed by the statistics of Table 21 is the improvement in accuracy that results when the cross-tabulation averages are supplemented by site-specific data, the greatest improvement being realized when the largest amount of site-specific data is used. Contrary to expectation, use of the midyear volume rather than the base-year volume did not significantly improve the accuracy. This counter-intuitive finding is not expected to be confirmed for situations in which the base-year to midyear span more closely approaches the 10- to 15-year period characteristic of design situations.

Examination of the mean errors of Table 21 reveals significant overestimate of design EAL's for coal-haul roads and almost neutral estimates for non-coal-haul roads. The bias for coal-haul roads is due primarily to the fact that the recommended design procedures substitute zero for negative estimates of changes in the traffic parameters through time. Thus, while the annual accumulation of EAL's on coal-haul roads was declining within the range of 5 to 18 percent during 1980-1984, the design estimates were generally based on a conservative, "no-decline" scenario. The much larger standard deviations for the coal-haul roads may partially reflect the above tendency for overestimation. Probably of much greater significance, however, is the fact that only six road-type categories are used to typify coal-haul roads while 40 are used for non-coal-haul roads. Furthermore, coal-haul roads seem to demonstrate inherently more variability than non-coal-haul roads in the rate at which EAL's accumulate.

Perhaps the most significant entry of Table 21 is the standard deviation of 52 percent that characterizes the error variability when limiting design estimates for non-coal-haul roads to the cross-tabulation matrix. Whether actual design estimates would be characterized by such large variability is unknown: perhaps the gains achieved by use of a larger database on which to make the projections would be canceled by the losses by projecting to a considerably more distant future. In any event, the advantage of fortifying the design with at least a site-specific estimate of the base-year volume is an obvious and important one

IMPLEMENTATION

Development of a series of computer programs for processing available vehicle classification and weight data was the primary task of this study. These programs are used to generate summary statistics which describe the character of the vehicle population on Kentucky highways and the nature of its destructive effect on pavement performance. The primary use of these statistics was intended to be the generation of equivalent-axleload estimates for the design of flexible pavements and overlays. Additionally, the historical summaries, both for individual sites as well as for different classes of highways, are available for possible use in a comprehensive pavement management system. In addition to pavement analysis and design, the data generated herein can be used to support any activity, such as a revenue study, an accident investigation, or a geometric design, requiring knowledge of the numbers and types of vehicles traveling on Kentucky highways.

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TABLE 1. LOCAL CONDITIONS USED IN 1968 STUDY (3)

Local Condition	Code	Description
Road Type	1	Interstate-Numbered Rural Route
	2	US-Numbered Rural Route
	3	KY-Numbered Rural Route
	4	Other Rural Route
Direction	1	Serves Predominantly North-South Traffic
	2	Serves Predominantly East-West Traffic
Alternate Route	1	Alternate Route Provides Inferior Service
	2	No Alternate Route or Same Quality of Service
	3	Alternate Route Provides Superior Service
Service Provided	1	Primarily Provides Service to Major Recreational Activity
	2	Provides Significant Service to Major Recreational Activity
	3	Provides Some Service to Recreational Activity
	4	Ordinary
	5	Provides Some Service to Mining Activity
	6	Provides Significant Service to Major Mining Activity
	7	Primarily Provides Service to Major Mining Activity
	8	Provides More Than Ordinary Service to Industrial Activity
	9	Primarily Provides Service to Major Industrial Activity
Volume	1	0-499 Vehicles per Day
	2	500-999 Vehicles per Day
	3	1000-1999 Vehicles per Day
	4	2000-2999 Vehicles per Day
	5	3000-3999 Vehicles per Day
	6	4000-5999 Vehicles per Day
	7	6000-7999 Vehicles per Day
	8	8000-9999 Vehicles per Day
	9	10000-13999 Vehicles per Day
	10	14000 or more Vehicles per Day
Maximum Allowable Gross Weight	1	30,000 Pounds
	2	42,000 Pounds
	3	59,640 Pounds
	4	73,280 Pounds
Geographical Area	1	Western (Highway Districts 1 and 2)
	2	South Central (Highway Districts 3, 4, and 8)
	3	North Central (Highway Districts 5, 6, and 7)
	4	Eastern (Highway Districts 9, 10, 11, and 12)
Season	1	Winter (January-March)
	2	Spring (April-June)
	3	Summer (July-September)
	4	Fall (October-December)

TABLE 2. CANDIDATE LOCAL CONDITIONS AS RECORDED WITHIN CLASSIFICATION DATABASE

Local Condition	Code	Description
County	-	Counties can be aggregated to form larger geographical areas
Direction	-	
Federal Highway System	1	Federal-Aid Interstate
	2	Other Federal-Aid Primary
	3	Federal-Aid Urban
	8	Non-Federal-Aid
State Highway System	1	Interstate
	2	Parkway
	3	Primary
	4	State Secondary
	5	Rural Secondary
	6	Unclassified
	7	State Property Service Road
	8	Local
Functional Class	1	Rural, Interstate
	2	Rural, Principal Arterial
	6	Rural, Minor Arterial
	7	Rural, Major Collector
	8	Rural, Minor Collector
	9	Rural, Local
	11	Urban, Interstate
	12	Urban, Freeway and Expressway
	14	Urban, Principal Arterial
	16	Urban, Minor Arterial
	17	Urban, Collector
	19	Urban, Local
Highway Weight Limit	-	
Volume	-	

TABLE 3. LOCAL CONDITIONS USED IN CURRENT STUDY

Local Condition	Code	Description
Geographic Area	1	Western (Highway Districts 1 and 2)
	2	South Central (Highway Districts 3, 4, and 8)
	3	North Central (Highway Districts 5, 6, and 7)
	4	Eastern (Highway Districts 9 through 12)
Federal Highway System	1	Federal-Aid Interstate
	2	Other Federal-Aid Primary
	3	Federal-Aid Urban
	4	Federal-Aid Secondary
	5	Non-Federal-Aid
Volume	1	Less Than 5,000 AADT
	2	5,000 or More AADT
Coal-Haul Category	-	Coal Trucks Comprise Less Than 1% of Trucks
	1	Coal Trucks Comprise From 1-4.99% of Trucks
	2	Coal Trucks Comprise From 5-19.99% of Trucks
	3	Coal Trucks Comprise 20% or More of Trucks

TABLE 4. VEHICLE TYPES

Vehicle Code	Vehicle Type
1	Motorcycle
2	Passenger Car
3	Other 2-Axle, 4-Tired Vehicle
4	Bus, School
5	Bus, Other
6	Single-Unit Truck, 2 Axles, 6 Tires
7	Single-Unit Truck, 3 Axles
8	Single-Unit Truck, 4 or More Axles
9	Single-Trailer Truck, 4 or Fewer Axles
10	Single-Trailer Truck, 5 Axles
11	Single-Trailer Truck, 6 or More Axles
12	Multi-Trailer Truck, 5 or Fewer Axles
13	Multi-Trailer Truck, 6 Axles
14	Multi-Trailer Truck, 7 or More Axles

TABLE 5. EFFECT OF COUNT DURATION ON ACCURACY OF AADT ESTIMATES

Length of Count (Hours)	Average Error (Percent)	Standard Deviation of Error (Percent)
16-23	2.1	16.3
24	-7.4	18.0
25-47	5.4	12.1
48 or more	-4.4	15.7

TABLE 6. EFFECT OF VOLUME LEVEL ON ACCURACY OF AADT ESTIMATES

Annual Average Daily Traffic (vpd)	Average Error (Percent)	Standard Deviation of Error (Percent)
662-1499	-4.2	16.9
1500-1999	-0.5	16.9
2000-3999	0.6	15.0
4000-7999	-4.0	19.7
8000 or more	6.3	12.7

TABLE 7. AVERAGE NUMBER OF AXLES BY AXLE AND VEHICLE TYPES[a]

Vehicle Type	Steering	Other Single	Tandem	Tridem	Quad	Total
NON-TRUCKS						
Motorcycles	1.000	1.000				2.000
Passenger Cars	1.000	1.000				2.000
Other 2-Axle, 4-Tire Vehicles	1.000	1.000				2.000
BUSES						
School	1.000	1.000				2.000
Other	1.000	1.700				2.700
SINGLE-UNIT TRUCKS						
2 Axles, 6 Tires	1.000	1.000				2.000
3 Axles	1.000		1.000			3.000
4 or More Axles	1.000			1.000		4.000
SINGLE-TRAILER TRUCKS						
4 or Less Axles	1.000	1.212	0.789			3.791
5 Axles	1.000	0.046	1.973	0.003		5.000
6 or More Axles	1.000	0.008	0.951	1.017	0.030	6.080
MULTI-TRAILER TRUCKS						
5 or Less Axles	1.000	3.980	0.010			5.000
6 Axles	1.000	3.000	1.000			6.000
7 or More Axles	1.000	2.000	2.000			7.000

[a]Average based on 1969-1982 data.

TABLE 8. DAMAGE FACTORS BY AXLE TYPE AND LOAD

Damage Factors					
Load Interval Code	Steering Axle	Other Single Axle	Tandem Axle (5' Span)	Tridem Axle (10' Span)	Quad Axle (15' Span)
1	0.0001	0.0004	0.0007	0.0007	0.0006
2	0.0030	0.0027	0.0029	0.0029	0.0029
3	0.0138	0.0120	0.0113	0.0115	0.0115
4	0.0387	0.0406	0.0359	0.0363	0.0366
5	0.0855	0.113	0.0966	0.0970	0.0980
6	0.163	0.277	0.231	0.230	0.232
7	0.281	0.613	0.502	0.497	0.502
8	0.451	1.25	1.02	0.998	1.01
9	0.685	2.41	1.94	1.89	1.90
10	0.997	4.40	3.52	3.41	3.43
11	1.40	7.68	6.14	5.91	5.92
12	1.91	12.9	10.3	9.89	9.88
13	2.55	21.1	16.8	16.0	16.0
14	3.33	33.5	26.8	25.3	25.2
15	4.27	51.9	41.5	39.1	38.7
16	5.39	78.6	63.0	59.0	58.3

Load Interval (Kips)					
Load Interval Code	Steering Axle	Other Single Axle	Tandem Axle (5' Span)	Tridem Axle (10' Span)	Quad Axle (15' Span)
1	0.0-1.5	0.0-2.5	0.0-5.0	0.0-7.5	0.0-10.0
2	1.6-3.0	2.6-5.0	5.1-10.0	7.6-15.0	10.1-20.0
3	3.1-4.5	5.1-7.5	10.1-15.0	15.1-22.5	20.1-30.0
4	4.6-6.0	7.6-10.0	15.1-20.0	22.6-30.0	30.1-40.0
5	6.1-7.5	10.1-12.5	20.1-25.0	30.1-37.5	40.1-50.0
6	7.6-9.0	12.6-15.0	25.1-30.0	37.6-45.0	50.1-60.0
7	9.1-10.5	15.1-17.5	30.1-35.0	45.1-52.5	60.1-70.0
8	10.6-12.0	17.6-20.0	35.1-40.0	52.6-60.0	70.1-80.0
9	12.1-13.5	20.1-22.5	40.1-45.0	60.1-67.5	80.1-90.0
10	13.6-15.0	22.6-25.0	45.1-50.0	67.6-75.0	90.1-100.0
11	15.1-16.5	25.1-27.5	50.1-55.0	75.1-82.5	100.1-110.0
12	16.6-18.0	27.6-30.0	55.1-60.0	82.6-90.0	110.1-120.0
13	18.1-19.5	30.1-32.5	60.1-65.0	90.1-97.5	120.1-130.0
14	19.6-21.0	32.6-35.0	65.1-70.0	97.6-105.0	130.1-140.0
15	21.1-22.5	35.1-37.5	70.1-75.0	105.1-112.5	140.1-150.0
16	22.6 or more	37.6 or more	75.1 or more	112.6 or more	150.1 or more

TABLE 9. MEANS AND VARIATIONS IN EAL'S PER AXLE

Vehicle Type	Axle Type	Mean	Standard Deviation	Coefficient of Variation (Percent)
Single-Unit Truck, 2 Axles, 6 Tires	Steering (Type 1)	0.061	0.076	125
	Other Single (Type 2)	0.234	0.797	340
Single-Trailer Truck, 4 Axles	Steering (Type 1)	0.208	0.111	53
	Other Single (Type 2)	0.324	0.587	181
	Tandem (Type 3)	0.049	0.122	247
Single-Trailer Truck, 5 Axles	Steering (Type 1)	0.248	0.097	39
	Tandem (Type 3)	0.158	0.183	116
All Types	Steering (Type 1)	0.270	0.224	83
	Other Single (Type 2)	0.240	0.449	187
	Tandem (Type 3)	0.158	0.200	127

TABLE 10. AXLELOAD DISTRIBUTIONS FOR BUSES

Steering Axles		Other Single Axles	
Load Interval (Kips)	Percentage in Interval	Load Interval (Kips)	Percentage in Interval
0.5-1.5	0.46	0.0-2.5	1.92
1.6-3.0	3.44	2.6-5.0	11.81
3.1-4.5	7.96	5.1-7.5	19.20
4.6-6.0	14.03	7.6-10.0	14.92
6.1-7.5	13.52	10.1-12.5	10.92
7.6-9.0	17.06	12.6-15.0	16.15
9.1-10.5	18.59	15.1-17.5	16.79
10.6-12.0	18.07	17.6-20.0	7.62
12.1-13.5	4.01	20.1-22.5	0.54
13.6-15.0	1.73	22.6-25.0	0.11
15.1-16.5	0.43	25.1-27.5	0.02
16.6-18.0	0.12	27.6-30.0	-
18.1-19.5	0.44	30.1-32.5	-
19.6-21.0	0.14	32.6-35.0	-

TABLE 11. YEAR-TO-YEAR VARIATION IN TRAFFIC PARAMETERS (US127 IN MERCER COUNTY)

Year	AADT	Percent of Trucks	Percent of Coal Trucks	Axles / Non-Coal Truck	Axles / Coal Truck	EAL's / Non-Coal Axle	EAL's / Coal Axle	Annual EAL's (1000's)
1984								
1983	8,135	10.7	3.2	3.38	4.35	0.141	1.435	226
1982	7,779	9.0	0.0	3.42	-	0.143	-	138
1981	8,133	11.4	0.0	3.49	-	0.155	-	196
1980	8,133	10.6	0.8	3.30	4.33	0.154	1.663	188
1979	8,133	9.8	0.0	3.48	-	0.138	-	152
1978	9,460	9.9	0.0	3.48	-	0.137	-	178
1977	7,717	10.5	0.0	3.39	-	0.142	-	155
1976	7,589	10.3	0.0	3.32	-	0.145	-	150
1975								
1974								
1973								
1972								
1971	5,525	14.6	0.0	3.24	-	0.128	-	131
1970	4,689	16.5	0.0	3.40	-	0.125	-	128
1969	4,864	15.5	0.0	3.35	-	0.146	-	142

TABLE 12. YEAR-TO-YEAR VARIATION IN AVERAGE EQUIVALENT AXLELOADS (LOW-VOLUME, FEDERAL-AID PRIMARY ROADS IN NORTH CENTRAL KENTUCKY)

Year	Average Annual Number of EAL's (1000's)	Standard Deviation of EAL's (1000's)	Number of Stations
1984	-	-	-
1983	44	28	9
1982	58	59	7
1981	50	19	5
1980	26	-	1
1979	58	15	5
1978	40	30	20
1977	46	32	4
1976	53	42	7
1975	55	33	11
1974	-	-	-
1973	19	4	3
1972	-	-	-
1971	36	19	7
1970	54	41	14
1969	-	-	-

TABLE 13. COMPARISON OF CHANGES IN EAL ESTIMATES WITH CHANGES IN FLEXIBLE PAVEMENT THICKNESS[a]

EAL'S In Design Lane	Design Pavement Thickness (Inches)	Percent Change In EAL Estimate	Design Pavement Thickness (Inches)	Change in Pavement Thickness (Inches)	Change in Pavement Thickness (Percent)
10,000	9.6	+50	10.8	+1.2	+12.5
100,000	15.3	+50	16.3	+1.0	+6.5
1,000,000	20.5	+50	21.5	+1.0	+4.9
10,000	9.6	-50	8.7	-0.9	-9.4
100,000	15.3	-50	14.4	-0.9	-5.9
1,000,000	20.5	-50	19.5	-0.9	-4.4

[a]Pavement thickness based on Kentucky design curves for pavements with 33 percent asphaltic concrete and a CBR of 5 (Reference 7).

TABLE 14. LANE DISTRIBUTION RECOMMENDATIONS OF THE ASPHALT INSTITUTE

Number of Lanes (Two Directions)	Percentage of Trucks in Design Lane
2	50
4	45 (35-48)[a]
6 or More	40 (25-48)[a]

[a]Probable range.

TABLE 15. STATE LANE DISTRIBUTION PRACTICES[a]

State	Highway Type: Total Number of Lanes	Highway Type: Other	Percentage of Unidirectional EAL's (or Trucks) in Design Lane
Alabama	4	Rural	95
	4	Urban	85
	6		70
Arizona	4		100
	6		80
	8		60
California[b]	4	Divided	100
	More than 4	Divided	80
Delaware	4		90
	6		80
Georgia[c]	4	Rural, Freeway	85-100
	4	Rural, Free Access	70-100
	4	Urban, Freeway	60-80
	4	Urban, Free Access	60-80
	6	Rural, Freeway	70
	6	Urban, Freeway	60
Illinois	4		90
	6 or More	Rural	80
	6 or More	Urban	74
Indiana	4		90
	6		80
Louisiana	All		100
Massachusetts	4	Divided	90
	6 or More	Divided	80
Montana	Multilane	< 4,000 (Future ADT)	100
		4,000-8,000	95
		8,000-12,000	90
		12,000-20,000	85
Nebraska[d]	4		80
	6		70
Nevada	All		100
New Hampshire	Multilane		70-80

TABLE 15. (Continued)

State	Highway Type: Total Number of Lanes	Highway Type: Other	Percentage of Unidirectional EAL's (or Trucks) in Design Lane
New Jersey	All		100
North Carolina[e]	Multilane		80
Pennsylvania	4		90
	6 or More		80
Rhode Island	4		90
	6 or More		80
South Carolina	4		75-90
	6		60-75
Tennessee	Multilane	< 5,000 (ADT)	95
		5,000-10,000	90
		10,000-15,000	85
		15,000-20,000	80
		20,000-30,000	75
		30,000-40,000	70
		40,000 or More	60
Texas	4		80-100
	6 or More		60-80
Utah	4	Rural Interstate	100
	4	Other	80
	6 or More		70
Virginia	Multilane		80
Washington	4		85
	6		75
	8		65

[a]Five states excluded from this tabulation include Florida, Maryland, and Ohio which use the AASHTO factors, Hawaii which uses the California factors, and Michigan which uses Taragin (11).

[b]Lane use by trucks in California may differ from that in other states because of state laws restricting trucks to outside lanes except for passing.

[c]Tabulated factors apply only to truck traffic. Georgia procedure utilizes a different set of factors for vehicles other than trucks.

[d]Tabulated factors apply only to heavy commercial truck traffic. For light vehicle traffic, a 50-percent factor is used for both four- and six-lane highways.

[e]Results of Alexander and Graves (12) are used for special cases such as urban, high-volume facilities.

TABLE 16. STANDARD DISTRIBUTION OF HOURLY VOLUMES

Ratio of Hourly Volume to AADT	Hours in Year
0.145	12
0.135	12
0.125	12
0.115	12
0.105	72
0.0936	380
0.0832	500
0.0763	500
0.0713	500
0.0666	500
0.0616	500
0.0562	500
0.0500	500
0.0424	500
0.0343	500
0.0269	500
0.0205	500
0.0152	500
0.0109	500
0.0076	500
0.0054	500
0.0040	500
0.0016	260

TABLE 17. COMPARISON OF VOLUME-BASED LANE DISTRIBUTION FACTORS[a]

Four-Lane Roadways

Two-Way AADT	Alexander & Graves (12)	Montana	PCA[b]	Tennessee	Eq. 13 (FT = 0.15)
5,000	95	95	92	90-95	97
10,000	94	90	86	85-90	95
15,000	93	85	83	80-85	93
20,000	92	85	81	75-80	91
25,000	91	-	79	75	89
30,000	90	-	77	70-75	87
35,000	89	-	76	70	85
40,000	88	-	75	60-70	83

Six-Lane Roadways

Two-Way AADT	Alexander & Graves (12)	Montana	PCA[b]	Tennessee	Eq. 14 (FT = 0.15)
10,000	78	90	74	85-90	80
20,000	76	85	68	75-80	75
30,000	74	-	65	70-75	70
40,000	72	-	63	60-70	65
50,000	70	-	61	-	60
60,000	68	-	59	-	55
70,000	66	-	58	-	49
80,000	64	-	57	-	44

[a]For comparative purposes, these factors are expressed as a percentage of the undirectional volumes in the design lane.

[b]The PCA has adopted factors developed at the University of Illinois (10).

TABLE 18. AVERAGE ANNUAL BIDIRECTIONAL EAL'S (1000'S) ON NON-COAL-HAUL ROADS IN 1984

Volume	Federal Aid Class	Area			
		West	South-Central	North-Central	East
Low	Interstate	-	-	-	-
	Primary	74	55	48	44
	Urban	12	18	16	10
	Secondary	35	29	30	20
	Non-FA	8	8	8	14
High	Interstate	739	1713	1654	839
	Primary	151	137	129	155
	Urban	54	76	107	37
	Secondary	-	-	150	-
	Non-FA	57	109	42	11

TABLE 19. AVERAGE ANNUAL BIDIRECTIONAL EAL'S (1000'S) ON COAL-HAUL ROADS IN 1984

Volume	Level of Coal Haulage		
	Low	Intermediate	High
Low	37	87	477
High	454	478	902

TABLE 20. SUMMARY OF EAL ESTIMATES

Station/ County	Annual Number of Equivalent Axleloads (1000's)				
		Estimated			
	Actual	Cross Tabulation Matrix	Base-Year Volume	Midyear Volume	Base-Year Volume and % Trucks
Coal-Haul Roads					
P40/68	70	128	128	119	118
L50/96	108	128	148	138	90
P09/24	113	73	91	83	164
P13/22	114	608	503	456	295
P11/35	146	128	169	216	226
P43/36	158	608	683	603	344
P41/32	179	608	534	500	361
P05/102	202	608	665	609	456
P07/47	206	650	809	900	243
L53/74	264	128	206	228	288
P32/100	371	128	195	193	355
P18/48	422	895	400	417	309
L58/103	460	650	246	253	407
P37/16	574	607	515	462	1162
P31/7	753	895	318	334	496
P15/113	783	608	1022	881	1759
P12/98	852	1720	1762	1997	927
OU8/30	1019	1720	2181	2694	1390
P42/10	1482	1720	1067	998	1312
L57/63	1511	650	655	837	1118
L56/105	1646	650	814	994	1117
Non-Coal-Haul Roads					
P19/106	8	12	7	7	9
P30/33	13	19	17	18	14
P36/92	16	24	14	15	18
P28/112	18	20	11	11	7
P16/41	27	20	28	33	26
P29/83	28	72	50	47	32
P34/1	33	54	39	41	65
P08/43	35	16	23	23	34
P10/42	47	87	70	64	60
P01/37	60	20	42	42	72
P45/114	62	20	94	101	57
P24/78	64	72	82	84	55
P38/71	66	59	40	41	52
P39/79	84	46	32	29	107
P84/56	98	96	100	120	87

TABLE 20. (Continued)

Station/ County	Annual Number of Equivalent Axleloads (1000's)				
	Actual	Estimated			
		Cross Tabulation Matrix	Base-Year Volume	Midyear Volume	Base-Year Volume and % Trucks
P35/46	101	88	82	91	89
P26/9	120	173	72	73	107
L46/38	132	87	122	119	177
P49/59	145	96	138	169	119
P25/84	178	174	114	118	134
P21/56	208	174	303	293	181
OU2/56	289	96	77	110	154
L55/106	900	1300	858	726	1053
L59/52	1131	1300	564	551	1040
257/118	1323	747	1031	1042	1192
L54/47	1415	1503	1703	1710	1835
P23/41	1543	1311	1229	1257	1530

TABLE 21. ACCURACY OF DESIGN ESTIMATES

Road Type	Methodology	Error (Percent)	
		Mean	Standard Deviation
Coal Haul	Cross-Tabulation	73	130
	Base-Year Volume	68	130
	Midyear Volume	68	124
	Base-Year Volume and % Trucks	38	60
Non-Coal Haul	Cross-Tabulation	3	52
	Base-Year Volume	-7	36
	Midyear Volume	4	36
	Base-Year Volume and % Trucks	1	28

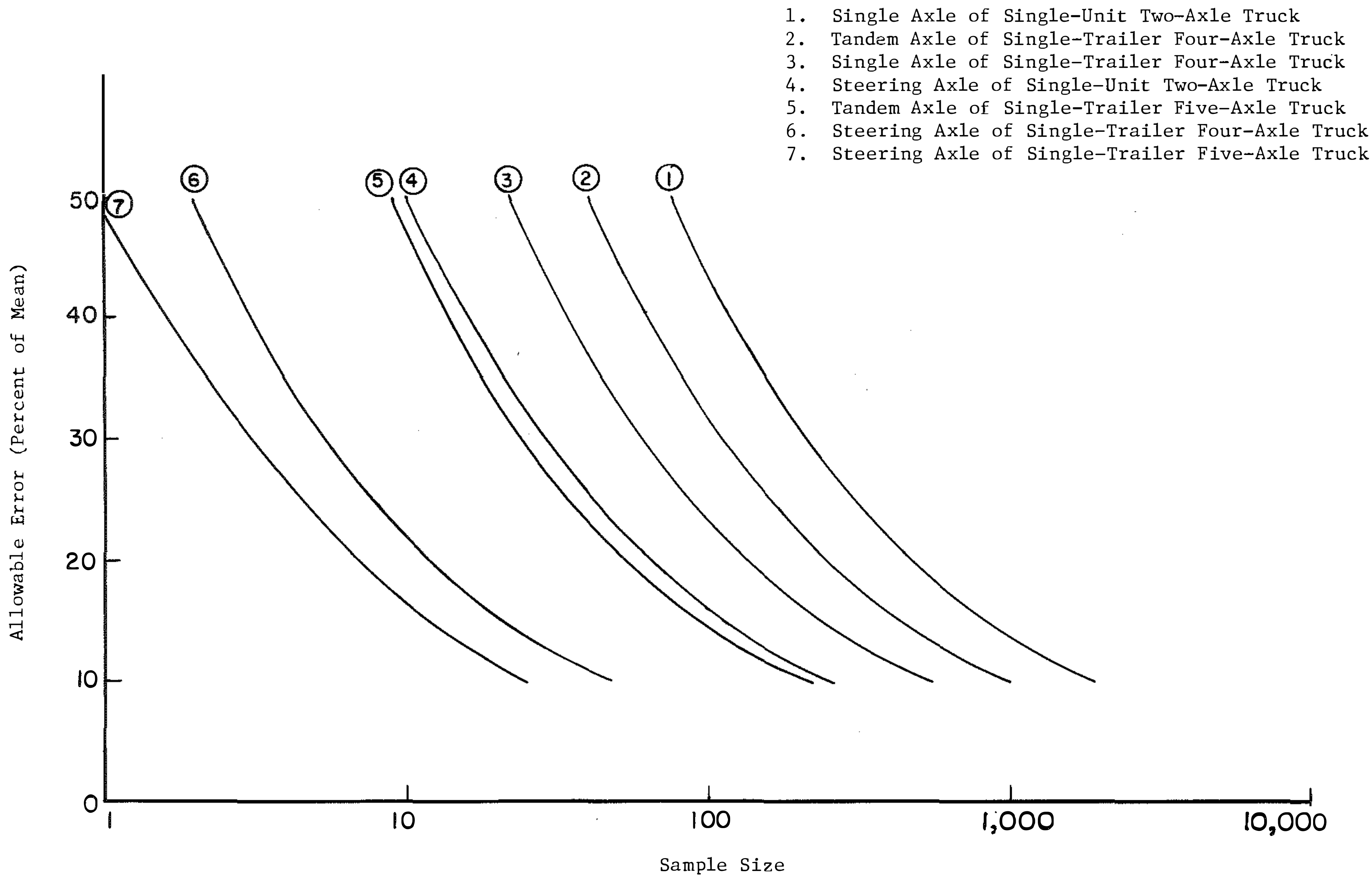

Figure 1. Required Sample Size for 20-Percent Risk

ESTIMATION OF EQUIVALENT AXLELOAD ACCUMULATIONS

COUNTY ______________________ DATE ______________________

NAME ______________________

ROUTE ID:

Road Name ______________________ Route No __________

Project No ______________________

Project Limits ______________________

____

Ref Stations ______________________

Federal Aid	Volume (Midyear)	Area	Coal Haul (Midyear) (Percent Trucks Hauling Coal)
____ Interstate	____ Less Than 5000	____ West	____ Less Than 1.00
____ FAP	____ 5000 or More	____ South Central	____ 1 - 4.99
____ FAU		____ North Central	____ 5 - 19.99
____ FAS		____ East	____ 20 or more
____ Non FA			

DATES:

Base Year ________ Design Period (Years) ________ Project Midyear ________

TRAFFIC PARAMETERS:

	Unadjusted Base Year Estimate		Site-Specific Adjustment		Adjusted Base Year Estimate		Increment		Project Midyear Estimate
Volume (AADT)	____	x	____	=	____	+	____	=	____
Percent Trucks (%T)	____	x	____	=	____	+	____	=	____
Percent Trucks Hauling Coal (%CT)	____	x	____	=	____	+	____	=	____
Non-Coal Trucks									
Axles/Truck (A/NCT)	____	x	____	=	____	+	____	=	____
EAL's/Axle (EAL/NCA)	____	x	____	=	____	+	____	=	____
Coal Trucks									
Axles/Truck (A/CT)	____	x	____	=	____	+	____	=	____
EAL's/Axle (EAL/CA)	____	x	____	=	____	+	____	=	____

DAILY EAL'S AT MIDYEAR:

4-Tired Vehicles

____ (AADT) x ____ (1-(%T/100)) x 0.005 = ____________

Non-Coal Trucks

____ (AADT) x ____ ((%T/100)(1-%CT/100)) x ____ (A/NCT) x ____ (EAL/NCA) = ____________

Coal Trucks

____ (AADT) x ____ ((%T/100)(%CT/100)) x ____ (A/CT) x ____ (EAL/CA) = ____________

Total Midyear Daily EAL's = ____________

DESIGN EAL'S:

____ (Midyear Daily EAL's (No. of Lanes ____)) x 365 x ____ (Design Period) x ____ (Lane Adjustment (1 or 2 Way ____)) = ____ (Design EAL's in Critical Lane)

Figure 2. Worksheet for Calculating Design EAL's

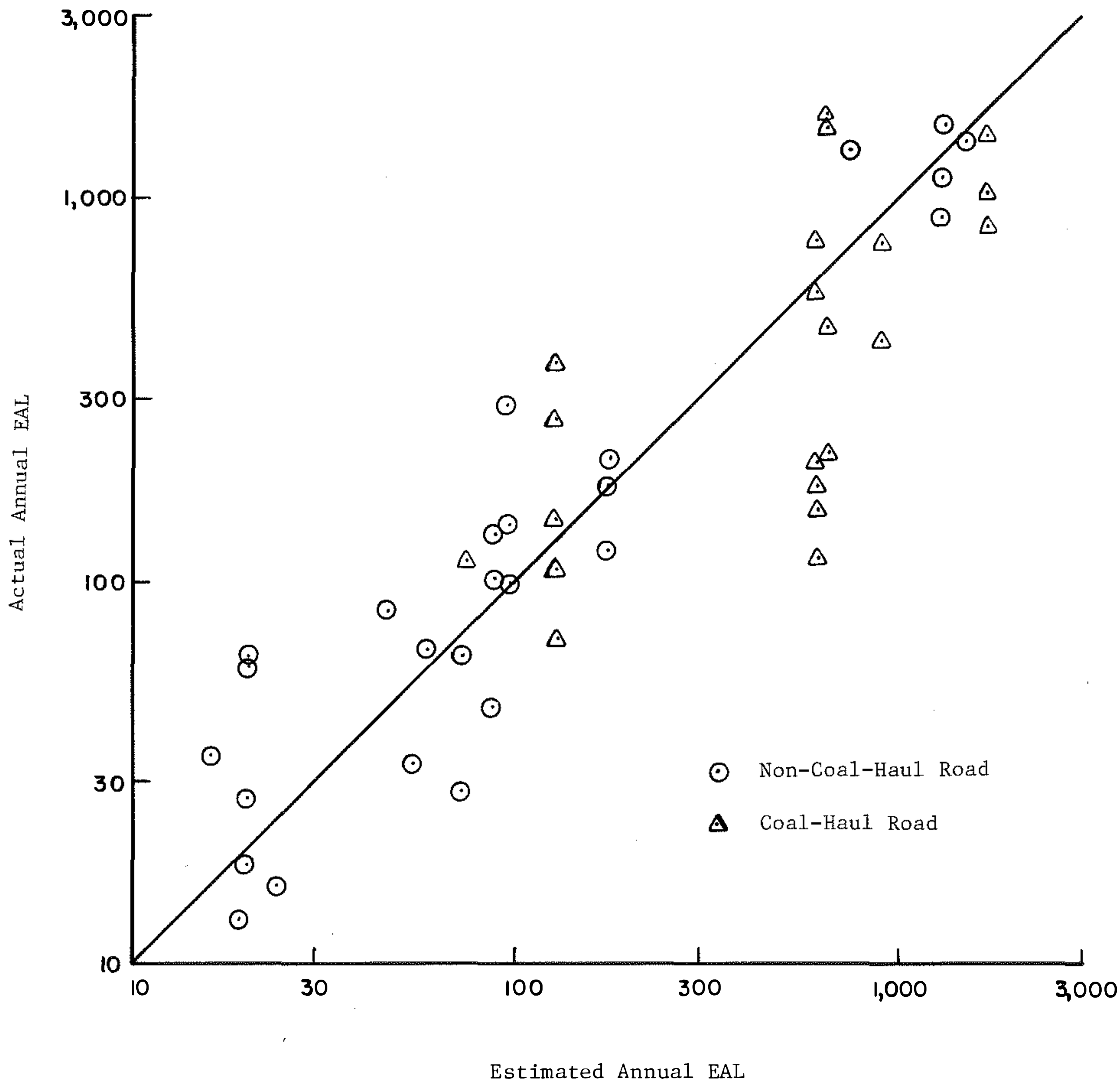

Figure 3. Comparison of Cross-Tabulation EAL Estimates with Actual EAL's

APPENDIX A

EVALUATION OF PAST EWL DESIGN ESTIMATES

One of the original tasks of this study was to evaluate the accuracy of past EWL design estimates. As originally planned, this task was to have involved comparisons of former EWL estimates, made for purposes of pavement design, with the subsequent accumulation of EWL's in service.

However, because the procedure for estimating design EWL's has changed through the years, the utility of such comparisons was soon questionned. Evaluating the accuracy of procedures no longer in use was seen to be of limited or no value. More importantly, the difficulty--if not the impossibility--of obtaining accurate estimates of historical EWL accumulations on roadways for which design estimates had been made soon became clear. It was decided, therefore, to compare some hypothetical design estimates using the 1959 design procedure (Appendix B) with actual EWL accumulations on a selected set of roadways for which reasonably accurate estimates could be made of historical patterns.

Because calculations were performed by hand, only a limited number of locations could be investigated. In selecting these locations, the following criteria were used: 1) a variety of roadway types must be investigated, 2) the roadways must have been open to traffic for the better part of a 20-year period encompassing the calendar years of 1963-1982, and 3) on-site vehicle weight and classification data had to be available to support reasonably accurate estimates of actual EWL accumulations. Ultimately, seven locations were selected for evaluation (Table A-1).

As detailed in Appendix B, traffic parameters used in the 1959 design procedure included the following:

1) percentage of trucks (in base year),

2) average number of axles per truck (in base year),

3) AADT (average during 20-year design life), and

4) axleload distribution (weighted average during base period).

In actual practice, selection of appropriate values for these design parameters requires an extensive knowledge of prevailing traffic characteristics--and application of considerable engineering judgment. Because designs for this comparison were to be made in retrospect, it was impossible to duplicate decisions that would have been made by the designer, operating as always with incomplete information. It was decided, therefore, to use the best of <u>currently</u> available information to make the design estimates, thereby eliminating effects of incomplete information and the effects of judgmental inaccuracies as well.

Percentage of trucks and average number of axles per truck were calculated for each site using data from the first year in which vehicle classification data were available, normally 1963 or 1964. The actual arithmetic-average AADT during the 20-year period was used to represent the volume parameter. Basic axleload distributions were taken as the composite from all main rural stations for the years of 1960, 1961, and 1962. For application to a given location, these were weighted by the fractions of the individual vehicle types that were observed during the 1963 or 1964 classification counts at the location in question. In each case, calculations were performed using the 1959 worksheet (2). Conventional damage factors were used with a maximum factor of 128 being applied for all single axleloads in excess of 11.5 tons.

Determination of the actual accumulation of EWL's was a tedious process in which each location was analyzed on a year-by-year basis. The 20-year accumulation represented a simple summation of the individual-year estimates. In analyzing each location, only data that had been collected at that location were used. Thus, no statewide average data were used in estimating actual accumulations of EWL's.

The contribution of each vehicle type to the total EWL accumulation was estimated. The number of vehicles of each type was estimated from available classification counts. With exception of Station U2 for which only summer counts were available, the numbers used to represent annual conditions were averages of the available seasonal counts. Axleload distributions taken at the site in question were used in the EWL calculations. If sufficient numbers of specific vehicle types had not been weighed to establish reliable distributions, best estimates were made. These usually involved examining data from other years at the location in question or from other similar locations for which larger numbers of vehicles had been weighed. More extensive extrapolations were necessary for the lower volume locations than for those with greater traffic density. With the exception of buses for which the damage was expressed as 5 EWL's per bus passage, the conventional damage factors were used.

Results of the computations, presented in Table A-2, show differences between design and actual EWL's ranging from an underestimate of 59 percent to an overestimate of 47 percent. For each of these two extremes, the difference in pavement thickness for a relatively weak subgrade (a CBR of 5) is about 1.5 inches. No general pattern is evident that indicates any particular bias in the estimate: nor is there any apparent effect of volume level or percentage of trucks.

If consideration of design accuracy were limited to the above analysis, it is doubtful that the 1959 Kentucky procedure would be judged to be seriously deficient. The degree of underdesign or overdesign is not considered to be excessive, and there is no consistent tendency for either. Furthermore, it is clear that the large variability within sampled classification and weight data is partly responsible for the disparity between the historical accumulations and design estimates.

Of additional significance, however, is the fact that the design estimates made herein are much more accurate than could be expected in more realistic design situations. Essentially they are based on "perfect," after-the-fact knowledge. Much larger variations between real design estimates and actual accumulations can be anticipated. For this reason, no conclusive demonstration of the adequacy of past design estimates can be developed using analyses similar to that employed herein.

TABLE A-1. SITES USED FOR EWL EVALUATION

Loadometer Station Number	Route	County
46	US 51	Fulton
50	US 27	Pendleton
53	US 27	McCreary
54	I 65	Hardin
55	I 64	Shelby
56	I 75	Scott
U2	Crittenden Drive	Jefferson

TABLE A-2. ACCURACY OF EWL DESIGN ESTIMATES

Station	AADT (vpd)	Percent Trucks	20-Year Design EWL's	20-Year Actual EWL's	Difference (% of Actual)
46	3,100	24.6 (1963)	63,000,000	82,000,000	-23
50	2,400	14.8 (1963)	22,000,000	15,000,000	47
53	3,200	23.8 (1963)	57,000,000	60,000,000	- 5
54	15,300	26.0 (1963)	337,000,000	379,000,000	-11
55	12,500	22.5 (1964)	233,000,000	187,000,000	24
56	18,300	19.5 (1964)	289,000,000	418,000,000	-31
U2	15,300	12.1 (1963)	59,000,000	144,000,000	-59

APPENDIX B

ESTIMATION OF EWL'S (1959 DESIGN PROCEDURE)

The 1959 methodology for the structural design of flexible pavements expressed the destructive effects of traffic in terms of the bidirectional number of equivalent 5,000-pound wheel loads expected during the design life (2). The procedure that has evolved for estimating these EWL accumulations is described as follows:

1) Estimate the bidirectional AADT for the first year of operation. Various adjustment factors used in the EWL estimate are based on this volume measure.

2) Estimate the average percentage of trucks. It is assumed that this percentage will not change significantly during the design life. The estimate is based on the most recent classification count at the design location or at a nearby location of similar characteristics. Considered to be trucks in this determination are buses and all types of trucks having six or more tires.

3) Estimate the initial average number of axles per truck. This is computed using the same classification count data as in Step 2: buses are included in the calculation. No adjustment is made to account for any changes that might occur between the date on which the data were collected and the date of the first year of operation. Because of the nature of the damage factors used in the 1959 Kentucky design, no distinction is made among the several types of truck axles.

4) Estimate the average bidirectional AADT for the 20-year design period.

5) Estimate the average daily bidirectional truck volume for the 20-year design period by dividing the product of the average AADT (Step 4) and the percentage of trucks (Step 2) by 100.

6) Adjust the initial average number of axles per truck (Step 3) to an average value for the 20-year design period by applying the additive factors of Table B-1. The adjustments of this table are based on an analysis of trend data and reflect increasing future utilization of truck types having larger numbers of axles.

7) Calculate the total number of truck axles anticipated during the 20-year design life using the average truck volume and the average number of axles per truck. This is the product of the average daily truck volume (Step 5), the adjusted average number of axles per truck (Step 6), 365, and 20.

8) Estimate the initial distribution of axleloads for truck axles. This is a weighted average of the axleload distributions for the different truck types. The individual distributions are statewide averages taken from all rural loadometer stations for the most recent three survey periods. The individual distributions are then weighted by the percentages of the various vehicle types determined from the same classification count data as in Step 2. No adjustment is made to account for any changes that might occur between the date of data collection and the date

of the first year of operation. Axles weighing less than 4 1/2 tons are ignored and those weighing more than 12 1/2 tons are added to the 11 1/2 to 12 1/2 ton category.

9) Estimate the average distribution of axleloads for the 20-year design period by applying additive corrections as given in Table B-2. These corrections are based on an analysis of trend data that indicates that average weights of truck axles have generally increased with time.

10) Calculate the total number of truck axles within each axleload interval during the design life using the total number of truck axles (Step 7) and the average distribution of axleloads (Step 9).

11) Compute the EWL's within each axleload category by multiplying the total number of axles in each category (Step 10) by the damage factors of Table B-3.

12) Sum the EWL's of Step 11 to obtain the final estimate of the total, bidirectional design EWL's.

TABLE B-1. CHANGE IN AVERAGE NUMBER OF AXLES PER TRUCK

Initial AADT (vpd)	Change in Average Number of Axles per Truck
0-399	0
400-999	0.04
1000-1999	0.08
2000-2999	0.14
3000 or more	0.19

TABLE B-2. CHANGE IN PERCENTAGE OF AXLES IN VARIOUS LOAD INTERVALS

Initial AADT (vpd)	Axleload Interval (Kips)							
	9-11	11-13	13-15	15-17	17-19	19-21	21-23	23-25
0-399	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
400-999	0.01	0.01	0.04	0.0	0.01	0.0	0.0	0.0
1000-1999	0.04	0.04	0.11	0.04	0.04	0.01	0.0	0.0
2000-2999	0.08	0.11	0.23	0.12	0.09	0.04	0.0	0.0
3000 or more	0.09	0.13	0.27	0.15	0.11	0.05	0.0	0.0

TABLE B-3. EWL DAMAGE FACTORS

Axleload Interval (kips)	EWL Factor
Less than 9	0
9-11	1
11-13	2
13-15	4
15-17	8
17-19	16
19-21	32
21-23	64
23 or more	128

APPENDIX C

DOCUMENTATION OF COMPUTER PROGRAM FOR LINEAR SMOOTHING OF TRAFFIC PARAMETERS

A. Overview

1. Objective of Program. SMOOTH was developed to "smooth" the traffic-parameter output from EALCAL, thereby filling in missing annual data and providing the design engineer with chronological trends.

2. Program Narrative. Annual, averaged, traffic parameters output from EALCAL and stored on tape are read. Up to fifteen consecutive years of data may be analyzed in one run of SMOOTH. For each set of parameters with values for four or more years in a ten-year period, a weighted, linear least squares fit is calculated. The weighting factor for each parameter is a product of the year number (with the most distant year being year one) and the number of stations involved in the annual average. Using the least square fit, annual mean values are calculated over the range of the data and, by extrapolation, for up to two years beyond the first and last years of available data. Due to the weighting procedures, estimates made using SMOOTH are expected to be best for the run year and progressively worse for previous years.

3. Programming Language. The programming language is FORTRAN IV.

4. Operating Environment. The object deck of the program is located as member SMOOTH in the OS disk load module library UKU.@KTR05.TRAF1. It is designed to be executed by the IBM 3081 at the University of Kentucky, Lexington, Kentucky.

B. Input (Logical Unit 15)

1. Internal Data and Parameter Specifications. No internal data or parameters are specified.

2. External Data. The external input data are located on tape 23195. This tape contains output from EALCAL consisting of mean values for each of the 46 cells for each traffic parameter stored by year in files MEAN.STDDEV.YR__. The codes for the 46 cells are shown in Table 3 and the format for this data is as described in the output format of the EALCAL program in Section IV.G.4 of Research Report UKTRP-84-30(6).

C. Output (Logical Unit 6)

1. Files. No files are produced.

2. Reports. One report will be produced consisting of two matrices for each traffic parameter, a 40-cell matrix for non-coal-haul roads and a six-cell matrix for coal-haul roads. Each cell lists the estimated value of the mean for the current year and for the 14 previous years taken from the linear least-squares fit as well as the annual change expressed as a percentage of the most recent data estimated. Missing values are indicated by asterisks. An example of the printout for the Annual Average Daily Traffic using 1984 and previous data is shown in Figure C-1. Similar printouts are produced for all other parameters (Appendix G). This report is a "smoothed" version of a report produced by EALCAL and

described in Section IV.C.2.c. of Research Report UKTRP-84-30(6).

D. Using the Program

1. Preliminaries.

a. Before executing SMOOTH, it is necessary to have executed EALCAL for the current year's data.

b. Job control language records must be prepared for the processing of each year's data. When processing data for 1984 or later, 15 consecutive years of data are used, including the current year. The DD record beginning with GO.FT15F001 must correspond to the most distant year, the DD record beginning with GO.FT15F002 corresponds to the following year, etc. Example JCL is shown in Figure C-2 and may be found in the OS disk library UKU.@KTR05.EAL.JCL as member SMOOTH.

2. Program Execution. The program, in object form, is stored in the OS disk load library UKU.@KTR05.TRAF1 as member SMOOTH. JCL must be prepared as indicated and submitted to run the program.

3. Interpretation of Output. The output report is self explanatory. EAL's are recorded in thousands and asterisks indicate that no estimate was made due to insufficient data.

E. Edit Checks. No edit checks are made.

F. Processing and Computations

1. From the EALCAL output summary tape, 23195, averaged means for the current year and the 14 previous years are read.

2. The 15 years of data (or the data available) are smoothed using a weighted, linear least-squares fit.

3. Annual mean values are taken from the least-squares fit curve and the report is printed.

4. The program source is stored in OS disk library UKU.@KTR05.EAL.SOURCE as member SMOOTH. The program listing is shown in Figure C-3.

ANNUAL AVERAGE DAILY TRAFFIC
NON-COAL-HAULING ROADS

LOCAL CONDITION FA	VOL	GA	ANNUAL CHANGE (%)	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	3979.	*******	*******	*******	*******	*******
1	1	2	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	3	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	2125.
1	1	4	0.000	*******	*******	*******	*******	*******	*******	*******	*******	4860.	*******	*******	*******	*******	3180.	4868.
1	2	1	1.887	8326.	8169.	8012.	7855.	7698.	7541.	7384.	7227.	7069.	6912.	6755.	*******	*******	*******	*******
1	2	2	2.282	21491.	21001.	20510.	20020.	19529.	19039.	18548.	18058.	17568.	17077.	16587.	16096.	15606.	15115.	14625.
1	2	3	4.743	40650.	38722.	36794.	34866.	32938.	31010.	29081.	27153.	25225.	23297.	21369.	19441.	17513.	15585.	13657.
1	2	4	0.644	12061.	11984.	11906.	11829.	11751.	11673.	11596.	11518.	11440.	11363.	11285.	11208.	11130.	11052.	10975.
1	AVERAGE		5.101	31287.	29691.	28095.	26499.	24903.	23307.	21711.	20115.	18519.	16923.	15327.	13731.	12135.	10538.	8942.
2	1	1	-0.892	2586.	2609.	2632.	2656.	2679.	2702.	2725.	2748.	2771.	2794.	2817.	2840.	2863.	2886.	2909.
2	1	2	-1.845	2377.	2420.	2464.	2508.	2552.	2596.	2640.	2684.	2727.	2771.	2815.	2859.	2903.	2947.	2990.
2	1	3	2.788	3584.	3484.	3384.	3284.	3184.	3084.	2984.	2884.	2785.	2685.	2585.	2485.	2385.	2285.	2185.
2	1	4	-1.300	2191.	2219.	2248.	2276.	2305.	2333.	2362.	2390.	2419.	2447.	2476.	2504.	2533.	2561.	2590.
2	2	1	-0.377	9618.	9654.	9691.	9727.	9763.	9799.	9836.	9872.	9908.	9945.	9981.	10017.	10054.	10090.	10126.
2	2	2	-0.492	9691.	9738.	9786.	9834.	9881.	9929.	9977.	10025.	10072.	10120.	10168.	10215.	10263.	10311.	10358.
2	2	3	-0.139	13839.	13858.	13878.	13897.	13916.	13936.	13955.	13974.	13993.	14013.	14032.	14051.	14070.	14090.	14109.
2	2	4	-1.651	8147.	8281.	8416.	8550.	8685.	8819.	8954.	9089.	9223.	9358.	9492.	9627.	9761.	9896.	10030.
2	AVERAGE		2.618	7131.	6944.	6757.	6571.	6384.	6197.	6011.	5824.	5637.	5451.	5264.	5077.	4891.	4704.	4518.
3	1	1	-6.382	1670.	1776.	1883.	1989.	2096.	2202.	2309.	2416.	2522.	2629.	2735.	2842.	2948.	3055.	3161.
3	1	2	-4.328	2045.	2133.	2222.	2310.	2399.	2487.	2576.	2664.	2753.	2841.	2930.	3018.	3107.	3195.	3284.
3	1	3	0.875	2268.	2248.	2228.	2208.	2188.	2168.	2149.	2129.	2109.	2089.	2069.	2049.	2030.	2010.	1990.
3	1	4	1.347	2109.	2080.	2052.	2023.	1995.	1967.	1938.	1910.	1881.	1853.	1825.	1796.	1768.	1739.	1711.
3	2	1	-4.351	8014.	8362.	8711.	9060.	9408.	9757.	10106.	10454.	10803.	11152.	11501.	11849.	12198.	12547.	12895.
3	2	2	1.637	9712.	9553.	9394.	9235.	9076.	8918.	8759.	8600.	8441.	8282.	8123.	7964.	7805.	7646.	7487.
3	2	3	-1.901	11224.	11437.	11651.	11864.	12077.	12291.	12504.	12718.	12931.	13144.	13358.	13571.	13785.	13998.	14211.
3	2	4	0.516	7666.	7626.	7587.	7547.	7508.	7468.	7428.	7389.	7349.	7310.	7270.	7231.	7191.	7151.	7112.
3	AVERAGE		-6.211	4507.	4787.	5067.	5347.	5627.	5907.	6187.	6467.	6747.	7027.	7307.	7587.	7867.	8147.	8427.
4	1	1	2.743	1980.	1926.	1872.	1817.	1763.	1709.	1655.	1600.	1546.	1492.	1437.	1383.	1329.	1274.	1220.
4	1	2	3.000	1923.	1866.	1808.	1750.	1693.	1635.	1577.	1520.	1462.	1404.	1346.	1289.	1231.	1173.	1116.
4	1	3	3.063	2434.	2360.	2285.	2211.	2136.	2061.	1987.	1912.	1838.	1763.	1689.	1614.	1540.	1465.	1390.
4	1	4	-3.159	1114.	1149.	1185.	1220.	1255.	1290.	1325.	1361.	1396.	1431.	1466.	1501.	1537.	1572.	1607.
4	2	1	-1.988	*******	5940.	6059.	6177.	6295.	6413.	6531.	6649.	6767.	6885.	7003.	7122.	7240.	7358.	7476.
4	2	2	-0.874	*******	6362.	6418.	6474.	6529.	6585.	6640.	6696.	6752.	6807.	6863.	6918.	6974.	7030.	7085.
4	2	3	1.832	7561.	7422.	7284.	7145.	7007.	6868.	6730.	6591.	6453.	6314.	6176.	6037.	5899.	5760.	5622.
4	2	4	0.262	*******	*******	*******	7277.	7257.	7238.	7219.	7200.	7181.	7162.	7143.	7124.	7105.	7086.	7067.
4	AVERAGE		2.041	2284.	2237.	2191.	2144.	2098.	2051.	2004.	1958.	1911.	1864.	1818.	1771.	1725.	1678.	1631.
5	1	1	-7.821	532.	574.	615.	657.	699.	740.	782.	823.	865.	907.	948.	990.	1031.	1073.	1115.
5	1	2	-0.472	715.	719.	722.	726.	729.	732.	736.	739.	742.	746.	749.	753.	756.	759.	763.
5	1	3	-0.564	830.	835.	840.	844.	849.	854.	858.	863.	868.	872.	877.	882.	886.	891.	896.
5	1	4	-0.016	1038.	1038.	1038.	1038.	1039.	1039.	1039.	1039.	1039.	1039.	1040.	1040.	1040.	1040.	1040.
5	2	1	0.000	*******	*******	*******	*******	*******	*******	5471.	*******	*******	*******	*******	*******	13289.	*******	*******
5	2	2	-6.544	5312.	5660.	6007.	6355.	6703.	7050.	7398.	7746.	8093.	8441.	8788.	9136.	9484.	9831.	10179.
5	2	3	-6.978	5849.	6257.	6665.	7074.	7482.	7890.	8298.	8706.	9114.	9523.	9931.	10339.	10747.	11155.	11563.
5	2	4	-0.744	7922.	7980.	8039.	8098.	8157.	8216.	8275.	8334.	8393.	8452.	8511.	8570.	8629.	8688.	8747.
5	AVERAGE		-5.332	947.	998.	1048.	1099.	1149.	1200.	1250.	1301.	1351.	1402.	1452.	1503.	1553.	1604.	1654.

COAL-HAULING ROADS

LOCAL CONDITION VOL	CT	ANNUAL CHANGE (%)	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	-2.903	1937.	1993.	2049.	2105.	2162.	2218.	2274.	*******	*******	*******	*******	*******	*******	*******	*******
1	2	-1.761	2216.	2255.	2294.	2334.	2373.	2412.	2451.	*******	*******	*******	*******	*******	*******	*******	*******
1	3	2.726	2473.	2405.	2338.	2270.	2203.	2136.	2068.	*******	*******	*******	*******	*******	*******	*******	*******
2	1	-5.273	12304.	12953.	13602.	14251.	14900.	15548.	16197.	*******	*******	*******	*******	*******	*******	*******	*******
2	2	-9.250	10493.	11464.	12434.	13405.	14376.	15346.	16317.	*******	*******	*******	*******	*******	*******	*******	*******
2	3	-2.154	8844.	9034.	9225.	9415.	9606.	9796.	9987.	*******	*******	*******	*******	*******	*******	*******	*******

Figure C-1 Output for Smooth Program

```
/*CLASS  A
//SMOOTH JOB (5035-51219),'TR',REGION=400K
..INCLUDE 51219 PASSWORD
/*JOBPARM  P=R,T=(0,25),L=4,LINECT=66
/*SETUP  TAPE=(23195)
//SMOOTH EXEC PGM=SMOOTH
//STEPLIB  DD DSN=UKU.@KTR05.TRAF1,DISP=SHR
//FT06F001 DD SYSOUT=A
//FT07F001 DD SYSOUT=B
//GO.FT15F001  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(2,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR70
//GO.FT15F002  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(3,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR71
//GO.FT15F003  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(4,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR72
//GO.FT15F004  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(5,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR73
//GO.FT15F005  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(6,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR74
//GO.FT15F006  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(7,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR75
//GO.FT15F007  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(8,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR76
//GO.FT15F008  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(9,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR77
//GO.FT15F009  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(10,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR78
//GO.FT15F010  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(11,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR79
//GO.FT15F011  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(12,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR80
//GO.FT15F012  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(13,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR81
//GO.FT15F013  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(14,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR82
//GO.FT15F014  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(15,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR83
//GO.FT15F015  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(16,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR84
/*
```

Figure C-2. Example of JCL for SMOOTH

```
C$JOB           ,T=(0,15),L=66
      REAL AADT(11,6,2,4,20),OUT(20),CNTS(11,6,2,4,20),MINVAL
      INTEGER YR,CH,FA,VOL,GA,CT,MINYR,MAXYR,YRS,LO,HI,YEAR,YRHD(20)
      MINYR = 1000
      YRS = 15
 100  DO 200 YR = 1,YRS
         DO 170 CH = 1,11
            DO 150 I = 1,40
               READ(15,5000) YEAR,FA,VOL,GA,CNT,ADT
               AADT(CH,FA,VOL,GA,YR) = ADT
               CNTS(CH,FA,VOL,GA,YR) = CNT
 150        CONTINUE
            DO 170 I = 1,6
               READ(15,5010) VOL,CT,CNT,ADT
               AADT(CH,6,VOL,CT,YR) = ADT
               CNTS(CH,6,VOL,CT,YR) = CNT
 170     CONTINUE
         IF (YEAR.LT.MINYR) MINYR = YEAR
         YRHD(YRS-YR+1) = YEAR
         READ(15,5000,END=200)
 200  CONTINUE
      MAXYR = MINYR + 14
      DO 800 CH = 1,11
      MINVAL=0.
      IF (CH.EQ.4.OR.CH.EQ.5) MINVAL = 2.
      IF (CH.EQ. 1) WRITE(6,7000)
 7000 FORMAT('1',T44,'       ANNUAL AVERAGE DAILY TRAFFIC    ')
      IF (CH.EQ. 2) WRITE(6,7100)
 7100 FORMAT('1',T44,'              PERCENT TRUCKS           ')
      IF (CH.EQ. 3) WRITE(6,7200)
 7200 FORMAT('1',T44,'        PERCENT TRUCKS HAULING COAL    ')
     IF (CH.EQ. 4) WRITE(6,7300)
 7300 FORMAT('1',T44,'    AXLES PER TRUCK (NON-COAL-HAULING)')
     IF (CH.EQ. 5) WRITE(6,7400)
 7400 FORMAT('1',T44,'        AXLES PER TRUCK (COAL-HAULING)  ')
     IF (CH.EQ. 6) WRITE(6,7500)
 7500 FORMAT('1',T44,'   EAL''S PER TRUCK AXLE (NON-COAL-HAULING) ')
     IF (CH.EQ. 7) WRITE(6,7600)
 7600 FORMAT('1',T44,'    EAL''S PER TRUCK AXLE (COAL-HAULING)    ')
     IF (CH.EQ. 8) WRITE(6,7700)
 7700 FORMAT('1',T36,'    2-DIRECTIONAL EAL''S IN 1000''S DUE TO ',
    * '4-TIRED VEHICLES ')
     IF (CH.EQ. 9) WRITE(6,7800)
 7800 FORMAT('1',T35,'2-DIRECTIONAL EAL''S IN 1000''S DUE TO NON-COAL',
    * '-HAULING VEHICLES')
     IF (CH.EQ.10) WRITE(6,7900)
 7900 FORMAT('1',T35,' 2-DIRECTIONAL EAL''S IN 1000''S DUE TO COAL-',
    * 'HAULING VEHICLES  ')
     IF (CH.EQ.11) WRITE(6,8000)
 8000 FORMAT('1',T44,'    TOTAL 2-DIRECTIONAL EAL''S IN 1000''S ')
     IF (CH.EQ.12) WRITE(6,8100)
 8100 FORMAT('1',T44,'             STATIONS PER CATEGORY ')
         WRITE(6,6010)
         WRITE(6,6020)
         WRITE(6,6030)
         WRITE(6,6040)  (YRHD(YR),YR=1,YRS)
         DO 400 FA = 1,5
             DO 300 VOL = 1,2
                DO 300 GA = 1,4
                   CO   = 0
```

Figure C-3. FORTRAN listing of SMOOTH

```
            SW    = 0.
            SWX   = 0.
            SWY   = 0.
            SWXX  = 0.
            SWXY  = 0.
            A     = 0.
            B     = 0.
            LO    = 20
            HI    = 1
            DO 250 YR = 1,YRS
               WT = CNTS(CH,FA,VOL,GA,YR) * YR
               Y  = AADT(CH,FA,VOL,GA,YR)
               OUT(YR) = Y
               IF (OUT(YR).EQ.0.AND.WT.EQ.0) OUT(YR) = 1111111
               IF (WT.EQ.0.) GOTO 250
                  IF (YR.LT.LO) LO = YR
                  IF (YR.GT.HI) HI = YR
                  CO    = CO + 1
                  SW    = SW + WT
                  SWX   = SWX + WT * YR
                  SWY   = SWY + WT * Y
                  SWXX  = SWXX + WT * YR * YR
                  SWXY  = SWXY + WT * YR * Y
250         CONTINUE
            IF (CO.LT.4) GOTO 290
               B=(SWXY-(SWX*SWY)/SW)/(SWXX-(SWX*SWX)/SW)
               A=(SWY-B*SWX)/SW
               DO 260 YR = 1,YRS
                  OUT(YR) = A + B * YR
                  IF (OUT(YR).LT.MINVAL) OUT(YR) = MINVAL
                  IF (YR.LT.LO-2) OUT(YR) = 1111111
                  IF (YR.GT.HI+2) OUT(YR) = 1111111
260            CONTINUE
               HI = YRS
290         IF (OUT(HI).EQ.1111111.AND.HI.GT.1) HI = HI - 1
            IF (OUT(HI).EQ.1111111.AND.HI.GT.1) GOTO 290
            IF (OUT(HI).NE.0) B = B * 100. / OUT(HI)
            IF (OUT(HI).EQ.1111111) B = 0
            IF (CH.EQ.1.OR.CH.GE.8)
     *      WRITE(6,6100) FA,VOL,GA,B,
     *                    (OUT(YRS-YR+1),YR=1,YRS)
            IF (CH.NE.1.AND.CH.LT.8)
     *      WRITE(6,6110) FA,VOL,GA,B,
     *                    (OUT(YRS-YR+1),YR=1,YRS)
300      CONTINUE
         CO    = 0
         SW    = 0.
         SWX   = 0.
         SWY   = 0.
         SWXX  = 0.
         SWXY  = 0.
         A     = 0.
         B     = 0.
         LO    = 20
         HI    = 1
         DO 350 VOL = 1,2
            DO 350 GA = 1,4
               DO 350 YR = 1,YRS
                  WT = CNTS(CH,FA,VOL,GA,YR) * YR
                  Y  = AADT(CH,FA,VOL,GA,YR)
                  OUT(YR) = Y
```

Figure C-3. (continued)

```
                 IF (OUT(YR).EQ.0.AND.WT.EQ.0) OUT(YR) = 1111111
                 IF (WT.EQ.0.) GOTO 350
                    IF (YR.LT.LO) LO = YR
                    IF (YR.GT.HI) HI = YR
                    CO   = CO + 1
                    SW   = SW + WT
                    SWX  = SWX + WT * YR
                    SWY  = SWY + WT * Y
                    SWXX = SWXX + WT * YR * YR
                    SWXY = SWXY + WT * YR * Y
350        CONTINUE
           IF (CO.LT.4) GOTO 370
           IF ((SWXX-(SWX*SWX)/SW).EQ.0) GOTO 370
              B=(SWXY-(SWX*SWY)/SW)/(SWXX-(SWX*SWX)/SW)
              A=(SWY-B*SWX)/SW
              DO 360 YR = 1,YRS
                 OUT(YR) = A + B * YR
                 IF (OUT(YR).LT.MINVAL) OUT(YR) = MINVAL
                 IF (YR.LT.LO-2) OUT(YR) = 1111111
                 IF (YR.GT.HI+2) OUT(YR) = 1111111
360           CONTINUE
              HI = YRS
           GOTO 390
370        DO 380 YR = 1 , YRS
              OUT(YR) = 1111111
380        CONTINUE
390        IF (OUT(HI).EQ.1111111.AND.HI.GT.1) HI = HI - 1
           IF (OUT(HI).EQ.1111111.AND.HI.GT.1) GOTO 390
           IF (OUT(HI).NE.0) B = B * 100. / OUT(HI)
           IF (OUT(HI).EQ.1111111) B = 0
           IF (CH.EQ.1.OR.CH.GE.8)
     *     WRITE(6,6200) FA,B,(OUT(YRS-YR+1),YR=1,YRS)
           IF (CH.NE.1.AND.CH.LT.8)
     *     WRITE(6,6210) FA,B,(OUT(YRS-YR+1),YR=1,YRS)
400     CONTINUE
500      WRITE(6,6015)
         WRITE(6,6020)
         WRITE(6,6030)
         WRITE(6,6050)  (YRHD(YR),YR=1,YRS)
         DO 600 VOL = 1,2
            DO 600 CT = 1,3
               CO   = 0
               SW   = 0.
               SWX  = 0.
               SWY  = 0.
               SWXX = 0.
               SWXY = 0.
               A    = 0.
               B    = 0.
               LO   = 20
               HI   = 1
               DO 550 YR = 1,YRS
                  WT = CNTS(CH,6,VOL,CT,YR) * YR
                  Y  = AADT(CH,6,VOL,CT,YR)
                  OUT(YR) = Y
                  IF (OUT(YR).EQ.0.AND.WT.EQ.0) OUT(YR) = 1111111
                  IF (WT.EQ.0.) GOTO 550
                     IF (YR.LT.LO) LO = YR
                     IF (YR.GT.HI) HI = YR
                     CO   = CO + 1
                     SW   = SW + WT
```

Figure C-3. (continued)

```
                    SWX  = SWX + WT * YR
                    SWY  = SWY + WT * Y
                    SWXX = SWXX + WT * YR * YR
                    SWXY = SWXY + WT * YR * Y
 550            CONTINUE
                IF (CO.LT.4) GOTO 590
                IF ((SWXX-(SWX*SWX)/SW).EQ.0) GOTO 590
                  B=(SWXY-(SWX*SWY)/SW)/(SWXX-(SWX*SWX)/SW)
                  A=(SWY-B*SWX)/SW
                  DO 560 YR = 1,YRS
                    OUT(YR) = A + B * YR
                    IF (OUT(YR).LT.MINVAL) OUT(YR) = MINVAL
                    IF (YR.LT.LO-2) OUT(YR) = 1111111
                    IF (YR.GT.HI+2) OUT(YR) = 1111111
 560              CONTINUE
                  HI = YRS
 590            IF (OUT(HI).EQ.1111111.AND.HI.GT.1) HI = HI - 1
                IF (OUT(HI).EQ.1111111.AND.HI.GT.1) GOTO 590
                IF (OUT(HI).NE.0) B = B * 100. / OUT(HI)
                IF (OUT(HI).EQ.1111111) B = 0
                IF (CH.EQ.1.OR.CH.GE.8)
     *          WRITE(6,6400) VOL,CT,B,
     *                   (OUT(YRS-YR+1),YR=1,YRS)
                IF (CH.NE.1.AND.CH.LT.8)
     *          WRITE(6,6410) VOL,CT,B,
     *                   (OUT(YRS-YR+1),YR=1,YRS)
 600        CONTINUE
 800    CONTINUE
        WRITE(6,6000)
5000    FORMAT(I2,1X,3I1,F4.0,F25.3)
5010    FORMAT(3X,2I1,F5.0,F25.3)
6000    FORMAT('1',T35,A62)
6010    FORMAT(T55,'NON-COAL-HAULING ROADS')
6015    FORMAT('0',T55,'  COAL-HAULING ROADS')
6020    FORMAT('        LOCAL        ANNUAL ')
6030    FORMAT('     CONDITION      CHANGE ',T59,'AVERAGE VALUE')
6040    FORMAT('     FA VOL  GA     ( % )   ',20I7)
6050    FORMAT('         VOL  CT    ( % )   ',20I7)
6100    FORMAT(I7,2I4,F9.3,3X,20F7.0)
6110    FORMAT(I7,2I4,F9.3,3X,20F7.3)
6200    FORMAT(I7,' AVERAGE',F9.3,3X,20F7.0)
6210    FORMAT(I7,' AVERAGE',F9.3,3X,20F7.3)
6400    FORMAT(I11,I4,F9.3,3X,20F7.0)
6410    FORMAT(I11,I4,F9.3,3X,20F7.3)
         STOP
         END
C$ENTRY
C$STOP
```

Figure C-3. (continued)

APPENDIX D

DOCUMENTATION OF REVISIONS AND ADDITIONS TO PROGRAMS PRESENTED IN RESEARCH REPORT UKTRP-84-30

During the development of the original version of the CLASSUM program, assumptions were made regarding the "purity" of the classification data as received from Frankfort. Based on these assumptions, the format and supposed order of the data records were utilized in the program code and a minimal number of error checks were made. During production, various problems arose, indicating that the ordering could not be assumed and that further error checking was required. Additionally, in the original version, "bad" data were flagged; however, those data were incorrectly used in calculating the hourly and seasonal adjustment factors. To correct these problems and to make other improvements, the following changes were made in the CLASSUM program:

1) An internal data sort was added to assure the correct order in the classification data records.

2) After the hourly and seasonal adjustment factors are calculated and possibly erroneous data flagged, the data are analyzed again and the factors recalculated without using the erroneous information.

3) Code was added to allow the program to recognize, and appropriately handle, a "lumped" data count--one for which the sum of multiple hours of data is recorded for a single hour.

4) The code was modified so that an hourly count of zero for a specific count could not be projected, either hourly or seasonally, into a non-zero estimate for that vehicle count.

5) The code was modified so that if station information, that is, "98" or "99" records were missing, the data for that station would be ignored.

6) Limits of 2/3 and 3/2 were set for the seasonal adjustment factors, with the exception of school buses and motorcycles, for which the limits were set to 1/4 and 4.

7) The seasonal codes were changed to the following:
Winter - January, February and December
Spring - March, April and May
Summer - June, July and August
Fall - September, October and November

Additionally, the EALCAL program was modified as follows:

1) The code was modified so that parameters involving coal-haul vehicles on non-coal-haul roads were more accurately calculated.

2) Default estimates for the numbers of the various types of axles for each vehicle were recalculated (Table 7).

3) The five-year moving average routine was suppressed in favor of the SMOOTH output.

APPENDIX E

EXPLANATION OF APPLICATION OF THE FIVE COMPUTER PROGRAMS USED TO PRODUCE DATA FOR THE EAL ESTIMATING PROCEDURE

This appendix provides explicit instructions (to a user having minimal knowledge of the University of Kentucky IBM mainframe computer, JCL and CMS) for running the software for the estimation of equivalent axleloads (EAL's). This software consists of a system of five programs--LOADOMTR, CLASSUM, CLASEDIT, EALCAL and SMOOTH discussed in other parts of this report. Additionally, a utility program (identified as TAPECOPY) is provided to copy the original data to permanent storage tapes.

All five system programs have been written in FORTRAN IV and were compiled to create object code (load) modules. A particular program may be run by submitting, from CMS, a batch job consisting of JCL referring to the appropriate load module and input and output files. Example JCL files are stored on OS disk at the University of Kentucky Computing Center (UKCC) in the partitioned dataset library named UKU.@KTR05.EAL.JCL as members LOADOMTR, CLASSUM, CLASEDIT, EALCAL, SMOOTH and TAPECOPY. The FORTRAN sources for the five system programs are stored in the OS disk library UKU.@KTR05.EAL.SOURCE with the same respective member names. Similarly, the load modules are stored in the load module library UKU.@KTR05.TRAF1, again with the same member names.

Figure E-1 is a simple, but complete, picture of the processing procedure taking the raw data (from Frankfort) to the final output. As can be seen from the figure, five computer tapes (22347, 23033, 23194, 23235 and 23195) are updated. These tapes are permanently stored at UKCC. Tapemaps for these tapes may be found in the tapemap book located in Room 204, Transportation Research Building. (If not available, tapemaps should be made before processing is begun.) The raw truck weight data is used to produce the loadometer tape, 23194, and the raw classification data is used to produce the classification summary tape, 23235. These two processes are completely independent; in fact, new truck weight data is, typically, available only in even years. These two tapes are then used together with the traffic parameters tape, 23195, to update the traffic parameters tape. This tape is then used as input to SMOOTH to produce the final printed output.

Two copies of all printed output on 14 7/8" x 11" computer paper are required. For convenience, all printed output should be routed to the CMS user ID reader and stored temporarily for review and printing. It is essential, in fact, that the output from the CLASSUM program be routed to the reader since the "punch" file (device 7) output containing the error (flagged) listing must be saved as a CMS data file, edited and used as input to the CLASEDIT program. Once in the reader, the output files may be printed, using the appropriate forms, when desired.

Preparing the JCL

Example JCL for each of the programs is shown (Figure E-2 through E-7) for completeness even though this information may be found elsewhere in this report or in report UKTRP-84-30(6). The JCL files may be created on a CMS user ID manually or, more efficiently, by using the CMS command OSXEDIT to copy the example files from OS disk to CMS files. In most cases, new JCL may be created from the old files by shifting the DD record numbers and adding the DD records for the new files. Although these files may be named any legitimate CMS name, for convenience, these are referred to in this appendix as TAPECOPY JCL, LOADOMTR JCL, CLASSUM JCL, CLASEDIT JCL, EALCAL JCL and SMOOTH JCL. Additionally, the JCL shown here has been prepared to produce a new tapemap each time a tape is updated. The JCL for each particular step is discussed in more detail below.

Copy Raw Data to Permanent Tapes

The raw truck weight and classification data must be copied to permanent tapes 22347 and 23033, respectively. Truck weight data consists of three files (referred to as "card 2", "card 4" and "card 7" data) per year of data. New truck weight data files should be named according to the convention already established (see the tapemap of tape 22347) and added to the end of the tape. When using TAPECOPY, one EXEC step per file to be copied is required with the SYSUT1 DD record corresponding to the input file (to be copied) and the SYSTU2 DD record corresponding to the output file. An example showing the JCL for copying the 1984 truck weight data is shown in Figure E-2.

Classification data consists of one file per year of data. New data should be added to the end of tape 23033 following the established naming convention as seen from the tapemap. Figure E-3 shows the JCL as used to copy the 1984 classification data using TAPECOPY.

The TAPECOPY JCL as stored on OS disk is the JCL for copying the 1984 truck weight data. Clearly, a copy of this can be modified very readily to copy the classification data as well.

Creating the Loadometer Tape (23194)

After new data is added to the permanent truck weight tape, 22347, this tape is used as input to the LOADOMTR program to create a new file on the truck weight summary (loadometer) tape, 23194. The JCL to achieve this is created by editing LOADOMTR JCL. Only the most recent "card 2" and "card 7" data are used as input from the truck weight tape, 22347, and should correspond to the FT05F001 and FT05F002 DD records, respectively. The tape output file from this program is added at the end of the loadometer tape, 23194, according to the FT14F001 DD record. Figure E-4 shows the JCL for the 1984 processing. Two copies of the printed output should be made on 14 7/8" x 11" computer paper.

Creating the Classification Summary Tape (23235)

After new data is added to the permanent classification tape, 23033, this tape is used as input to the CLASSUM program to create a new file on the classification summary tape, 23235. The JCL to achieve this is created by editing CLASSUM JCL. The only changes required are associated with SORTIN DD record in the SORT EXEC step and the FT16F001 and FT16F002 DD records in the CLASSUM EXEC step. The SORTIN DD record should correspond to the most recent classification data on the classification tape, 23033. The FT16F001 and FT16F002 DD records correspond to the two new files to be added to the end of the classification summary tape. The only changes required in both cases are the file numbers and the year. Figure E-5 shows the JCL for the 1984 processing. Two copies of the printed output should be made on 14 7/8" x 11" computer paper.

In addition to producing an updated classification summary tape and a printed output, the CLASSUM program produces (as a punch file) an error file consisting of records for stations which have been flagged as having "bad" or questionable data. This file may be edited (in CMS) and used as input to CLASEDIT, along with the updated classification summary tape, to make corrections on this tape. The Federal-aid code or AADT may corrected. Even though these stations have been flagged, the information as shown in the error file has been included on the updated classification summary tape. To delete a station from the classification summary tape a field (Federal-aid or AADT) should be filled with asterisks.

If no changes or deletions are desired, the CLASEDIT program need not be run; otherwise, after the editing of the error file is complete, CLASEDIT JCL should be modified appropriately and submitted. The edited error file should correspond to the GO.SYSIN DD record. This file is shown as "EDIT 84" and is "INCLUDED" in the jobstream in the 1984 example shown in Figure E-6. The FT15F001 and FT15F002 DD records correspond to the two newly created files on the classification summary tape, 23235, and should be identical to the FT16F001 and FT16F002 DD records in the CLASSUM JCL. When the JCL for the CLASEDIT program is complete CLASEDIT should be submitted. The classification summary tape will reflect the changes made in the error file; however, a new printout is not produced. The CLASSUM printed output previously produced must be edited (by hand) in order that the changes made in the error file be indicated in the printed output as well as on the classification summary tape.

Creating the Traffic Parameters Summary Tape (23195)

After the loadometer tape (23194) and the classification summary tape (23235) have been updated, these tapes are used along with the traffic parameters summary tape (23195) as input to the EALCAL program to produce an updated traffic parameters summary tape.

EALCAL JCL must be modified so that the FT14F0xx DD records ("xx" ranges from 01 to 15) correspond to the most recent (maximum of 15) files on the loadometer tape (23194) in decending chronological order. In other words, the FT14F001 DD record corresponds to the most recent year of data on the loadometer tape, the FT14F002 DD record corresponds to the next most recent file, etc.

The FT15F001 DD record corresponds to the most recent file on the classification summary tape ,23235.

The FT16F001 DD record corresponds to the traffic parameters file to be created using this program. This file should be added at the end of the traffic parameters summary tape (23195) with the DISP parameter on the JCL record coded as "DISP=(NEW,KEEP)." Note that all other JCL records in EALCAL JCL should use "DISP=(OLD,KEEP)." The FT16F0xx DD records ("xx" ranges from 02 to 99) correspond to the most recent existing files on the traffic parameters summary tape (23195) in decending chronological order. In other words, the FT16F002 DD record corresponds to the most recent year of existing data on the traffic parameters summary tape, etc. Figure E-7 shows the JCL for the 1984 processing. After preparation is complete, EALJCL JCL is submitted, producing a printed output and a updated traffic parameters summary tape, 23195. Two copies of the printed output should be made on 14 7/8" x 11" computer paper.

Running the SMOOTH Program

The updated traffic parameters summary tape is used as input to the SMOOTH program. The SMOOTH JCL must be modified so that the FT15F0xx DD records ("xx" ranges from 01 to 15) correspond to the 15 most recent files in chronologically ascending order. In other words, FT15F001 DD corresponds to the most distant file used and FT15F015 DD corresponds to the most recent file. Figure E-8 shows the JCL for the 1984 processing.

After preparation, SMOOTH JCL is submitted producing a printed output. Two copies of this output should be made on 14 7/8" x 11" computer paper.

After all processing is complete and two copies of all output printed, one copy of each should be stored in the appropriate binder at KTRP and the other copies should be delivered to Division of Planning, Kentucky Department of Highways.

Finally, old tapemaps of all tapes updated should be replaced in the tapemap book by the new tapemaps.

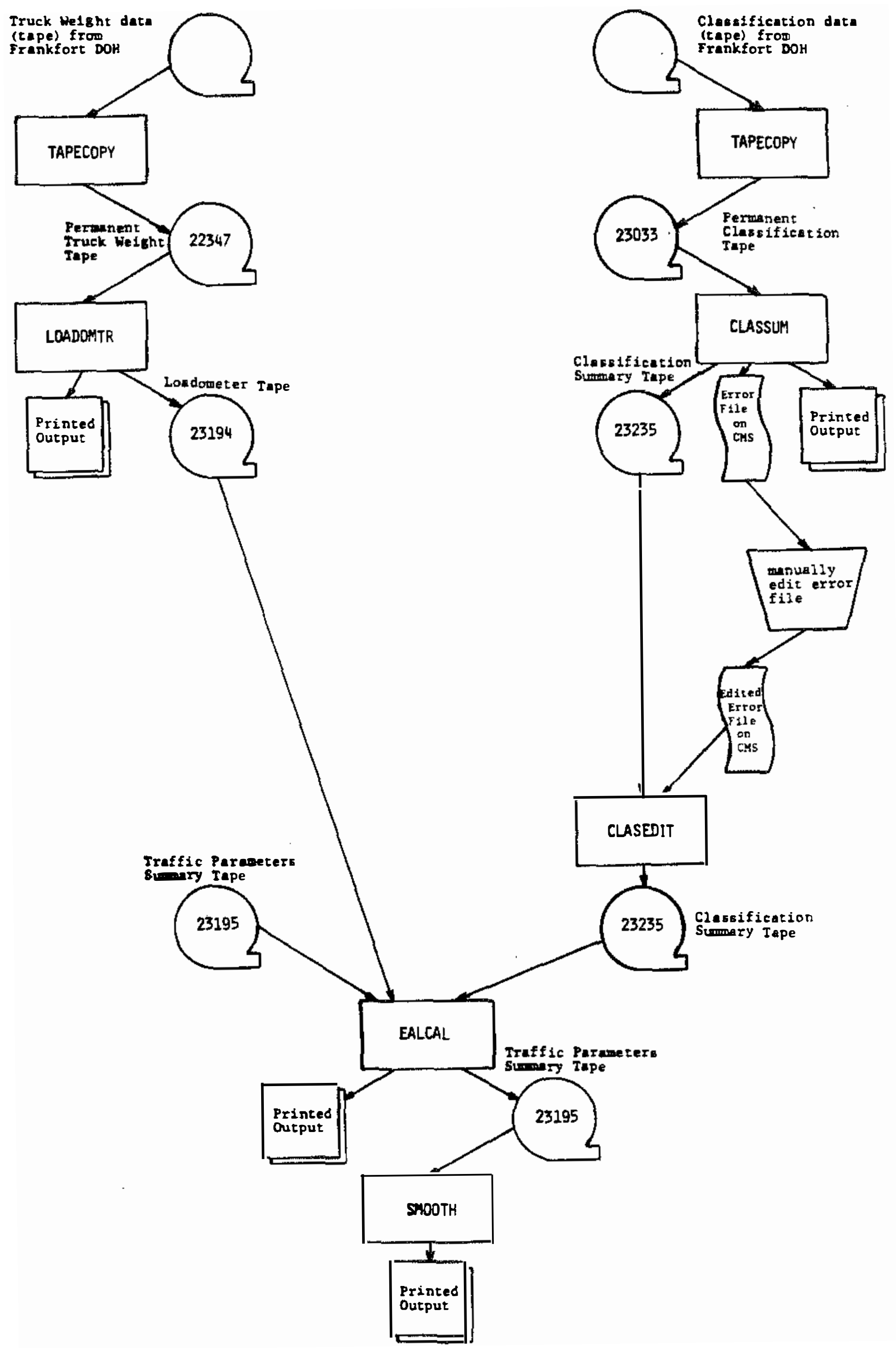

Figure E-1. An Overview of the Processing Procedure

```
//TAPECOPY JOB  (5035-51219),ISENHOUR,REGION=500K
..INCLUDE PASS WORD
/*SETUP  TAPE=(24077)
/*SETUP  TAPE=(22347,RINGIN)
/*JOBPARM  P=R,T=(,45)
//TAPECOPY EXEC PGM=IEBGENER
//SYSPRINT  DD  SYSOUT=A
//SYSUT1 DD VOL=(PRIVATE,RETAIN,SER=24077),UNIT=3400-6,
// LABEL=(003,SL),DSN=TT.TRKWT84.CARD7,
// DISP=(OLD,KEEP),DCB=(LRECL=80,BLKSIZE=12960,RECFM=FB,DEN=4)
//SYSUT2 DD VOL=(PRIVATE,RETAIN,SER=22347),UNIT=3400-6,
// LABEL=(029,SL),DSN=TT.TRKWT84.CARD7,
// DISP=(NEW,KEEP),DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4)
//SYSIN DD * DUMMY
/*
//TAPECOPY EXEC PGM=IEBGENER
//SYSPRINT  DD  SYSOUT=A
//SYSUT1 DD VOL=(PRIVATE,RETAIN,SER=24077),UNIT=3400-6,
// LABEL=(002,SL),DSN=TT.TRKWT84.CARD4,
// DISP=(OLD,KEEP),DCB=(LRECL=80,BLKSIZE=12960,RECFM=FB,DEN=4)
//SYSUT2 DD VOL=(PRIVATE,RETAIN,SER=22347),UNIT=3400-6,
// LABEL=(030,SL),DSN=TT.TRKWT84.CARD4,
// DISP=(NEW,KEEP),DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4)
//SYSIN DD * DUMMY
/*
//TAPECOPY EXEC PGM=IEBGENER
//SYSPRINT  DD  SYSOUT=A
//SYSUT1 DD VOL=(PRIVATE,RETAIN,SER=24077),UNIT=3400-6,
// LABEL=(001,SL),DSN=TT.TRKWT84.CARD2,
// DISP=(OLD,KEEP),DCB=(LRECL=80,BLKSIZE=12960,RECFM=FB,DEN=4)
//SYSUT2 DD VOL=(PRIVATE,RETAIN,SER=22347),UNIT=3400-6,
// LABEL=(031,SL),DSN=TT.TRKWT84.CARD2,
// DISP=(NEW,KEEP),DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4)
//SYSIN DD * DUMMY
/*
//MAP      EXEC TAPEMAP,TAPE=22347
/*
```

Figure E-2. Example of JCL using TAPECOPY to copy truck weight data to permanent tape

```
//TAPECOPY JOB  (5035-51219),ISENHOUR,REGION=500K
..INCLUDE PASS WORD
/*SETUP  TAPE=(24076)
/*SETUP  TAPE=(23033,RINGIN)
/*JOBPARM  P=R,T=(,45)
//TAPECOPY EXEC PGM=IEBGENER
//SYSPRINT  DD  SYSOUT=A
//SYSUT1 DD VOL=(PRIVATE,RETAIN,SER=24076),UNIT=3400-6,
// LABEL=(001,SL),DSN=TT.E21.VCR.Y1984,
// DISP=(OLD,KEEP),DCB=(LRECL=80,BLKSIZE=12960,RECFM=FB,DEN=4)
//SYSUT2 DD VOL=(PRIVATE,RETAIN,SER=23033),UNIT=3400-6,
// LABEL=(010,SL),DSN=VCR.YR1984,
// DISP=(NEW,KEEP),DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4)
//SYSIN DD * DUMMY
/*
//MAP      EXEC TAPEMAP,TAPE=23033
/*
```

Figure E-3. Example of JCL using TAPECOPY to copy classification data

```
//LOADOMTR JOB 5035-51219,' SALSMAN ',MSGLEVEL=(1,1),
// TIME=(1,00),REGION=268K
/*JOBPARM  W,P=R,L=4
/*SETUP TAPE=(22347)
/*SETUP TAPE=(23194,RINGIN)
..INCLUDE 51219 PASSWORD
//LOADOMTR EXEC PGM=LOADOMTR
//STEPLIB  DD DSN=UKU.@KTR05.TRAF1,DISP=SHR
//FT06F001 DD SYSOUT=A
//FT07F001 DD SYSOUT=B
/*
//GO.FT05F001 DD DSN=TT.TRKWT84.CARD2,UNIT=3400-6,VOL=SER=22347,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(31,SL,,IN)
//GO.FT05F002 DD DSN=TT.TRKWT84.CARD7,UNIT=3400-6,VOL=SER=22347,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(29,SL,,IN)
//GO.FT14F001 DD DSN=FWT.YR84,UNIT=3400-6,VOL=SER=23194,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(14,SL,,IN)
/*
//MAP      EXEC TAPEMAP,TAPE=23194
/*
```

Figure E-4. Example of JCL for LOADMTR

```
/*CLASS  A
//CLASSUM  JOB (5035-51219),'MARK',REGION=598K
..INCLUDE 51219 PASSWORD
/*JOBPARM  W,P=S,L=12,T=3
/*SETUP  TAPE=(23033)
/*SETUP  TAPE=(23235,RINGIN)
//SORT EXEC SD,CYL=8
//SORTIN  DD  UNIT=3400-5,VOL=SER=23033,LABEL=(10,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=80,BLKSIZE=16000),
//     DSN=VCR.YR1984
//SORTOUT  DD  DCB=(RECFM=FB,LRECL=80,BLKSIZE=6160,DEN=4),
//     UNIT=RENTAL,DISP=(NEW,CATLG),DSN=UKU.@KTR05.VCRTEMP,
//     SPACE=(TRK,(100,50,1),RLSE)
//SYSIN  DD  *
 SORT  FIELDS=(1,3,CH,A,4,3,CH,A,78,2,CH,A)
 END
/*
//CLASSUM EXEC PGM=CLASSUM
//STEPLIB  DD DSN=UKU.@KTR05.TRAF1,DISP=SHR
//FT06F001 DD SYSOUT=A
//FT07F001 DD SYSOUT=B
//FT05F001 DD *
//GO.FT12F001  DD  UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.VCRTEMP
//GO.FT12F002  DD  UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.VCRTEMP
//GO.FT12F003  DD  UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.VCRTEMP
//GO.FT12F004  DD  UNIT=RENTAL,DISP=SHR,DSN=UKU.@KTR05.VCRTEMP
//GO.FT16F001  DD  UNIT=3400-5,VOL=SER=23235,LABEL=(29,SL,,IN),
//     DISP=(NEW,KEEP),DCB=(RECFM=FB,LRECL=80,BLKSIZE=16000),
//     DSN=CLASS.YR1984
//GO.FT16F002  DD  UNIT=3400-5,VOL=SER=23235,LABEL=(30,SL,,IN),
//     DISP=(NEW,KEEP),DCB=(RECFM=FB,LRECL=80,BLKSIZE=16000),
//     DSN=CLASSUM.YR1984
/*
//DELETE  EXEC PGM=IEFBR14
//D3  DD DSN=UKU.@KTR05.VCRTEMP,DISP=(OLD,DELETE)
/*
//MAP      EXEC TAPEMAP,TAPE=23235
/*
```

Figure E-5. Example of JCL for CLASSUM

```
//CLASEDIT JOB (5035-51219),'MARK',MSGLEVEL=(1,1),REGION=498K
..INCLUDE 51219 PASSWORD
/*JOBPARM  P=R,T=(1,00)
/*SETUP  TAPE=(23235,RINGIN)
//CLASEDIT EXEC PGM=CLASEDIT
//STEPLIB  DD DSN=UKU.@KTR05.TRAF1,DISP=SHR
//FT06F001 DD SYSOUT=A
//FT07F001 DD SYSOUT=B
//FT05F001 DD DDNAME=SYSIN
//GO.FT08F001   DD  DSN=&&TEMP1,DISP=(NEW,DELETE),UNIT=SYSDA,
//     SPACE=(TRK,(150,1),RLSE),DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000)
//GO.FT15F001  DD  UNIT=3400-5,VOL=SER=23235,LABEL=(30,SL,,IN),
//     DISP=OLD,DCB=(RECFM=FB,LRECL=80,BLKSIZE=16000),
//     DSN=CLASSUM.YR1984
//GO.FT15F002  DD  UNIT=3400-5,VOL=SER=23235,LABEL=(30,SL),
//     DISP=(NEW,KEEP),DCB=(RECFM=FB,LRECL=80,BLKSIZE=16000),
//     DSN=CLASSUM.YR1984
//GO.SYSIN DD *
..INCLUDE EDIT 84 A
/*
//TAPEMAP  EXEC TAPEMAP,TAPE=23235
/*
```

Figure E-6. Example of JCL for CLASEDIT

```
//EALCAL   JOB 5035-51219,' SALSMAN ',MSGLEVEL=(1,1),
// TIME=(1,00),REGION=380K
/*JOBPARM  W,P=R,L=4
/*SETUP TAPE=(23194)
/*SETUP TAPE=(23235)
/*SETUP TAPE=(23195,RINGIN)
..INCLUDE 51219 PASSWORD
//EALCAL EXEC PGM=EALCAL
//STEPLIB  DD DSN=UKU.@KTR05.TRAF1,DISP=SHR
//FT06F001 DD SYSOUT=A
//FT07F001 DD SYSOUT=B
//GO.FT14F001 DD DSN=FWT.YR84,UNIT=3400-6,VOL=SER=23194,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(14,SL,,IN)
//GO.FT14F002 DD DSN=FWT.YR82,UNIT=3400-6,VOL=SER=23194,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(13,SL,,IN)
//GO.FT14F003 DD DSN=FWT.YR80,UNIT=3400-6,VOL=SER=23194,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(12,SL,,IN)
//GO.FT14F004 DD DSN=FWT.YR78,UNIT=3400-6,VOL=SER=23194,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(11,SL,,IN)
//GO.FT14F005 DD DSN=FWT.YR77,UNIT=3400-6,VOL=SER=23194,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(10,SL,,IN)
//GO.FT14F006 DD DSN=FWT.YR76,UNIT=3400-6,VOL=SER=23194,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(9,SL,,IN)
//GO.FT14F007 DD DSN=FWT.YR75,UNIT=3400-6,VOL=SER=23194,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(8,SL,,IN)
//GO.FT14F008 DD DSN=FWT.YR74,UNIT=3400-6,VOL=SER=23194,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(7,SL,,IN)
//GO.FT14F009 DD DSN=FWT.YR73,UNIT=3400-6,VOL=SER=23194,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(6,SL,,IN)
//GO.FT14F010 DD DSN=FWT.YR72,UNIT=3400-6,VOL=SER=23194,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(5,SL,,IN)
//GO.FT14F011 DD DSN=FWT.YR71,UNIT=3400-6,VOL=SER=23194,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(4,SL,,IN)
//GO.FT14F012 DD DSN=FWT.YR70,UNIT=3400-6,VOL=SER=23194,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(3,SL,,IN)
//GO.FT14F013 DD DSN=FWT.YR69,UNIT=3400-6,VOL=SER=23194,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(2,SL,,IN)
//GO.FT15F001 DD DSN=CLASSUM.YR1984,UNIT=3400-6,VOL=SER=23235,
//  DCB=(LRECL=80,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(30,SL,,IN)
//GO.FT16F001 DD DSN=MEAN.STDDEV.YR84,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(NEW,KEEP),
//  LABEL=(16,SL,,IN)
//GO.FT16F002 DD DSN=MEAN.STDDEV.YR83,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(15,SL,,IN)
//GO.FT16F003 DD DSN=MEAN.STDDEV.YR82,UNIT=3400-6,VOL=SER=23195,
```

Figure E-7. Example of JCL for EALCAL

```
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(14,SL,,IN)
//GO.FT16F004 DD DSN=MEAN.STDDEV.YR81,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(13,SL,,IN)
//GO.FT16F005 DD DSN=MEAN.STDDEV.YR80,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(12,SL,,IN)
//GO.FT16F006 DD DSN=MEAN.STDDEV.YR79,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(11,SL,,IN)
//GO.FT16F007 DD DSN=MEAN.STDDEV.YR78,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(10,SL,,IN)
//GO.FT16F008 DD DSN=MEAN.STDDEV.YR77,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(9,SL,,IN)
//GO.FT16F009 DD DSN=MEAN.STDDEV.YR76,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(8,SL,,IN)
//GO.FT16F010 DD DSN=MEAN.STDDEV.YR75,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(7,SL,,IN)
//GO.FT16F011 DD DSN=MEAN.STDDEV.YR74,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(6,SL,,IN)
//GO.FT16F012 DD DSN=MEAN.STDDEV.YR73,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(5,SL,,IN)
//GO.FT16F013 DD DSN=MEAN.STDDEV.YR72,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(4,SL,,IN)
//GO.FT16F014 DD DSN=MEAN.STDDEV.YR71,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(3,SL,,IN)
//GO.FT16F015 DD DSN=MEAN.STDDEV.YR70,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(OLD,KEEP),
//  LABEL=(2,SL,,IN)
//GO.FT16F016 DD DSN=MEAN.STDDEV.YR69,UNIT=3400-6,VOL=SER=23195,
//  DCB=(LRECL=40,BLKSIZE=16000,RECFM=FB,DEN=4),DISP=(NEW,KEEP),
//  LABEL=(1,SL,,IN)
/*
//MAP      EXEC TAPEMAP,TAPE=23195
/*
```

Figure E-7. (continued)

```
/*CLASS  A
//SMOOTH JOB (5035-51219),'TR',REGION=400K
..INCLUDE 51219 PASSWORD
/*JOBPARM  P=R,T=(0,25),L=4,LINECT=66
/*SETUP  TAPE=(23195)
//SMOOTH EXEC PGM=SMOOTH
//STEPLIB  DD DSN=UKU.@KTR05.TRAF1,DISP=SHR
//FT06F001 DD SYSOUT=A
//FT07F001 DD SYSOUT=B
//GO.FT15F001  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(2,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR70
//GO.FT15F002  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(3,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR71
//GO.FT15F003  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(4,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR72
//GO.FT15F004  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(5,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR73
//GO.FT15F005  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(6,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR74
//GO.FT15F006  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(7,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR75
//GO.FT15F007  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(8,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR76
//GO.FT15F008  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(9,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR77
//GO.FT15F009  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(10,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR78
//GO.FT15F010  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(11,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR79
//GO.FT15F011  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(12,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR80
//GO.FT15F012  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(13,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR81
//GO.FT15F013  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(14,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR82
//GO.FT15F014  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(15,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR83
//GO.FT15F015  DD  UNIT=3400-5,VOL=SER=23195,LABEL=(16,SL,,IN),
//     DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=40,BLKSIZE=16000),
//     DSN=MEAN.STDDEV.YR84
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Figure E-8. Example of JCL for SMOOTH

APPENDIX F

CROSS-TABULATION MATRICES OF AVERAGE TRAFFIC PARAMETERS FOR 1970 THROUGH 1984

ANNUAL AVERAGE DAILY TRAFFIC

NON-COAL-HAULING ROADS

LOCAL CONDITION FA	VOL	GA	NO OF STAS.	STD DEV 84	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.	0.	*******	*******	*******	*******	*******	*******	*******	*******	*******	3979.	*******	*******	*******	*******	*******
1	1	2	0.	0.	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	3	0.	0.	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	2125.
1	1	4	0.	0.	*******	*******	*******	*******	*******	*******	*******	*******	4860.	*******	*******	*******	*******	3180.	4868.
1	2	1	0.	0.	*******	*******	10226.	7389.	5317.	*******	9824.	*******	6914.	*******	*******	*******	*******	*******	*******
1	2	2	1.	0.	19583.	19268.	18930.	21603.	19007.	20064.	19564.	18420.	17520.	17192.	*******	13686.	14592.	12659.	15285.
1	2	3	10.	23636.	33173.	48688.	29819.	21697.	35080.	23165.	37152.	17959.	29723.	24464.	*******	15668.	18541.	21918.	20544.
1	2	4	0.	0.	*******	6089.	15052.	7207.	12597.	15146.	13063.	13184.	9829.	11856.	*******	*******	8784.	7473.	9051.
2	1	1	3.	1089.	3616.	2783.	2294.	2521.	2511.	2762.	2877.	2770.	3338.	2321.	*******	3820.	2875.	2693.	2613.
2	1	2	10.	1238.	2538.	2225.	2625.	2647.	2419.	2946.	2887.	2625.	2835.	2622.	*******	2981.	2867.	2664.	2073.
2	1	3	7.	1170.	2694.	3593.	3457.	3392.	2795.	3874.	2382.	2138.	3047.	3256.	*******	2135.	2062.	2615.	2902.
2	1	4	2.	735.	2177.	2212.	2216.	2386.	1475.	2258.	2654.	2585.	2046.	2373.	*******	2737.	2387.	2946.	1940.
2	2	1	3.	1372.	6458.	9055.	10923.	9049.	6944.	13620.	7653.	6581.	6471.	10150.	*******	10320.	14720.	7482.	10776.
2	2	2	10.	6074.	11641.	9849.	7793.	9911.	9006.	11945.	8368.	12450.	17117.	5136.	*******	10274.	7125.	8449.	13249.
2	2	3	9.	4027.	10312.	13759.	14382.	13009.	19890.	12263.	15153.	18877.	9931.	10624.	*******	7175.	16481.	10988.	9814.
2	2	4	0.	0.	*******	8428.	7355.	7017.	9918.	8571.	10372.	8143.	7146.	12900.	*******	5896.	10898.	7277.	8405.
3	1	1	4.	1877.	2179.	1643.	2355.	2462.	2591.	1933.	*******	2111.	*******	2042.	*******	2918.	4158.	1177.	2119.
3	1	2	4.	991.	3374.	2174.	1851.	2874.	1902.	2274.	4734.	*******	1581.	1066.	*******	3767.	3507.	1046.	2553.
3	1	3	11.	1521.	2585.	2267.	2677.	2111.	1786.	2494.	465.	*******	2409.	2366.	*******	2032.	3404.	2745.	3365.
3	1	4	4.	1854.	2167.	2200.	2520.	1366.	1719.	1492.	*******	*******	1870.	4135.	*******	*******	3004.	1595.	*******
3	2	1	0.	0.	*******	7659.	8660.	9632.	*******	11914.	*******	25957.	*******	*******	*******	7689.	7137.	*******	*******
3	2	2	1.	0.	11436.	10032.	8588.	9298.	11141.	8744.	10557.	7935.	9163.	5870.	*******	9085.	7330.	9573.	7997.
3	2	3	37.	7521.	13497.	11140.	14096.	10379.	14897.	13964.	12953.	13728.	16107.	10270.	*******	14365.	13551.	12254.	9266.
3	2	4	0.	0.	*******	7471.	9374.	6804.	*******	7347.	*******	*******	5408.	6582.	*******	*******	7946.	9618.	6410.
4	1	1	3.	522.	1795.	1873.	3394.	1325.	1331.	2141.	1521.	1711.	1511.	1457.	*******	2084.	1448.	1257.	1203.
4	1	2	5.	1364.	1930.	1995.	2330.	1667.	1439.	1630.	1746.	1546.	1548.	1140.	*******	1087.	1396.	1473.	1206.
4	1	3	13.	1457.	1693.	2402.	2162.	2321.	3421.	2145.	1743.	1885.	1748.	1967.	*******	1101.	1453.	1966.	2263.
4	1	4	10.	1097.	1167.	863.	616.	800.	1397.	1871.	1573.	1365.	1494.	901.	*******	1336.	2517.	1352.	963.
4	2	1	0.	0.	*******	*******	*******	5586.	7015.	5918.	6655.	*******	5679.	8443.	*******	5999.	7428.	*******	*******
4	2	2	0.	0.	*******	*******	*******	7185.	5374.	*******	6461.	*******	8240.	6734.	*******	*******	*******	7694.	*******
4	2	3	4.	4975.	12857.	9700.	7890.	5679.	*******	6525.	5531.	7873.	6447.	6462.	*******	7679.	5595.	8665.	7172.
4	2	4	1.	0.	15000.	*******	*******	*******	*******	8876.	5986.	7600.	5013.	5102.	*******	6985.	8160.	6257.	*******
5	1	1	2.	308.	847.	553.	332.	324.	318.	892.	1505.	889.	486.	366.	*******	1135.	1358.	647.	908.
5	1	2	15.	249.	409.	1070.	610.	583.	935.	778.	1037.	690.	734.	313.	*******	976.	1701.	814.	429.
5	1	3	22.	1171.	1050.	669.	1066.	1818.	1212.	850.	555.	675.	718.	1077.	*******	691.	1270.	605.	1191.
5	1	4	20.	569.	579.	1912.	705.	703.	620.	1513.	1032.	989.	1167.	558.	*******	1209.	1601.	913.	1025.
5	2	1	0.	0.	*******	*******	*******	*******	*******	*******	5471.	*******	*******	*******	*******	*******	13289.	*******	*******
5	2	2	0.	0.	*******	5115.	*******	*******	*******	*******	*******	*******	*******	15074.	*******	*******	8093.	*******	*******
5	2	3	1.	0.	8700.	5837.	*******	*******	*******	*******	*******	9450.	16469.	8018.	*******	*******	10086.	*******	8325.
5	2	4	0.	0.	*******	8491.	7226.	6865.	*******	*******	*******	*******	6504.	10584.	*******	5300.	9128.	6558.	10138.

COAL-HAULING ROADS

LOCAL CONDITION VOL	CT	NO OF STAS.	STD DEV 84	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	7.	854.	2116.	2012.	1874.	1940.	2377.	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	14.	1572.	1743.	2301.	1957.	2523.	2658.	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	3	25.	1267.	1881.	2441.	2323.	2340.	2051.	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	8.	9252.	12626.	12281.	14603.	15213.	12714.	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	5.	4485.	8772.	9365.	15550.	13755.	8917.	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	3	9.	4889.	11433.	9039.	8252.	10965.	6012.	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******

Figure F-1 Cross-Tabulation Matrix with Average Values for Annual Average Daily Traffic

PERCENT TRUCKS

NON-COAL-HAULING ROADS

LOCAL CONDITION FA	VOL	GA	NO OF STAS.	STD DEV 84	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	11.364	*******	*******	*******	*******	*******
1	1	2	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	3	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	14.265
1	1	4	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	16.756	*******	*******	*******	*******	13.440	21.000
1	2	1	0.	0.0	*******	*******	36.933	22.156	25.329	*******	33.611	*******	8.337	*******	*******	*******	*******	*******	*******
1	2	2	1.	0.0	34.047	31.971	29.684	27.529	30.667	28.882	29.785	32.998	30.229	25.499	*******	24.323	30.519	22.491	17.647
1	2	3	10.	11.020	15.457	19.511	20.393	28.548	22.364	24.362	19.700	24.964	21.782	18.545	*******	21.244	17.109	17.982	17.812
1	2	4	0.	0.0	*******	27.424	24.019	23.204	26.950	28.335	24.884	25.473	23.926	19.753	*******	*******	20.377	18.591	15.352
2	1	1	3.	5.410	12.715	10.726	11.985	12.247	16.258	15.163	15.448	16.530	16.111	15.392	*******	20.135	9.581	14.908	13.799
2	1	2	10.	14.959	14.358	11.529	10.569	10.941	13.081	13.294	11.510	14.875	11.421	11.172	*******	12.757	10.523	12.815	13.106
2	1	3	7.	3.053	8.599	5.857	7.697	6.642	6.303	8.949	9.432	9.558	8.753	9.083	*******	5.883	13.559	9.497	10.577
2	1	4	2.	3.226	14.750	6.319	4.752	12.716	18.239	12.446	12.511	13.509	11.335	15.099	*******	11.489	8.800	12.283	13.122
2	2	1	3.	3.569	5.972	7.508	7.871	6.215	17.391	9.996	14.742	17.016	10.201	14.290	*******	4.284	3.594	13.037	15.489
2	2	2	10.	1.695	5.625	7.172	8.496	6.552	5.752	7.155	8.366	8.079	3.289	11.983	*******	5.744	7.602	6.972	9.116
2	2	3	9.	3.520	6.894	4.956	6.104	6.280	4.719	8.228	7.905	11.041	9.265	7.673	*******	12.424	9.018	8.501	7.178
2	2	4	0.	0.0	*******	6.684	1.729	8.699	11.415	15.591	15.013	16.897	14.638	7.719	*******	12.028	7.986	20.029	7.444
3	1	1	4.	2.425	3.322	3.023	4.098	3.947	16.305	6.786	*******	11.446	*******	4.164	*******	1.439	4.436	2.810	9.730
3	1	2	4.	1.395	3.276	4.203	5.518	3.386	4.448	6.242	5.648	*******	8.851	8.819	*******	4.723	8.728	10.608	15.845
3	1	3	11.	1.785	3.396	3.588	2.824	3.593	2.417	2.441	5.014	*******	9.454	20.797	*******	3.826	22.754	9.725	8.408
3	1	4	4.	1.381	2.554	2.059	1.985	2.295	4.435	5.357	*******	*******	1.952	2.016	*******	*******	5.172	8.964	*******
3	2	1	0.	0.0	*******	2.622	5.564	3.284	*******	4.269	*******	4.892	*******	*******	*******	6.440	3.869	*******	*******
3	2	2	1.	0.0	1.912	3.542	5.023	4.029	3.555	7.854	3.240	5.651	3.165	29.612	*******	5.189	5.683	2.323	5.445
3	2	3	37.	2.710	4.031	4.704	3.910	4.214	4.209	5.632	5.779	6.183	3.520	5.011	*******	4.712	2.853	5.296	5.070
3	2	4	0.	0.0	*******	1.812	2.652	3.823	*******	6.806	*******	*******	16.401	10.622	*******	*******	1.909	6.374	6.080
4	1	1	3.	5.339	10.770	8.091	5.655	5.609	8.860	9.838	10.682	9.040	8.815	8.954	*******	3.909	6.385	7.837	10.819
4	1	2	5.	2.229	5.951	7.382	4.689	9.163	7.552	10.027	9.410	11.822	9.185	10.078	*******	7.575	8.671	10.209	9.814
4	1	3	13.	4.524	7.288	5.782	5.485	6.937	4.902	8.125	7.330	10.025	8.397	8.456	*******	7.573	6.420	6.889	7.690
4	1	4	10.	2.354	4.350	6.065	7.744	5.623	8.896	9.650	15.276	13.205	10.323	11.597	*******	6.338	7.652	10.400	10.224
4	2	1	0.	0.0	*******	*******	*******	8.892	11.423	10.990	13.296	*******	6.310	3.781	*******	2.608	5.144	*******	*******
4	2	2	0.	0.0	*******	*******	*******	6.221	6.562	*******	5.892	*******	7.342	7.861	*******	*******	*******	7.282	*******
4	2	3	4.	1.103	4.078	11.446	2.966	5.700	*******	10.225	5.849	3.603	4.633	3.935	*******	6.799	4.646	8.165	5.730
4	2	4	1.	0.0	3.560	*******	*******	*******	*******	7.653	14.951	5.104	14.742	4.567	*******	5.980	6.080	8.829	*******
5	1	1	2.	1.362	2.432	6.393	6.006	3.795	7.009	4.425	7.123	5.805	3.774	5.376	*******	4.776	6.661	6.761	8.217
5	1	2	15.	6.006	8.300	6.282	4.608	7.956	7.183	7.646	6.125	8.167	6.861	6.086	*******	4.777	4.264	8.707	9.941
5	1	3	22.	2.645	3.846	4.968	5.407	5.600	8.500	6.096	6.099	8.068	7.819	5.216	*******	6.393	4.803	9.248	4.103
5	1	4	20.	4.529	5.104	4.057	5.167	9.503	9.465	8.560	11.824	11.138	6.803	9.788	*******	8.379	3.638	8.866	14.716
5	2	1	0.	0.0	*******	*******	*******	*******	*******	*******	5.369	*******	*******	*******	*******	*******	3.276	*******	*******
5	2	2	0.	0.0	*******	2.203	*******	*******	*******	*******	*******	*******	*******	24.783	*******	*******	4.782	*******	*******
5	2	3	1.	0.0	1.532	9.095	*******	*******	*******	*******	*******	6.152	10.865	4.296	*******	*******	1.187	*******	1.519
5	2	4	0.	0.0	*******	2.002	3.353	1.651	*******	*******	*******	*******	2.519	5.541	*******	2.626	3.846	6.901	7.543

COAL-HAULING ROADS

LOCAL CONDITION VOL	CT	NO OF STAS.	STD DEV 84	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	7.	5.461	9.514	7.299	7.153	9.590	11.938	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	14.	4.718	7.873	9.183	8.505	9.783	12.280	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	3	25.	11.982	18.194	15.707	19.288	15.372	18.302	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	8.	12.402	15.806	10.563	12.497	11.421	17.472	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	5.	8.111	11.279	10.209	10.493	12.517	10.409	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	3	9.	11.100	14.860	13.825	15.978	13.602	26.589	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******

Figure F-2. Cross-Tabulation Matrix with Average Values for Percent Trucks

PERCENT OF TRUCKS HAULING COAL

NON-COAL-HAULING ROADS

LOCAL CONDITION FA	VOL	GA	NO OF STAS.	STD DEV 84	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	2	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	3	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	4	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	1	0.	0.0	*******	*******	0.881	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	2	1.	0.0	0.145	0.0	0.0	0.020	0.016	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	3	10.	0.118	0.078	0.127	0.203	0.435	0.439	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	4	0.	0.0	*******	0.970	0.576	0.246	0.821	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	1	3.	0.0	0.0	0.0	0.069	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	2	10.	0.197	0.078	0.032	0.0	0.046	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	3	7.	0.0	0.0	0.072	0.082	0.107	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	4	2.	0.0	0.0	0.149	0.0	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	1	3.	0.0	0.0	0.0	0.285	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	2	10.	0.0	0.0	0.117	0.0	0.053	0.164	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	3	9.	0.084	0.028	0.055	0.0	0.220	0.336	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	4	0.	0.0	*******	0.335	0.0	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	1	1	4.	0.0	0.0	0.022	0.0	0.0	0.149	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	1	2	4.	0.0	0.0	0.0	0.036	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	1	3	11.	0.0	0.0	0.0	0.0	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	1	4	4.	0.0	0.0	0.0	0.0	0.0	0.184	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	2	1	0.	0.0	*******	0.0	0.051	0.422	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	2	2	1.	0.0	0.0	0.0	0.0	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	2	3	37.	0.050	0.012	0.057	0.0	0.019	0.165	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	2	4	0.	0.0	*******	0.0	0.256	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	1	1	3.	0.289	0.167	0.075	0.0	0.0	0.018	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	1	2	5.	0.0	0.0	0.0	0.0	0.075	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	1	3	13.	0.0	0.0	0.032	0.128	0.048	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	1	4	10.	0.0	0.0	0.0	0.0	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	2	1	0.	0.0	*******	*******	*******	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	2	2	0.	0.0	*******	*******	*******	0.128	0.264	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	2	3	4.	0.061	0.030	0.0	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	2	4	1.	0.0	0.564	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	1	1	2.	0.0	0.0	0.0	0.0	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	1	2	15.	0.0	0.0	0.0	0.0	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	1	3	22.	0.0	0.0	0.0	0.0	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	1	4	20.	0.0	0.0	0.0	0.0	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	2	1	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	2	2	0.	0.0	*******	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	2	3	1.	0.0	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	2	4	0.	0.0	*******	0.952	0.0	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******

COAL-HAULING ROADS

LOCAL CONDITION VOL	CT	NO OF STAS.	STD DEV 84	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	7.	1.068	2.561	2.761	3.426	2.377	2.415	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	14.	3.852	11.755	10.064	10.346	13.107	9.824	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	3	25.	19.790	45.720	49.202	47.999	44.067	40.978	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	8.	1.544	2.453	2.048	2.140	2.517	2.272	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	5.	5.350	12.018	12.661	12.470	12.329	11.350	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	3	9.	12.825	38.492	34.843	34.321	35.128	34.071	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******

Figure F-3. Cross-Tabulation Matrix with Average Values for Percent of Trucks Hauling Coal

AXLES PER TRUCK (NON-COAL-HAULING)

NON-COAL-HAULING ROADS

LOCAL CONDITION FA	VOL	GA	NO OF STAS.	STD DEV 84	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	3.739	*******	*******	*******	*******	*******
1	1	2	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	3	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	3.307
1	1	4	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	4.355	*******	*******	*******	*******	3.093	3.872
1	2	1	0.	0.0	*******	*******	4.492	4.490	4.353	*******	4.550	*******	3.490	*******	*******	*******	*******	*******	*******
1	2	2	1.	0.0	4.502	4.539	4.517	4.435	4.433	4.416	4.444	4.487	4.389	4.350	*******	4.463	4.258	4.296	4.163
1	2	3	10.	0.512	4.001	4.200	4.225	4.337	4.171	4.367	4.103	4.273	4.299	4.233	*******	4.198	4.212	4.040	4.042
1	2	4	0.	0.0	*******	4.401	4.330	4.383	4.329	4.354	4.244	4.251	4.248	4.196	*******	*******	4.137	4.111	3.972
2	1	1	3.	0.545	3.683	3.566	3.470	3.606	3.788	3.622	3.508	3.709	3.627	3.645	*******	4.254	3.389	3.327	3.342
2	1	2	10.	0.581	2.948	3.338	3.130	3.193	3.263	3.221	3.113	3.193	2.995	3.158	*******	3.445	3.131	3.135	2.910
2	1	3	7.	0.318	3.041	2.837	2.878	2.886	2.000	3.029	2.902	2.725	2.876	3.072	*******	2.759	3.119	2.765	2.662
2	1	4	2.	0.0	3.117	2.638	2.691	3.157	2.986	3.092	3.116	3.005	3.095	3.181	*******	2.762	2.702	2.815	2.640
2	2	1	3.	0.583	3.081	3.333	2.981	3.069	3.747	3.526	3.508	3.818	3.498	3.774	*******	2.929	3.352	3.365	3.691
2	2	2	10.	0.422	2.962	3.184	2.959	2.966	2.728	2.767	3.039	3.025	2.876	3.078	*******	2.761	2.785	2.775	3.105
2	2	3	9.	0.574	3.065	2.806	2.814	2.801	2.181	3.070	3.195	3.448	2.827	3.104	*******	3.582	3.281	2.759	2.931
2	2	4	0.	0.0	*******	2.708	2.316	2.983	3.197	3.522	3.345	3.488	3.495	3.249	*******	3.325	3.043	3.390	2.654
3	1	1	4.	0.781	2.438	2.331	2.293	2.455	3.557	2.401	*******	3.093	*******	2.541	*******	2.192	2.726	2.091	2.767
3	1	2	4.	0.192	2.274	2.589	2.483	2.532	2.541	2.175	3.033	*******	2.930	2.856	*******	2.285	2.661	2.403	2.973
3	1	3	11.	0.377	2.399	2.415	2.316	2.489	2.260	2.452	2.156	*******	3.069	3.094	*******	2.185	2.584	2.373	2.566
3	1	4	4.	0.059	2.121	2.393	2.229	2.362	2.397	2.331	*******	*******	2.000	2.178	*******	*******	2.377	2.592	*******
3	2	1	0.	0.0	*******	2.512	2.880	2.530	*******	2.780	*******	2.813	*******	*******	*******	2.934	2.831	*******	*******
3	2	2	1.	0.0	2.366	2.664	2.781	2.558	2.537	2.847	2.622	2.752	2.367	3.809	*******	2.766	2.615	2.445	2.329
3	2	3	37.	0.436	2.561	2.544	2.660	2.569	2.655	2.813	2.813	2.606	2.569	2.609	*******	3.014	2.449	2.218	2.422
3	2	4	0.	0.0	*******	2.409	2.316	2.302	*******	2.802	*******	*******	4.579	2.915	*******	*******	2.267	2.624	2.474
4	1	1	3.	0.376	3.461	2.696	2.590	2.720	2.972	2.784	2.939	2.812	2.934	2.839	*******	2.579	2.610	2.482	2.774
4	1	2	5.	0.212	2.442	2.814	2.616	2.687	2.559	2.710	2.643	2.669	2.519	2.621	*******	2.365	2.407	2.489	2.555
4	1	3	13.	0.378	2.468	2.750	2.624	2.757	2.542	2.697	2.462	2.656	2.531	2.529	*******	2.428	2.405	2.360	2.362
4	1	4	10.	0.765	2.027	2.388	2.555	2.455	3.026	2.786	2.944	2.709	2.693	2.811	*******	2.528	2.585	2.555	2.426
4	2	1	0.	0.0	*******	*******	*******	2.854	3.539	3.435	3.735	*******	3.365	2.775	*******	2.268	3.001	*******	*******
4	2	2	0.	0.0	*******	*******	*******	2.589	3.124	*******	2.856	*******	2.910	2.706	*******	*******	*******	2.819	*******
4	2	3	4.	0.206	2.568	3.697	2.533	2.735	*******	3.033	2.922	2.523	2.210	2.689	*******	2.468	2.472	3.115	2.762
4	2	4	1.	0.0	2.349	*******	*******	*******	*******	3.039	3.141	2.497	3.781	2.882	*******	2.847	2.712	2.740	*******
5	1	1	2.	0.146	2.354	2.529	2.642	1.848	2.689	2.206	2.487	2.336	2.208	2.180	*******	2.343	2.652	2.284	2.403
5	1	2	15.	0.150	2.172	2.484	2.028	2.327	2.447	2.348	2.346	2.147	2.236	1.990	*******	2.192	2.222	2.254	2.210
5	1	3	22.	0.529	2.098	2.245	2.743	2.455	2.598	2.262	2.326	2.343	2.257	2.376	*******	2.286	2.328	2.248	2.027
5	1	4	20.	0.853	2.172	2.486	2.522	2.540	2.712	2.563	2.761	2.608	2.631	2.292	*******	2.507	2.208	2.448	2.368
5	2	1	0.	0.0	*******	*******	*******	*******	*******	*******	2.900	*******	*******	*******	*******	*******	2.823	*******	*******
5	2	2	0.	0.0	*******	2.383	*******	*******	*******	*******	*******	*******	*******	4.288	*******	*******	2.625	*******	*******
5	2	3	1.	0.0	2.128	2.637	*******	*******	*******	*******	*******	2.488	3.240	2.654	*******	*******	2.147	*******	2.032
5	2	4	0.	0.0	*******	2.098	2.376	2.141	*******	*******	*******	*******	2.956	2.710	*******	2.199	2.467	2.359	2.766

COAL-HAULING ROADS

LOCAL CONDITION VOL	CT	NO OF STAS.	STD DEV 84	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	7.	0.388	2.905	2.665	2.718	2.890	3.084	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	14.	0.418	2.627	2.910	2.716	2.846	2.959	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	3	25.	0.496	2.801	3.203	3.197	3.040	3.330	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	8.	0.985	3.633	3.369	3.685	3.397	3.714	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	5.	0.419	3.397	3.339	3.279	3.682	3.216	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	3	9.	0.666	3.441	3.180	3.257	3.085	3.639	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******

Figure F-4. Cross-Tabulation Matrix with Average Values for Axles per Truck (Non-Coal-Hauling)

AXLES PER TRUCK (COAL-HAULING)

NON-COAL-HAULING ROADS

LOCAL CONDITION FA	VOL	GA	NO OF STAS.	STD DEV 84	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	2	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	3	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	4	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	1	0.	0.0	*******	*******	4.368	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	2	1.	0.0	4.280	*******	*******	4.500	4.358	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	3	4.	0.0	4.356	4.334	4.400	4.359	4.316	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	4	0.	0.0	*******	4.243	4.361	4.500	4.242	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	1	0.	0.0	*******	*******	4.333	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	2	2.	0.500	4.646	5.000	*******	4.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	3	0.	0.0	*******	4.000	4.333	5.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	4	0.	0.0	*******	4.333	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	1	0.	0.0	*******	*******	4.353	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	2	0.	0.0	*******	4.641	*******	4.679	4.279	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	3	1.	0.0	4.000	4.214	*******	4.315	4.333	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	4	0.	0.0	*******	4.500	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	1	1	0.	0.0	*******	5.000	*******	*******	4.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	1	2	0.	0.0	*******	*******	5.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	1	3	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	1	4	0.	0.0	*******	*******	*******	*******	3.789	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	2	1	0.	0.0	*******	*******	5.000	4.500	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	2	2	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	2	3	2.	0.707	4.500	4.208	*******	4.256	4.333	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	2	4	0.	0.0	*******	*******	4.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	1	1	1.	0.0	4.000	5.000	*******	*******	5.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	1	2	0.	0.0	*******	*******	*******	5.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	1	3	0.	0.0	*******	5.000	5.000	5.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	1	4	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	2	1	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	2	2	0.	0.0	*******	*******	*******	4.358	4.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	2	3	1.	0.0	5.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	2	4	1.	0.0	4.333	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	1	1	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	1	2	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	1	3	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	1	4	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	2	1	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	2	2	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	2	3	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	2	4	0.	0.0	*******	4.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******

COAL-HAULING ROADS

LOCAL CONDITION VOL	CT	NO OF STAS.	STD DEV 84	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	7.	0.335	4.326	4.288	4.340	4.286	4.369	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	14.	0.635	4.160	4.380	3.974	4.245	4.308	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	3	25.	0.621	3.888	4.113	3.939	4.092	4.307	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	8.	0.053	4.372	4.319	4.366	4.320	4.322	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	5.	0.041	4.326	4.230	4.365	4.353	4.324	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	3	9.	0.264	4.360	4.268	4.346	4.134	4.384	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******

Figure F-5. Cross-Tabulation Matrix with Average Values for Axles per Truck (Coal-Hauling)

EAL'S PER TRUCK AXLE (NON-COAL-HAULING)

NON-COAL-HAULING ROADS

LOCAL CONDITION FA	VOL	GA	NO OF STAS.	STD DEV 84	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	0.134	*******	*******	*******	*******	*******
1	1	2	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	3	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	0.125
1	1	4	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	0.138	*******	*******	*******	*******	0.126	0.122
1	2	1	0.	0.0	*******	*******	0.142	0.153	0.155	*******	0.138	*******	0.146	*******	*******	*******	*******	*******	*******
1	2	2	1.	0.0	0.163	0.143	0.142	0.153	0.154	0.139	0.138	0.137	0.139	0.134	*******	0.127	0.126	0.125	0.126
1	2	3	10.	0.0	0.161	0.144	0.143	0.156	0.153	0.138	0.139	0.138	0.139	0.133	*******	0.127	0.124	0.125	0.125
1	2	4	0.	0.0	*******	0.142	0.140	0.154	0.152	0.138	0.136	0.137	0.137	0.131	*******	*******	0.122	0.125	0.124
2	1	1	3.	0.0	0.162	0.145	0.147	0.160	0.158	0.137	0.136	0.141	0.143	0.131	*******	0.127	0.122	0.124	0.125
2	1	2	10.	0.0	0.166	0.149	0.152	0.159	0.156	0.141	0.139	0.145	0.151	0.131	*******	0.125	0.117	0.128	0.125
2	1	3	7.	0.0	0.165	0.159	0.151	0.158	0.146	0.144	0.135	0.152	0.152	0.130	*******	0.131	0.118	0.125	0.121
2	1	4	2.	0.042	0.167	0.144	0.146	0.158	0.153	0.137	0.137	0.146	0.146	0.124	*******	0.122	0.118	0.122	0.127
2	2	1	3.	0.0	0.183	0.156	0.151	0.161	0.162	0.134	0.135	0.139	0.144	0.130	*******	0.125	0.126	0.121	0.123
2	2	2	10.	0.0	0.169	0.147	0.151	0.162	0.167	0.157	0.136	0.147	0.152	0.129	*******	0.123	0.118	0.125	0.123
2	2	3	9.	0.0	0.167	0.164	0.160	0.166	0.205	0.144	0.148	0.147	0.159	0.128	*******	0.128	0.120	0.145	0.131
2	2	4	0.	0.0	*******	0.149	0.172	0.164	0.160	0.137	0.134	0.138	0.136	0.124	*******	0.127	0.119	0.124	0.122
3	1	1	4.	0.032	0.176	0.174	0.168	0.169	0.165	0.140	*******	0.151	*******	0.132	*******	0.122	0.125	0.120	0.129
3	1	2	4.	0.0	0.195	0.165	0.166	0.177	0.202	0.202	0.105	*******	0.153	0.132	*******	0.121	0.113	0.123	0.136
3	1	3	11.	0.0	0.188	0.177	0.156	0.183	0.187	0.155	0.139	*******	0.148	0.094	*******	0.136	0.117	0.121	0.129
3	1	4	4.	0.0	0.194	0.166	0.165	0.185	0.217	0.171	*******	*******	0.167	0.133	*******	*******	0.144	0.126	*******
3	2	1	0.	0.0	*******	0.175	0.169	0.164	*******	0.143	*******	0.141	*******	*******	*******	0.125	0.121	*******	*******
3	2	2	1.	0.0	0.170	0.152	0.162	0.170	0.185	0.158	0.124	0.161	0.169	0.131	*******	0.124	0.122	0.146	0.125
3	2	3	37.	0.0	0.186	0.173	0.152	0.181	0.160	0.131	0.132	0.179	0.161	0.125	*******	0.134	0.126	0.148	0.127
3	2	4	0.	0.0	*******	0.172	0.163	0.179	*******	0.135	*******	*******	0.087	0.124	*******	*******	0.120	0.130	0.147
4	1	1	3.	0.0	0.160	0.155	0.149	0.159	0.163	0.131	0.133	0.151	0.150	0.132	*******	0.123	0.118	0.127	0.131
4	1	2	5.	0.0	0.172	0.159	0.166	0.167	0.160	0.158	0.142	0.155	0.160	0.132	*******	0.122	0.121	0.125	0.125
4	1	3	13.	0.0	0.171	0.154	0.141	0.169	0.176	0.131	0.140	0.178	0.157	0.125	*******	0.129	0.118	0.133	0.125
4	1	4	10.	0.057	0.155	0.157	0.167	0.165	0.160	0.134	0.132	0.148	0.149	0.129	*******	0.124	0.124	0.129	0.124
4	2	1	0.	0.0	*******	*******	*******	0.165	0.158	0.138	0.134	*******	0.144	0.133	*******	0.122	0.126	*******	*******
4	2	2	0.	0.0	*******	*******	*******	0.161	0.157	*******	0.138	*******	0.151	0.129	*******	*******	*******	0.123	*******
4	2	3	4.	0.0	0.176	0.149	0.139	0.172	*******	0.113	0.133	0.156	0.162	0.139	*******	0.148	0.119	0.123	0.119
4	2	4	1.	0.0	0.182	*******	*******	*******	*******	0.129	0.135	0.142	0.120	0.128	*******	0.127	0.116	0.124	*******
5	1	1	2.	0.0	0.194	0.185	0.173	0.131	0.173	0.137	0.135	0.159	0.173	0.126	*******	0.124	0.118	0.129	0.123
5	1	2	15.	0.0	0.185	0.161	0.155	0.176	0.181	0.139	0.147	0.150	0.166	0.124	*******	0.125	0.114	0.123	0.130
5	1	3	22.	0.053	0.183	0.171	0.165	0.188	0.158	0.156	0.155	0.187	0.162	0.151	*******	0.123	0.111	0.136	0.115
5	1	4	20.	0.066	0.164	0.200	0.177	0.191	0.206	0.134	0.135	0.155	0.159	0.116	*******	0.138	0.132	0.131	0.129
5	2	1	0.	0.0	*******	*******	*******	*******	*******	*******	0.137	*******	*******	*******	*******	*******	0.121	*******	*******
5	2	2	0.	0.0	*******	0.191	*******	*******	*******	*******	*******	*******	*******	0.134	*******	*******	0.129	*******	*******
5	2	3	1.	0.0	0.218	0.170	*******	*******	*******	*******	*******	0.224	0.144	0.134	*******	*******	0.118	*******	0.120
5	2	4	0.	0.0	*******	0.152	0.163	0.160	*******	*******	*******	*******	0.141	0.124	*******	0.123	0.120	0.130	0.130

COAL-HAULING ROADS

LOCAL CONDITION VOL	CT	NO OF STAS.	STD DEV 84	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	7.	0.0	0.170	0.170	0.167	0.164	0.165	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	14.	0.0	0.170	0.156	0.167	0.170	0.164	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	3	25.	0.049	0.187	0.161	0.169	0.167	0.154	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	8.	0.0	0.168	0.152	0.148	0.159	0.160	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	5.	0.0	0.163	0.151	0.150	0.154	0.157	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	3	9.	0.0	0.166	0.160	0.155	0.167	0.151	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******

Figure F-6. Cross-Tabulation Matrix with Average Values for EAL's per Truck Axle (Non-Coal-Hauling)

EAL'S PER TRUCK AXLE (COAL-HAULING)

NON-COAL-HAULING ROADS

LOCAL CONDITION FA	VOL	GA	NO OF STAS.	STD DEV 84	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	2	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	3	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	4	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	1	0.	0.0	*******	*******	1.420	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	2	1.	0.0	1.542	*******	*******	1.420	1.187	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	3	4.	0.191	1.398	1.525	1.339	1.415	1.498	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	4	0.	0.0	*******	1.401	1.538	1.303	1.530	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	1	0.	0.0	*******	*******	1.681	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	2	2.	0.854	0.959	0.361	*******	2.471	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	3	0.	0.0	*******	2.506	1.681	0.368	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	4	0.	0.0	*******	1.681	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	1	0.	0.0	*******	*******	1.454	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	2	0.	0.0	*******	1.019	*******	0.778	1.572	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	3	1.	0.0	2.428	1.987	*******	1.604	1.663	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	4	0.	0.0	*******	1.394	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	1	1	0.	0.0	*******	0.361	*******	*******	2.471	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	1	2	0.	0.0	*******	*******	0.361	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	1	3	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	1	4	0.	0.0	*******	*******	*******	*******	0.638	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	2	1	0.	0.0	*******	*******	0.361	1.303	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	2	2	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	2	3	2.	1.465	1.392	2.002	*******	1.532	1.663	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
3	2	4	0.	0.0	*******	*******	2.506	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	1	1	1.	0.0	2.428	0.361	*******	*******	0.368	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	1	2	0.	0.0	*******	*******	*******	0.368	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	1	3	0.	0.0	*******	0.361	0.361	0.368	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	1	4	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	2	1	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	2	2	0.	0.0	*******	*******	*******	1.187	2.471	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	2	3	1.	0.0	0.356	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
4	2	4	1.	0.0	1.631	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	1	1	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	1	2	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	1	3	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	1	4	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	2	1	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	2	2	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	2	3	0.	0.0	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
5	2	4	0.	0.0	*******	2.506	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******

COAL-HAULING ROADS

LOCAL CONDITION VOL	CT	NO OF STAS.	STD DEV 84	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	7.	0.721	1.592	1.109	1.433	1.554	1.490	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	2	14.	0.577	1.496	1.300	1.982	1.330	1.459	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	3	25.	1.443	2.123	1.693	2.247	1.779	1.357	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	1	8.	0.102	1.365	1.486	1.424	1.436	1.457	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	2	5.	0.0	1.429	1.626	1.410	1.365	1.435	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
2	3	9.	0.426	1.312	1.510	1.355	1.695	1.295	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******

Figure F-7. Cross-Tabulation Matrix with Average Values for EAL's per Truck Axle (Coal-Hauling)

APPENDIX G

CROSS-TABULATION MATRICES OF TRAFFIC PARAMETERS PRODUCED FROM THE LINEAR SMOOTHING PROCEDURE

VARIABLES AND CODES DEFINED

NON-COAL-HAULING ROADS
COAL TRUCKS COMPRISE LESS THAN 1.0% OF THE TRUCK VOLUME

FA - FEDERAL AID CODES
- 1 - INTERSTATE
- 2 - FEDERAL AID PRIMARY
- 3 - FEDERAL AID URBAN
- 4 - FEDERAL AID SECONDARY
- 5 - NON-FEDERAL AID

GA - GEOGRAPHIC AREA CODES
- 1 - WEST (HIGHWAY DISTRICTS 1,2)
- 2 - SOUTH-CENTRAL (HIGHWAY DISTRICTS 3,4,8)
- 3 - NORTH-CENTRAL (HIGHWAY DISTRICTS 5,6,7)
- 4 - EAST (HIGHWAY DISTRICTS 9,10,11,12)

VOL - VOLUME CODES
- 1 - LESS THAN 5000 AADT
- 2 - 5000 OR MORE AADT

COAL-HAULING ROADS
COAL TRUCKS COMPRISE 1.0% OR MORE OF THE TRUCK VOLUME

CT - COAL-HAULING ROAD CODES
- 1 - COAL TRUCKS COMPRISE 1.0-4.99% OF THE TRUCK VOLUME
- 2 - COAL TRUCKS COMPRISE 5.0-20.00% OF THE TRUCK VOLUME
- 3 - COAL TRUCKS COMPRISE MORE THAN 20.0% OF THE TRUCK VOLUME

VOL - VOLUME CODES
- 1 - LESS THAN 5000 AADT
- 2 - 5000 OR MORE AADT

INDIVIDUAL CLASSIFICATION STATIONS

DIR OPR -DIRECTIONAL OPERATION CODES
- 1 - ONE-WAY OPERATION
- 2 - TWO-WAY OPERATION

FED AID - FEDERAL AID CODES
- 1 - INTERSTATE
- 2 - FEDERAL AID PRIMARY
- 3 - FEDERAL AID URBAN
- 4 - FEDERAL AID SECONDARY
- 5 - NON-FEDERAL AID

ANNUAL AVERAGE DAILY TRAFFIC
NON-COAL-HAULING ROADS

AVERAGE VALUE

LOCAL CONDITION FA	VOL	GA	ANNUAL CHANGE (%)	84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	3979.	*******	*******	*******	*******	*******
1	1	2	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	3	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	2125.
1	1	4	0.000	*******	*******	*******	*******	*******	*******	*******	*******	4860.	*******	*******	*******	*******	3180.	4868.
1	2	1	1.887	8326.	8169.	8012.	7855.	7698.	7541.	7384.	7227.	7069.	6912.	6755.	*******	*******	*******	*******
1	2	2	2.282	21491.	21001.	20510.	20020.	19529.	19039.	18548.	18058.	17568.	17077.	16587.	16096.	15606.	15115.	14625.
1	2	3	4.743	40650.	38722.	36794.	34866.	32938.	31010.	29081.	27153.	25225.	23297.	21369.	19441.	17513.	15585.	13657.
1	2	4	0.644	12061.	11984.	11906.	11829.	11751.	11673.	11596.	11518.	11440.	11363.	11285.	11208.	11130.	11052.	10975.
1	AVERAGE		5.101	31287.	29691.	28095.	26499.	24903.	23307.	21711.	20115.	18519.	16923.	15327.	13731.	12135.	10538.	8942.
2	1	1	-0.892	2586.	2609.	2632.	2656.	2679.	2702.	2725.	2748.	2771.	2794.	2817.	2840.	2863.	2886.	2909.
2	1	2	-1.845	2377.	2420.	2464.	2508.	2552.	2596.	2640.	2684.	2727.	2771.	2815.	2859.	2903.	2947.	2990.
2	1	3	2.788	3584.	3484.	3384.	3284.	3184.	3084.	2984.	2884.	2785.	2685.	2585.	2485.	2385.	2285.	2185.
2	1	4	-1.300	2191.	2219.	2248.	2276.	2305.	2333.	2362.	2390.	2419.	2447.	2476.	2504.	2533.	2561.	2590.
2	2	1	-0.377	9618.	9654.	9691.	9727.	9763.	9799.	9836.	9872.	9908.	9945.	9981.	10017.	10054.	10090.	10126.
2	2	2	-0.492	9691.	9738.	9786.	9834.	9881.	9929.	9977.	10025.	10072.	10120.	10168.	10215.	10263.	10311.	10358.
2	2	3	-0.139	13839.	13858.	13878.	13897.	13916.	13936.	13955.	13974.	13993.	14013.	14032.	14051.	14070.	14090.	14109.
2	2	4	-1.651	8147.	8281.	8416.	8550.	8685.	8819.	8954.	9089.	9223.	9358.	9492.	9627.	9761.	9896.	10030.
2	AVERAGE		2.618	7131.	6944.	6757.	6571.	6384.	6197.	6011.	5824.	5637.	5451.	5264.	5077.	4891.	4704	4518.
3	1	1	-6.382	1670.	1776.	1883.	1989.	2096.	2202.	2309.	2416.	2522.	2629.	2735.	2842.	2948.	3055.	3161.
3	1	2	-4.328	2045.	2133.	2222.	2310.	2399.	2487.	2576.	2664.	2753.	2841.	2930.	3018.	3107.	3195.	3284.
3	1	3	0.875	2268.	2248.	2228.	2208.	2188.	2168.	2149.	2129.	2109.	2089.	2069.	2049.	2030.	2010.	1990.
3	1	4	1.347	2109.	2080.	2052.	2023.	1995.	1967.	1938.	1910.	1881.	1853.	1825.	1796.	1768.	1739.	1711.
3	2	1	-4.351	8014.	8362.	8711.	9060.	9408.	9757.	10106.	10454.	10803.	11152.	11501.	11849.	12198.	12547.	12895.
3	2	2	1.637	9712.	9553.	9394.	9235.	9076.	8918.	8759.	8600.	8441.	8282.	8123.	7964.	7805.	7646.	7487.
3	2	3	-1.901	11224.	11437.	11651.	11864.	12077.	12291.	12504.	12718.	12931.	13144.	13358.	13571.	13785.	13998.	14211.
3	2	4	0.516	7666.	7626.	7587.	7547.	7508.	7468.	7428.	7389.	7349.	7310.	7270.	7231.	7191.	7151.	7112.
3	AVERAGE		-6.211	4507.	4787.	5067.	5347.	5627.	5907.	6187.	6467.	6747.	7027.	7307.	7587.	7867.	8147.	8427.
4	1	1	2.743	1980.	1926.	1872.	1817.	1763.	1709.	1655.	1600.	1546.	1492.	1437.	1383.	1329.	1274.	1220.
4	1	2	3.000	1923.	1866.	1808.	1750.	1693.	1635.	1577.	1520.	1462.	1404.	1346.	1289.	1231.	1173.	1116.
4	1	3	3.063	2434.	2360.	2285.	2211.	2136.	2061.	1987.	1912.	1838.	1763.	1689.	1614.	1540.	1465.	1390.
4	1	4	-3.159	1114.	1149.	1185.	1220.	1255.	1290.	1325.	1361.	1396.	1431.	1466.	1501.	1537.	1572.	1607.
4	2	1	-1.988	*******	5940.	6059.	6177.	6295.	6413.	6531.	6649.	6767.	6885.	7003.	7122.	7240.	7358.	7476.
4	2	2	-0.874	*******	6362.	6418.	6474.	6529.	6585.	6640.	6696.	6752.	6807.	6863.	6918.	6974.	7030.	7085.
4	2	3	1.832	7561.	7422.	7284.	7145.	7007.	6868.	6730.	6591.	6453.	6314.	6176.	6037.	5899.	5760.	5622.
4	2	4	0.262	*******	*******	*******	7277.	7257.	7238.	7219.	7200.	7181.	7162.	7143.	7124.	7105.	7086.	7067.
4	AVERAGE		2.041	2284.	2237.	2191.	2144.	2098.	2051.	2004.	1958.	1911.	1864.	1818.	1771.	1725.	1678.	1631.
5	1	1	-7.821	532.	574.	615.	657.	699.	740.	782.	823.	865.	907.	948.	990.	1031.	1073.	1115.
5	1	2	-0.472	715.	719.	722.	726.	729.	732.	736.	739.	742.	746.	749.	753.	756.	759.	763.
5	1	3	-0.564	830.	835.	840.	844.	849.	854.	858.	863.	868.	872.	877.	882.	886.	891.	896.
5	1	4	-0.016	1038.	1038.	1038.	1038.	1039.	1039.	1039.	1039.	1039.	1039.	1040.	1040.	1040.	1040.	1040.
5	2	1	0.000	*******	*******	*******	*******	*******	*******	5471.	*******	*******	*******	*******	*******	13289.	*******	*******
5	2	2	-6.544	5312.	5660.	6007.	6355.	6703.	7050.	7398.	7746.	8093.	8441.	8788.	9136.	9484.	9831.	10179.
5	2	3	-6.978	5849.	6257.	6665.	7074.	7482.	7890.	8298.	8706.	9114.	9523.	9931.	10339.	10747.	11155.	11563.
5	2	4	-0.744	7922.	7980.	8039.	8098.	8157.	8216.	8275.	8334.	8393.	8452.	8511.	8570.	8629.	8688.	8747.
5	AVERAGE		-5.332	947.	998.	1048.	1099.	1149.	1200.	1250.	1301.	1351.	1402.	1452.	1503.	1553.	1604.	1654.

COAL-HAULING ROADS

AVERAGE VALUE

LOCAL CONDITION VOL	CT	ANNUAL CHANGE (%)	84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	-2.903	1937.	1993.	2049.	2105.	2162.	2218.	2274.	*******	*******	*******	*******	*******	*******	*******	*******
1	2	-1.761	2216.	2255.	2294.	2334.	2373.	2412.	2451.	*******	*******	*******	*******	*******	*******	*******	*******
1	3	2.726	2473.	2405.	2338.	2270.	2203.	2136.	2068.	*******	*******	*******	*******	*******	*******	*******	*******
2	1	-5.273	12304.	12953.	13602.	14251.	14900.	15548.	16197.	*******	*******	*******	*******	*******	*******	*******	*******
2	2	-9.250	10493.	11464.	12434.	13405.	14376.	15346.	16317.	*******	*******	*******	*******	*******	*******	*******	*******
2	3	-2.154	8844.	9034.	9225.	9415.	9606.	9796.	9987.	*******	*******	*******	*******	*******	*******	*******	*******

Figure G-1. Cross-Tabulation Matrix with Results of Linear Smoothing for Annual Average Daily Traffic

PERCENT TRUCKS

NON-COAL-HAULING ROADS

LOCAL CONDITION FA	VOL	GA	ANNUAL CHANGE (%)	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	11.364	*******	*******	*******	*******	*******
1	1	2	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	3	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	14.265
1	1	4	0.000	*******	*******	*******	*******	*******	*******	*******	*******	16.756	*******	*******	*******	*******	13.440	21.000
1	2	1	7.738	34.171	31.527	28.882	26.238	23.594	20.950	18.306	15.662	13.018	10.374	7.730	*******	*******	*******	*******
1	2	2	1.547	31.960	31.466	30.971	30.477	29.983	29.489	28.994	28.500	28.006	27.511	27.017	26.523	26.029	25.534	25.040
1	2	3	0.530	21.827	21.711	21.595	21.480	21.364	21.248	21.133	21.017	20.901	20.786	20.670	20.554	20.439	20.323	20.207
1	2	4	2.363	28.417	27.745	27.073	26.402	25.730	25.059	24.387	23.715	23.044	22.372	21.700	21.029	20.357	19.686	19.014
1	AVERAGE		1.264	25.122	24.804	24.487	24.169	23.852	23.534	23.217	22.899	22.581	22.264	21.946	21.629	21.311	20.994	20.676
2	1	1	-4.120	11.559	12.036	12.512	12.988	13.464	13.940	14.417	14.893	15.369	15.845	16.321	16.798	17.274	17.750	18.226
2	1	2	-0.889	11.444	11.546	11.648	11.749	11.851	11.953	12.054	12.156	12.258	12.360	12.461	12.563	12.665	12.766	12.868
2	1	3	-6.415	6.109	6.501	6.893	7.285	7.677	8.069	8.460	8.852	9.244	9.636	10.028	10.420	10.812	11.204	11.596
2	1	4	-4.456	9.493	9.916	10.339	10.762	11.185	11.608	12.031	12.454	12.877	13.300	13.723	14.146	14.569	14 992	15.415
2	2	1	-7.991	7.417	8.010	8.602	9.195	9.788	10.380	10.973	11.566	12.158	12.751	13.344	13.937	14.529	15.122	15.715
2	2	2	-0.003	7.191	7.192	7.192	7.192	7.192	7.193	7.193	7.193	7.193	7.193	7.194	7.194	7.194	7.194	7.195
2	2	3	-9.345	5.004	5.471	5.939	6.406	6.874	7.342	7.809	8.277	8.744	9.212	9.680	10.147	10.615	11.082	11.550
2	2	4	-6.742	8.973	9.578	10.183	10.788	11.393	11.998	12.603	13.208	13.813	14.418	15.023	15.628	16.233	16.838	17.443
2	AVERAGE		-5.703	8.157	8.622	9.087	9.552	10.018	10.483	10.948	11.413	11.878	12.344	12.809	13.274	13.739	14.205	14.670
3	1	1	-14.583	3.032	3.474	3.916	4.358	4.800	5.242	5.684	6.126	6.569	7.011	7.453	7.895	8.337	8.779	9.221
3	1	2	-7.242	3.961	4.248	4.535	4.822	5.109	5.396	5.683	5.970	6.257	6.544	6.830	7.117	7.404	7.691	7.978
3	1	3	-12.827	3.127	3.528	3.929	4.330	4.731	5.132	5.533	5.934	6.336	6.737	7.138	7.539	7.940	8.341	8.742
3	1	4	-24.484	1.677	2.087	2.498	2.908	3.319	3.729	4.140	4.550	4.961	5.372	5.782	6.193	6.603	7.014	7.424
3	2	1	-8.743	2.940	3.198	3.455	3.712	3.969	4.226	4.483	4.740	4.997	5.254	5.511	5.768	6.025	6.283	6.540
3	2	2	-8.711	3.770	4.098	4.427	4.755	5.084	5.412	5.740	6.069	6.397	6.726	7.054	7.382	7.711	8.039	8.368
3	2	3	-0.643	4.524	4.553	4.582	4.611	4.640	4.669	4.698	4.727	4.756	4.785	4.814	4.844	4.873	4.902	4.931
3	2	4	-36.167	1.901	2.589	3.277	3.964	4.652	5.340	6.027	6.715	7.403	8.091	8.778	9.466	10.154	10.841	11.529
3	AVERAGE		-9.942	3.298	3.626	3.954	4.282	4.609	4.937	5.265	5.593	5.921	6.249	6.577	6.905	7.233	7.560	7.888
4	1	1	-0.756	8.456	8.520	8.584	8.648	8.712	8.776	8.840	8.904	8.968	9.032	9.096	9.160	9.224	9.288	9.352
4	1	2	-2.488	8.017	8.216	8.416	8.615	8.814	9.014	9.213	9.413	9.612	9.811	10.011	10.210	10.410	10.609	10.809
4	1	3	-2.468	6.489	6.649	6.809	6.969	7.129	7.289	7.449	7.610	7.770	7.930	8.090	8.250	8.410	8.570	8.730
4	1	4	-2.933	8.782	9.040	9.298	9.555	9.813	10.070	10.328	10.585	10.843	11.100	11.358	11.616	11.873	12.131	12.388
4	2	1	6.117	*******	13.904	13.053	12.203	11.352	10.502	9.651	8.801	7.950	7.100	6.249	5.399	4.548	3.697	2.847
4	2	2	-3.084	*******	5.761	5.938	6.116	6.294	6.471	6.649	6.827	7.004	7.182	7.360	7.537	7.715	7.893	8.071
4	2	3	3.825	8.685	8.353	8.020	7.688	7.356	7.024	6.692	6.359	6.027	5.695	5.363	5.031	4.698	4.366	4.034
4	2	4	5.151	*******	*******	*******	12.595	11.946	11.298	10.649	10.000	9.351	8.703	8.054	7.405	6.756	6.108	5.459
4	AVERAGE		-2.250	7.969	8.149	8.328	8.507	8.687	8.866	9.045	9.225	9.404	9.583	9.763	9.942	10.121	10.301	10.480
5	1	1	0.560	6.080	6.046	6.012	5.978	5.944	5.910	5.876	5.842	5.808	5.774	5.740	5.705	5.671	5.637	5.603
5	1	2	0.520	6.940	6.904	6.868	6.832	6.796	6.759	6.723	6.687	6.651	6.615	6.579	6.543	6.507	6.471	6.435
5	1	3	-2.964	5.223	5.378	5.533	5.688	5.842	5.997	6.152	6.307	6.462	6.616	6.771	6.926	7.081	7.236	7.390
5	1	4	-2.986	7.264	7.481	7.698	7.915	8.131	8.348	8.565	8.782	8.999	9.216	9.433	9.650	9.867	10.083	10.300
5	2	1	0.000	*******	*******	*******	*******	*******	*******	5.369	*******	*******	*******	*******	*******	3.276	*******	*******
5	2	2	-15.751	2.942	3.405	3.868	4.332	4.795	5.258	5.722	6.185	6.648	7.112	7.575	8.039	8.502	8.965	9.429
5	2	3	5.541	9 540	9.011	8.482	7.954	7.425	6.897	6.368	5.840	5.311	4.783	4.254	3.725	3.197	2.668	2.140
5	2	4	-13.428	1.908	2.164	2.420	2.676	2.932	3.189	3.445	3.701	3.957	4.213	4.469	4.726	4.982	5.238	5.494
5	AVERAGE		-1.584	6.318	6.419	6.519	6.619	6.719	6.819	6.919	7.019	7.119	7.219	7.319	7.419	7.520	7.620	7.720

COAL-HAULING ROADS

LOCAL CONDITION VOL	CT	ANNUAL CHANGE (%)	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	-16.755	6.522	7.614	8.707	9.800	10.892	11.985	13.078	*******	*******	*******	*******	*******	*******	*******	*******
1	2	-3.945	8.796	9.143	9.490	9.837	10.184	10.531	10.878	*******	*******	*******	*******	*******	*******	*******	*******
1	3	-2.839	15.939	16.392	16.844	17.297	17.749	18.202	18.654	*******	*******	*******	*******	*******	*******	*******	*******
2	1	-10.657	9.974	11.037	12.100	13.163	14.226	15.289	16.352	*******	*******	*******	*******	*******	*******	*******	*******
2	2	-4.256	10.030	10.457	10.884	11.311	11.738	12.165	12.592	*******	*******	*******	*******	*******	*******	*******	*******
2	3	-6.639	13.401	14.290	15.180	16.070	16.959	17.849	18.739	*******	*******	*******	*******	*******	*******	*******	*******

Figure G-2. Cross-Tabulation Matrix with Results of Linear Smoothing for Percent Trucks

PERCENT TRUCKS HAULING COAL
NON-COAL-HAULING ROADS

LOCAL CONDITION FA	VOL	GA	ANNUAL CHANGE (%)	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.000	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1	1	2	0.000	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1	1	3	0.000	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1	1	4	0.000	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1	2	1	0.000	*****	*****	0.881	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1	2	2	-0.005	0.000	0.003	0.008	0.013	0.018	0.023	0.028	*****	*****	*****	*****	*****	*****	*****	*****
1	2	3	-110.622	0.078	0.165	0.252	0.338	0.425	0.511	0.598	*****	*****	*****	*****	*****	*****	*****	*****
1	2	4	8.148	0.872	0.801	0.730	0.659	0.588	0.517	0.446	*****	*****	*****	*****	*****	*****	*****	*****
1	AVERAGE		-2.602	0.225	0.231	0.237	0.243	0.249	0.254	0.260	*****	*****	*****	*****	*****	*****	*****	*****
2	1	1	0.000	0.015	0.015	0.015	0.015	0.015	0.015	0.015	*****	*****	*****	*****	*****	*****	*****	*****
2	1	2	15.589	0.032	0.027	0.022	0.017	0.012	0.007	0.002	*****	*****	*****	*****	*****	*****	*****	*****
2	1	3	-7.756	0.071	0.077	0.082	0.088	0.093	0.099	0.104	*****	*****	*****	*****	*****	*****	*****	*****
2	1	4	30.514	0.156	0.108	0.061	0.013	0.000	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****
2	2	1	24.340	0.130	0.099	0.067	0.035	0.003	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****
2	2	2	9.784	0.109	0.099	0.088	0.077	0.067	0.056	0.045	*****	*****	*****	*****	*****	*****	*****	*****
2	2	3	-188.257	0.021	0.061	0.101	0.142	0.182	0.222	0.262	*****	*****	*****	*****	*****	*****	*****	*****
2	2	4	28.267	0.356	0.255	0.155	0.054	0.000	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****
2	AVERAGE		14.765	0.083	0.071	0.059	0.046	0.034	0.022	0.010	*****	*****	*****	*****	*****	*****	*****	*****
3	1	1	3.058	0.020	0.020	0.019	0.019	0.018	0.017	0.017	*****	*****	*****	*****	*****	*****	*****	*****
3	1	2	-1.492	0.009	0.009	0.010	0.010	0.010	0.010	0.010	*****	*****	*****	*****	*****	*****	*****	*****
3	1	3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****
3	1	4	-0.023	0.000	0.001	0.023	0.046	0.068	0.091	0.114	*****	*****	*****	*****	*****	*****	*****	*****
3	2	1	-0.083	0.000	0.044	0.126	0.209	0.292	0.375	*****	*****	*****	*****	*****	*****	*****	*****	*****
3	2	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****
3	2	3	16.234	0.055	0.046	0.037	0.028	0.019	0.010	0.001	*****	*****	*****	*****	*****	*****	*****	*****
3	2	4	-145.450	0.016	0.040	0.064	0.088	0.112	0.136	*****	*****	*****	*****	*****	*****	*****	*****	*****
3	AVERAGE		-21.573	0.014	0.018	0.021	0.024	0.027	0.030	0.033	*****	*****	*****	*****	*****	*****	*****	*****
4	1	1	21.535	0.073	0.058	0.042	0.026	0.010	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****
4	1	2	-35.629	0.013	0.018	0.023	0.028	0.033	0.038	0.042	*****	*****	*****	*****	*****	*****	*****	*****
4	1	3	-12.983	0.044	0.049	0.055	0.061	0.066	0.072	0.078	*****	*****	*****	*****	*****	*****	*****	*****
4	1	4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****
4	2	1	0.000	*****	*****	*****	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
4	2	2	0.000	*****	*****	*****	0.128	0.264	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
4	2	3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****	*****
4	2	4	0.000	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
4	AVERAGE		-2.716	0.030	0.031	0.032	0.033	0.034	0.034	0.035	*****	*****	*****	*****	*****	*****	*****	*****
5	1	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****
5	1	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****
5	1	3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****
5	1	4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****
5	2	1	0.000	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
5	2	2	0.000	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
5	2	3	0.000	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
5	2	4	36.363	1.047	0.666	0.286	0.000	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****	*****
5	AVERAGE		34.365	0.026	0.017	0.008	0.000	0.000	0.000	0.000	*****	*****	*****	*****	*****	*****	*****	*****

COAL-HAULING ROADS

LOCAL CONDITION VOL	CT	ANNUAL CHANGE (%)	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	3.216	2.910	2.816	2.723	2.629	2.536	2.442	2.349	*****	*****	*****	*****	*****	*****	*****	*****
1	2	-4.932	9.874	10.361	10.848	11.335	11.822	12.309	12.796	*****	*****	*****	*****	*****	*****	*****	*****
1	3	3.706	50.274	48.410	46.547	44.684	42.821	40.957	39.094	*****	*****	*****	*****	*****	*****	*****	*****
2	1	-5.660	2.007	2.120	2.234	2.347	2.461	2.574	2.688	*****	*****	*****	*****	*****	*****	*****	*****
2	2	1.785	12.830	12.601	12.372	12.143	11.914	11.685	11.456	*****	*****	*****	*****	*****	*****	*****	*****
2	3	0.077	34.778	34.751	34.725	34.698	34.671	34.644	34.618	*****	*****	*****	*****	*****	*****	*****	*****

Figure G-3. Cross-Tabulation Matrix with Results of Linear Smoothing for Percent Trucks Hauling Coal

AXLES PER TRUCK (NON-COAL-HAULING)

NON-COAL-HAULING ROADS

AVERAGE VALUE

LOCAL CONDITION FA	VOL	GA	ANNUAL CHANGE (%)	84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	3.739	*******	*******	*******	*******	*******
1	1	2	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	3	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	3.307
1	1	4	0.000	*******	*******	*******	*******	*******	*******	*******	*******	4.355	*******	*******	*******	*******	3.093	3.872
1	2	1	3.089	4.944	4.791	4.638	4.485	4.333	4.180	4.027	3.875	3.722	3.569	3.416	*******	*******	*******	*******
1	2	2	0.388	4.525	4.507	4.490	4.472	4.454	4.437	4.419	4.402	4.384	4.367	4.349	4.331	4.314	4.296	4.279
1	2	3	0.074	4.248	4.245	4.242	4.238	4.235	4.232	4.229	4.226	4.223	4.220	4.216	4.213	4.210	4.207	4.204
1	2	4	0.538	4.414	4.390	4.366	4.342	4.319	4.295	4.271	4.247	4.224	4.200	4.176	4.152	4.129	4.105	4.081
1	AVERAGE		0.406	4.366	4.349	4.331	4.313	4.295	4.278	4.260	4.242	4.224	4.207	4.189	4.171	4.153	4.136	4.118
2	1	1	0.013	3.590	3.590	3.590	3.589	3.589	3.588	3.588	3.587	3.587	3.586	3.586	3.585	3.585	3.585	3.584
2	1	2	0.672	3.298	3.276	3.254	3.232	3.210	3.187	3.165	3.143	3.121	3.099	3.077	3.054	3.032	3.010	2.988
2	1	3	-0.254	2.843	2.851	2.858	2.865	2.872	2.879	2.887	2.894	2.901	2.908	2.915	2.923	2.930	2.937	2.944
2	1	4	-0.357	2.928	2.938	2.949	2.959	2.969	2.980	2.990	3.001	3.011	3.022	3.032	3.042	3.053	3.063	3.074
2	2	1	-1.652	3.126	3.178	3.230	3.281	3.333	3.384	3.436	3.488	3.539	3.591	3.643	3.694	3.746	3.798	3.849
2	2	2	1.184	3.135	3.098	3.061	3.024	2.987	2.950	2.913	2.876	2.839	2.801	2.764	2.727	2.690	2.653	2.616
2	2	3	-1.577	2.768	2.811	2.855	2.899	2.942	2.986	3.030	3.073	3.117	3.161	3.204	3.248	3.292	3.335	3.379
2	2	4	-2.095	2.895	2.955	3.016	3.077	3.137	3.198	3.259	3.319	3.380	3.441	3.501	3.562	3.622	3.683	3.744
2	AVERAGE		-0.367	3.077	3.088	3.100	3.111	3.122	3.134	3.145	3.156	3.167	3.179	3.190	3.201	3.213	3.224	3.235
3	1	1	-1.296	2.323	2.353	2.383	2.413	2.444	2.474	2.504	2.534	2.564	2.594	2.624	2.654	2.684	2.714	2.745
3	1	2	0.260	2.536	2.530	2.523	2.516	2.510	2.503	2.497	2.490	2.484	2.477	2.470	2.464	2.457	2.451	2.444
3	1	3	-0.559	2.405	2.418	2.432	2.445	2.459	2.472	2.486	2.499	2.513	2.526	2.539	2.553	2.566	2.580	2.593
3	1	4	-0.024	2.345	2.345	2.346	2.346	2.347	2.347	2.348	2.349	2.349	2.350	2.350	2.351	2.351	2.352	2.353
3	2	1	-1.481	2.546	2.584	2.622	2.659	2.697	2.735	2.772	2.810	2.848	2.886	2.923	2.961	2.999	3.036	3.074
3	2	2	-0.126	2.675	2.678	2.681	2.685	2.688	2.691	2.695	2.698	2.702	2.705	2.708	2.712	2.715	2.718	2.722
3	2	3	-0.468	2.558	2.570	2.582	2.594	2.606	2.618	2.630	2.642	2.654	2.666	2.678	2.690	2.702	2.714	2.726
3	2	4	-2.319	2.352	2.407	2.461	2.516	2.570	2.625	2.679	2.734	2.789	2.843	2.898	2.952	3.007	3.061	3.116
3	AVERAGE		-0.924	2.431	2.453	2.476	2.498	2.521	2.543	2.566	2.588	2.611	2.633	2.655	2.678	2.700	2.723	2.745
4	1	1	0.092	2.836	2.834	2.831	2.828	2.826	2.823	2.821	2.818	2.815	2.813	2.810	2.808	2.805	2.802	2.800
4	1	2	0.830	2.763	2.740	2.717	2.694	2.672	2.649	2.626	2.603	2.580	2.557	2.534	2.511	2.488	2.465	2.442
4	1	3	1.048	2.770	2.741	2.712	2.683	2.654	2.625	2.596	2.567	2.538	2.509	2.480	2.451	2.422	2.393	2.364
4	1	4	-0.104	2.689	2.692	2.695	2.698	2.701	2.703	2.706	2.709	2.712	2.715	2.717	2.720	2.723	2.726	2.729
4	2	1	1.634	*******	3.608	3.549	3.490	3.431	3.372	3.313	3.254	3.195	3.136	3.077	3.018	2.959	2.900	2.841
4	2	2	-0.354	*******	2.771	2.781	2.791	2.801	2.811	2.820	2.830	2.840	2.850	2.860	2.869	2.879	2.889	2.899
4	2	3	1.869	3.197	3.137	3.078	3.018	2.958	2.898	2.839	2.779	2.719	2.659	2.600	2.540	2.480	2.420	2.361
4	2	4	1.507	*******	*******	*******	3.215	3.166	3.118	3.070	3.021	2.973	2.924	2.876	2.827	2.779	2.730	2.682
4	AVERAGE		0.523	2.789	2.775	2.760	2.746	2.731	2.716	2.702	2.687	2.673	2.658	2.643	2.629	2.614	2.600	2.585
5	1	1	0.601	2.476	2.461	2.446	2.431	2.416	2.401	2.386	2.372	2.357	2.342	2.327	2.312	2.297	2.282	2.267
5	1	2	0.902	2.357	2.336	2.315	2.294	2.272	2.251	2.230	2.209	2.187	2.166	2.145	2.124	2.102	2.081	2.060
5	1	3	0.170	2.363	2.359	2.354	2.350	2.346	2.342	2.338	2.334	2.330	2.326	2.322	2.318	2.314	2.310	2.306
5	1	4	0.465	2.606	2.594	2.582	2.570	2.558	2.546	2.534	2.521	2.509	2.497	2.485	2.473	2.461	2.449	2.437
5	2	1	0.000	*******	*******	*******	*******	*******	*******	2.900	*******	*******	*******	*******	*******	2.823	*******	*******
5	2	2	-1.678	2.444	2.485	2.526	2.567	2.608	2.649	2.690	2.731	2.772	2.813	2.854	2.895	2.936	2.977	3.018
5	2	3	0.413	2.669	2.658	2.647	2.636	2.625	2.614	2.603	2.592	2.581	2.569	2.558	2.547	2.536	2.525	2.514
5	2	4	-1.555	2.172	2.206	2.239	2.273	2.307	2.341	2.375	2.408	2.442	2.476	2.510	2.543	2.577	2.611	2.645
5	AVERAGE		0.268	2.423	2.416	2.410	2.403	2.397	2.390	2.384	2.377	2.371	2.364	2.358	2.351	2.345	2.338	2.332

COAL-HAULING ROADS

AVERAGE VALUE

LOCAL CONDITION VOL	CT	ANNUAL CHANGE (%)	84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	-3.919	2.603	2.705	2.807	2.909	3.011	3.113	3.215	*******	*******	*******	*******	*******	*******	*******	*******
1	2	0.791	2.889	2.866	2.843	2.820	2.797	2.774	2.752	*******	*******	*******	*******	*******	*******	*******	*******
1	3	0.321	3.190	3.180	3.169	3.159	3.149	3.139	3.128	*******	*******	*******	*******	*******	*******	*******	*******
2	1	-1.760	3.359	3.418	3.477	3.536	3.595	3.655	3.714	*******	*******	*******	*******	*******	*******	*******	*******
2	2	-1.242	3.305	3.347	3.388	3.429	3.470	3.511	3.552	*******	*******	*******	*******	*******	*******	*******	*******
2	3	-0.509	3.167	3.183	3.199	3.215	3.232	3.248	3.264	*******	*******	*******	*******	*******	*******	*******	*******

Figure G-4. Cross-Tabulation Matrix with Results of Linear Smoothing for Axles per Truck (Non-Coal-Hauling)

AXLES PER TRUCK (COAL-HAULING)
NON-COAL-HAULING ROADS

LOCAL CONDITION FA	VOL	GA	ANNUAL CHANGE (%)	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
1	1	2	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
1	1	3	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
1	1	4	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
1	2	1	0.000	****	****	4.368	****	****	****	****	****	****	****	****	****	****	****	****
1	2	2	0.000	****	****	****	4.500	4.358	****	****	****	****	****	****	****	****	****	****
1	2	3	-0.226	4.336	4.346	4.356	4.366	4.376	4.386	4.395	****	****	****	****	****	****	****	****
1	2	4	0.478	4.387	4.366	4.345	4.324	4.303	4.282	4.261	****	****	****	****	****	****	****	****
1	AVERAGE		-0.153	4.347	4.353	4.360	4.367	4.373	4.380	4.386	****	****	****	****	****	****	****	****
2	1	1	0.000	****	****	4.333	****	****	****	****	****	****	****	****	****	****	****	****
2	1	2	0.000	5.000	5.000	****	4.000	****	****	****	****	****	****	****	****	****	****	****
2	1	3	-8.404	3.847	4.171	4.494	4.817	5.141	5.464	****	****	****	****	****	****	****	****	****
2	1	4	0.000	4.333	4.333	****	****	****	****	****	****	****	****	****	****	****	****	****
2	2	1	0.000	****	****	4.353	****	****	****	****	****	****	****	****	****	****	****	****
2	2	2	0.566	4.635	4.609	4.583	4.557	4.530	4.504	4.478	****	****	****	****	****	****	****	****
2	2	3	-1.352	4.143	4.199	4.255	4.311	4.367	4.423	4.479	****	****	****	****	****	****	****	****
2	2	4	0.000	4.500	4.500	****	****	****	****	****	****	****	****	****	****	****	****	****
2	AVERAGE		1.122	4.534	4.483	4.432	4.381	4.330	4.280	4.229	****	****	****	****	****	****	****	****
3	1	1	0.000	5.000	5.000	****	****	4.000	****	****	****	****	****	****	****	****	****	****
3	1	2	0.000	****	****	5.000	****	****	****	****	****	****	****	****	****	****	****	****
3	1	3	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
3	1	4	0.000	****	****	****	****	3.789	****	****	****	****	****	****	****	****	****	****
3	2	1	0.000	****	****	5.000	4.500	****	****	****	****	****	****	****	****	****	****	****
3	2	2	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
3	2	3	-0.612	4.197	4.223	4.248	4.274	4.300	4.325	4.351	****	****	****	****	****	****	****	****
3	2	4	0.000	****	****	4.000	****	****	****	****	****	****	****	****	****	****	****	****
3	AVERAGE		1.016	4.437	4.392	4.347	4.302	4.257	4.212	4.167	****	****	****	****	****	****	****	****
4	1	1	0.000	5.000	5.000	****	****	5.000	****	****	****	****	****	****	****	****	****	****
4	1	2	0.000	****	****	****	5.000	****	****	****	****	****	****	****	****	****	****	****
4	1	3	0.000	5.000	5.000	5.000	5.000	5.000	5.000	****	****	****	****	****	****	****	****	****
4	1	4	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
4	2	1	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
4	2	2	0.000	****	****	****	4.358	4.000	****	****	****	****	****	****	****	****	****	****
4	2	3	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
4	2	4	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
4	AVERAGE		1.858	5.076	4.982	4.888	4.793	4.699	4.605	4.510	****	****	****	****	****	****	****	****
5	1	1	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
5	1	2	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
5	1	3	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
5	1	4	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
5	2	1	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
5	2	2	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
5	2	3	0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
5	2	4	0.000	4.000	4.000	****	****	****	****	****	****	****	****	****	****	****	****	****
5	AVERAGE		0.000	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****

COAL-HAULING ROADS

LOCAL CONDITION VOL	CT	ANNUAL CHANGE (%)	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	-0.578	4.255	4.280	4.305	4.329	4.354	4.378	4.403	****	****	****	****	****	****	****	****
1	2	1.546	4.354	4.287	4.220	4.152	4.085	4.018	3.950	****	****	****	****	****	****	****	****
1	3	-0.134	4.074	4.080	4.085	4.091	4.096	4.102	4.107	****	****	****	****	****	****	****	****
2	1	0.003	4.329	4.329	4.329	4.329	4.329	4.329	4.329	****	****	****	****	****	****	****	****
2	2	-0.868	4.243	4.279	4.316	4.353	4.390	4.427	4.464	****	****	****	****	****	****	****	****
2	3	0.442	4.296	4.277	4.258	4.239	4.220	4.201	4.182	****	****	****	****	****	****	****	****

Figure G-5. Cross Tabulation Matrix with Results of Linear Smoothing for Axles per Truck (Coal-Hauling)

EAL'S PER TRUCK AXLE (NON-COAL-HAULING)
NON-COAL-HAULING ROADS

LOCAL CONDITION FA	VOL	GA	ANNUAL CHANGE (%)	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	0.134	*******	*******	*******	*******	*******
1	1	2	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
1	1	3	0.000	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	*******	0.125
1	1	4	0.000	*******	*******	*******	*******	*******	*******	*******	*******	0.138	*******	*******	*******	*******	0.126	0.122
1	2	1	0.681	0.153	0.152	0.151	0.150	0.149	0.148	0.147	0.146	0.145	0.144	0.143	*******	*******	*******	*******
1	2	2	1.577	0.157	0.154	0.152	0.149	0.147	0.144	0.142	0.139	0.137	0.134	0.132	0.129	0.127	0.124	0.122
1	2	3	1.418	0.153	0.150	0.148	0.146	0.144	0.142	0.140	0.137	0.135	0.133	0.131	0.129	0.127	0.124	0.122
1	2	4	1.388	0.151	0.149	0.147	0.145	0.143	0.140	0.138	0.136	0.134	0.132	0.130	0.128	0.126	0.124	0.122
1	AVERAGE		1.441	0.153	0.151	0.149	0.147	0.144	0.142	0.140	0.138	0.136	0.133	0.131	0.129	0.127	0.125	0.122
2	1	1	1.592	0.157	0.155	0.152	0.150	0.147	0.145	0.142	0.140	0.137	0.135	0.132	0.130	0.127	0.125	0.122
2	1	2	1.551	0.160	0.157	0.155	0.152	0.150	0.147	0.145	0.142	0.140	0.137	0.135	0.132	0.130	0.128	0.125
2	1	3	2.195	0.165	0.161	0.158	0.154	0.150	0.147	0.143	0.140	0.136	0.132	0.129	0.125	0.121	0.118	0.114
2	1	4	1.711	0.157	0.154	0.152	0.149	0.146	0.144	0.141	0.138	0.135	0.133	0.130	0.127	0.125	0.122	0.119
2	2	1	2.465	0.166	0.162	0.158	0.154	0.150	0.145	0.141	0.137	0.133	0.129	0.125	0.121	0.117	0.113	0.109
2	2	2	1.449	0.160	0.157	0.155	0.153	0.150	0.148	0.146	0.143	0.141	0.139	0.136	0.134	0.132	0.130	0.127
2	2	3	2.268	0.173	0.169	0.165	0.161	0.157	0.153	0.149	0.145	0.141	0.137	0.134	0.130	0.126	0.122	0.118
2	2	4	2.273	0.162	0.158	0.155	0.151	0.147	0.144	0.140	0.136	0.132	0.129	0.125	0.121	0.118	0.114	0.110
2	AVERAGE		1.993	0.163	0.160	0.157	0.153	0.150	0.147	0.144	0.140	0.137	0.134	0.131	0.127	0.124	0.121	0.118
3	1	1	3.261	0.182	0.176	0.170	0.164	0.159	0.153	0.147	0.141	0.135	0.129	0.123	0.117	0.111	0.105	0.099
3	1	2	1.997	0.184	0.180	0.176	0.173	0.169	0.165	0.162	0.158	0.154	0.151	0.147	0.143	0.140	0.136	0.132
3	1	3	2.501	0.186	0.182	0.177	0.172	0.168	0.163	0.158	0.154	0.149	0.144	0.140	0.135	0.130	0.126	0.121
3	1	4	0.772	0.177	0.176	0.174	0.173	0.172	0.170	0.169	0.168	0.166	0.165	0.163	0.162	0.161	0.159	0.158
3	2	1	3.353	0.183	0.177	0.171	0.165	0.159	0.152	0.146	0.140	0.134	0.128	0.122	0.116	0.109	0.103	0.097
3	2	2	1.528	0.168	0.166	0.163	0.161	0.158	0.155	0.153	0.150	0.148	0.145	0.143	0.140	0.137	0.135	0.132
3	2	3	2.426	0.181	0.176	0.172	0.168	0.163	0.159	0.155	0.150	0.146	0.141	0.137	0.133	0.128	0.124	0.119
3	2	4	3.301	0.180	0.174	0.168	0.162	0.157	0.151	0.145	0.139	0.133	0.127	0.121	0.115	0.109	0.103	0.097
3	AVERAGE		2.494	0.182	0.178	0.173	0.169	0.164	0.160	0.155	0.151	0.146	0.141	0.137	0.132	0.128	0.123	0.119
4	1	1	1.792	0.163	0.160	0.157	0.154	0.151	0.148	0.145	0.142	0.139	0.136	0.134	0.131	0.128	0.125	0.122
4	1	2	2.183	0.175	0.171	0.167	0.163	0.160	0.156	0.152	0.148	0.144	0.141	0.137	0.133	0.129	0.125	0.121
4	1	3	1.693	0.165	0.162	0.159	0.156	0.153	0.151	0.148	0.145	0.142	0.140	0.137	0.134	0.131	0.128	0.126
4	1	4	1.909	0.164	0.161	0.158	0.154	0.151	0.148	0.145	0.142	0.139	0.136	0.133	0.129	0.126	0.123	0.120
4	2	1	2.423	*******	0.163	0.160	0.156	0.152	0.148	0.144	0.140	0.136	0.132	0.128	0.124	0.120	0.116	0.112
4	2	2	2.901	*******	0.170	0.165	0.160	0.155	0.150	0.145	0.140	0.135	0.130	0.125	0.120	0.115	0.111	0.106
4	2	3	1.877	0.159	0.156	0.153	0.150	0.147	0.144	0.141	0.138	0.135	0.132	0.129	0.126	0.123	0.120	0.117
4	2	4	1.340	*******	*******	*******	0.137	0.136	0.134	0.132	0.130	0.128	0.126	0.124	0.123	0.121	0.119	0.117
4	AVERAGE		1.944	0.167	0.164	0.160	0.157	0.154	0.151	0.147	0.144	0.141	0.138	0.134	0.131	0.128	0.125	0.121
5	1	1	3.097	0.183	0.177	0.171	0.166	0.160	0.154	0.149	0.143	0.138	0.132	0.126	0.121	0.115	0.109	0.104
5	1	2	2.637	0.180	0.175	0.170	0.166	0.161	0.156	0.151	0.147	0.142	0.137	0.132	0.128	0.123	0.118	0.113
5	1	3	2.080	0.183	0.179	0.175	0.171	0.168	0.164	0.160	0.156	0.152	0.149	0.145	0.141	0.137	0.133	0.130
5	1	4	3.115	0.194	0.188	0.182	0.176	0.170	0.163	0.157	0.151	0.145	0.139	0.133	0.127	0.121	0.115	0.109
5	2	1	0.000	*******	*******	*******	*******	*******	*******	0.137	*******	*******	*******	*******	*******	0.121	*******	*******
5	2	2	2.985	0.197	0.192	0.186	0.180	0.174	0.168	0.162	0.156	0.150	0.144	0.139	0.133	0.127	0.121	0.115
5	2	3	2.306	0.181	0.177	0.173	0.169	0.165	0.161	0.156	0.152	0.148	0.144	0.140	0.135	0.131	0 127	0.123
5	2	4	2.066	0.163	0.160	0.156	0.153	0.150	0.146	0.143	0.140	0.136	0.133	0.129	0.126	0.123	0.119	0.116
5	AVERAGE		2.731	0.184	0.179	0.174	0.169	0.164	0.159	0.154	0.149	0.144	0.139	0.134	0.129	0.124	0.119	0.114

COAL-HAULING ROADS

LOCAL CONDITION VOL	CT	ANNUAL CHANGE (%)	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	2.604	0.179	0.175	0.170	0.165	0.161	0.156	0.151	*******	*******	*******	*******	*******	*******	*******	*******
1	2	-0.278	0.164	0.165	0.165	0.166	0.166	0.167	0.167	*******	*******	*******	*******	*******	*******	*******	*******
1	3	0.907	0.168	0.167	0.165	0.164	0.162	0.161	0.159	*******	*******	*******	*******	*******	*******	*******	*******
2	1	0.838	0.160	0.158	0.157	0.156	0.154	0.153	0.152	*******	*******	*******	*******	*******	*******	*******	*******
2	2	1.512	0.159	0.157	0.154	0.152	0.149	0.147	0.145	*******	*******	*******	*******	*******	*******	*******	*******
2	3	2.279	0.170	0.166	0.162	0.158	0.154	0.150	0.147	*******	*******	*******	*******	*******	*******	*******	*******

Figure G-6. Cross-Tabulation Matrix with Results of Linear Smoothing for EAL's per Truck Axle (Non-Coal-Hauling)

EAL'S PER TRUCK AXLE (COAL-HAULING)
NON-COAL-HAULING ROADS

LOCAL CONDITION FA	VOL	GA	ANNUAL CHANGE (%)	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	1	0.000															
1	1	2	0.000															
1	1	3	0.000															
1	1	4	0.000															
1	2	1	0.000			1.420												
1	2	2	0.000				1.420	1.187										
1	2	3	2.205	1.506	1.472	1.439	1.406	1.373	1.340	1.307								
1	2	4	-2.904	1.360	1.399	1.439	1.478	1.517	1.557	1.596								
1	AVERAGE		1.430	1.481	1.460	1.439	1.418	1.397	1.375	1.354								
2	1	1	0.000			1.681												
2	1	2	0.000	0.356	0.361		2.471											
2	1	3	24.564	2.767	2.088	1.408	0.728	0.048	0.000									
2	1	4	0.000	1.631	1.681													
2	2	1	0.000			1.454												
2	2	2	-2.793	0.988	1.016	1.043	1.071	1.098	1.126	1.154								
2	2	3	6.132	2.010	1.887	1.764	1.641	1.517	1.394	1.271								
2	2	4	0.000	1.353	1.394													
2	AVERAGE		-7.076	1.254	1.343	1.431	1.520	1.609	1.698	1.786								
3	1	1	0.000	0.356	0.361			2.471										
3	1	2	0.000			0.361												
3	1	3	0.000															
3	1	4	0.000					0.638										
3	2	1	0.000			0.361	1.303											
3	2	2	0.000															
3	2	3	4.616	1.999	1.906	1.814	1.722	1.630	1.537	1.445								
3	2	4	0.000			2.506												
3	AVERAGE		3.230	1.600	1.548	1.497	1.445	1.393	1.342	1.290								
4	1	1	0.000	0.356	0.361			0.368										
4	1	2	0.000				0.368											
4	1	3	-1.001	0.356	0.360	0.363	0.367	0.370	0.374									
4	1	4	0.000															
4	2	1	0.000															
4	2	2	0.000				1.187	2.471										
4	2	3	0.000															
4	2	4	0.000															
4	AVERAGE		-93.098	0.196	0.378	0.560	0.742	0.925	1.107	1.289								
5	1	1	0.000															
5	1	2	0.000															
5	1	3	0.000															
5	1	4	0.000															
5	2	1	0.000															
5	2	2	0.000															
5	2	3	0.000															
5	2	4	0.000	2.428	2.506													
5	AVERAGE		0.000															

COAL-HAULING ROADS

LOCAL CONDITION VOL	CT	ANNUAL CHANGE (%)	AVERAGE VALUE 84	83	82	81	80	79	78	77	76	75	74	73	72	71	70
1	1	-11.426	1.086	1.210	1.334	1.458	1.582	1.706	1.830								
1	2	-5.904	1.367	1.448	1.529	1.609	1.690	1.771	1.852								
1	3	-1.427	1.764	1.789	1.814	1.840	1.865	1.890	1.915								
2	1	0.551	1.468	1.460	1.452	1.444	1.436	1.428	1.420								
2	2	4.558	1.614	1.541	1.467	1.394	1.320	1.246	1.173								
2	3	-1.639	1.456	1.480	1.504	1.528	1.552	1.576	1.599								

Figure G-7. Cross-Tabulation Matrix with Results of Linear Smoothing for EAL's per Truck Axle (Coal-Hauling)

APPENDIX H

GRAPHICAL COMPARISON OF AVERAGED TRAFFIC PARAMETERS AND TRAFFIC PARAMETERS PRODUCED BY LINEAR SMOOTHING

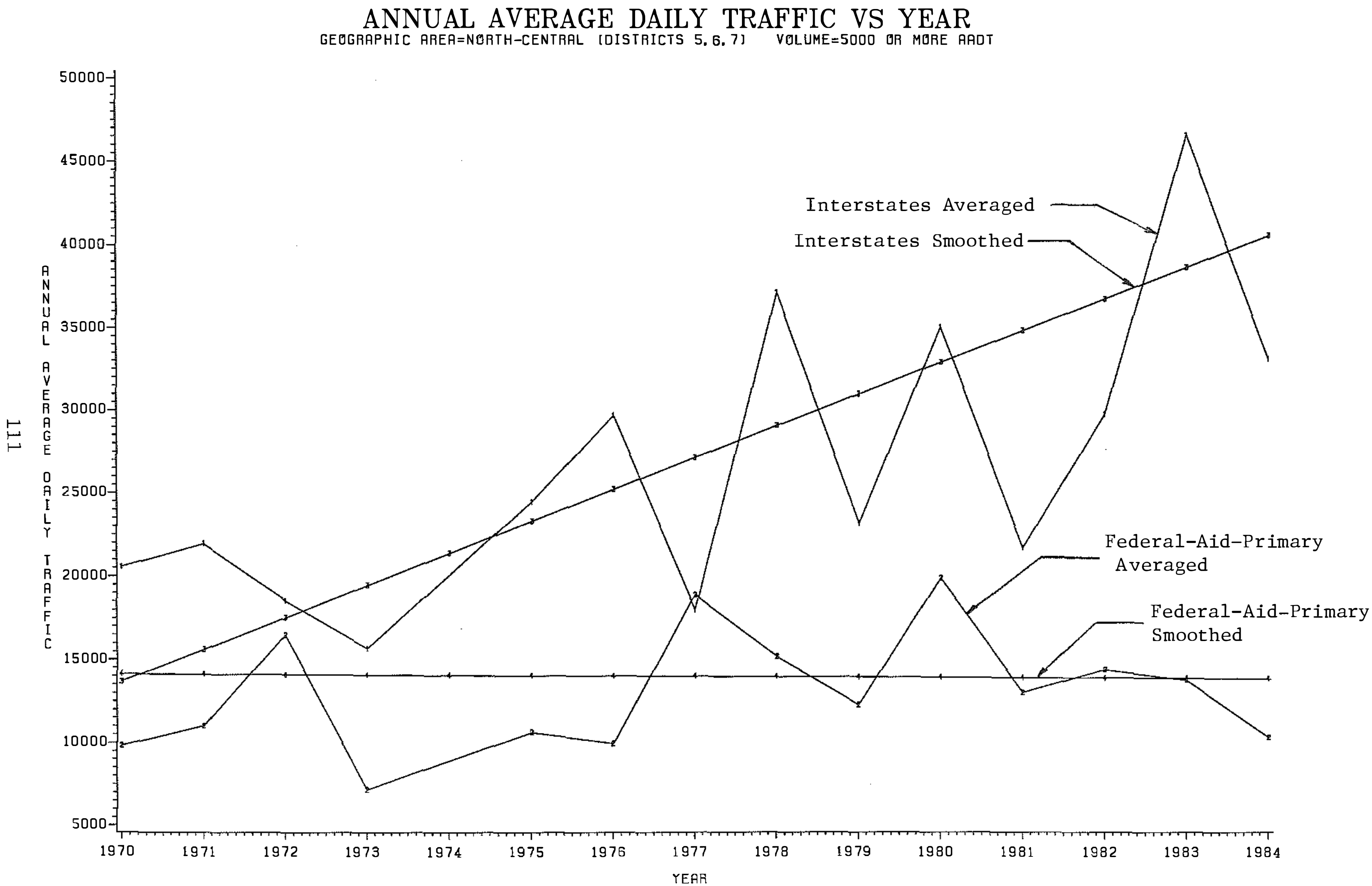

Figure H-1. Comparison of Annual Average Daily Traffic (Averaged Versus Smoothed) for Interstates and Federal-Aid Primary Routes

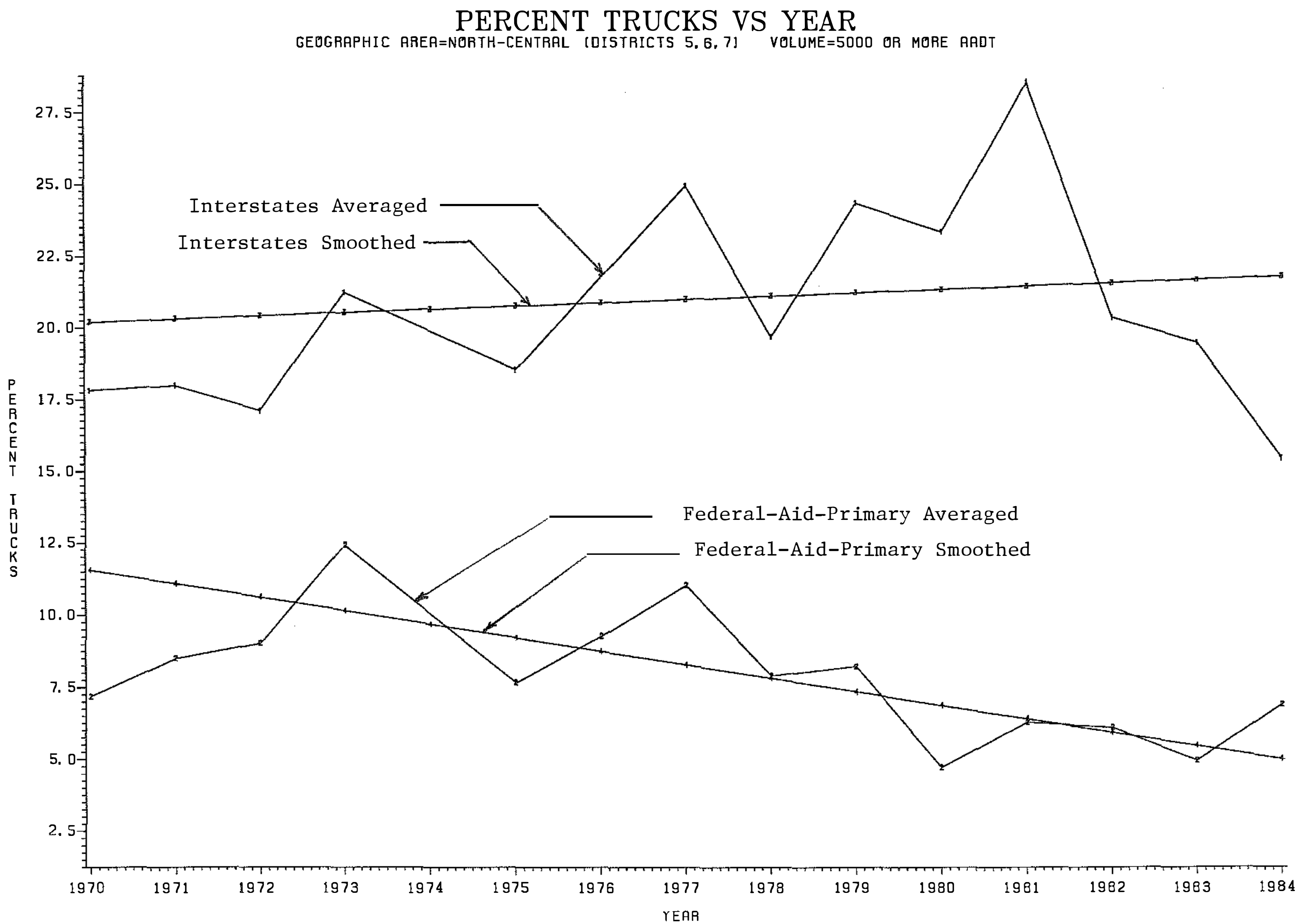

Figure H-2. Comparison of Percent Trucks - Non-Coal-Haul (Averaged Versus Smoothed) for Interstates and Federal-Aid-Primary Routes

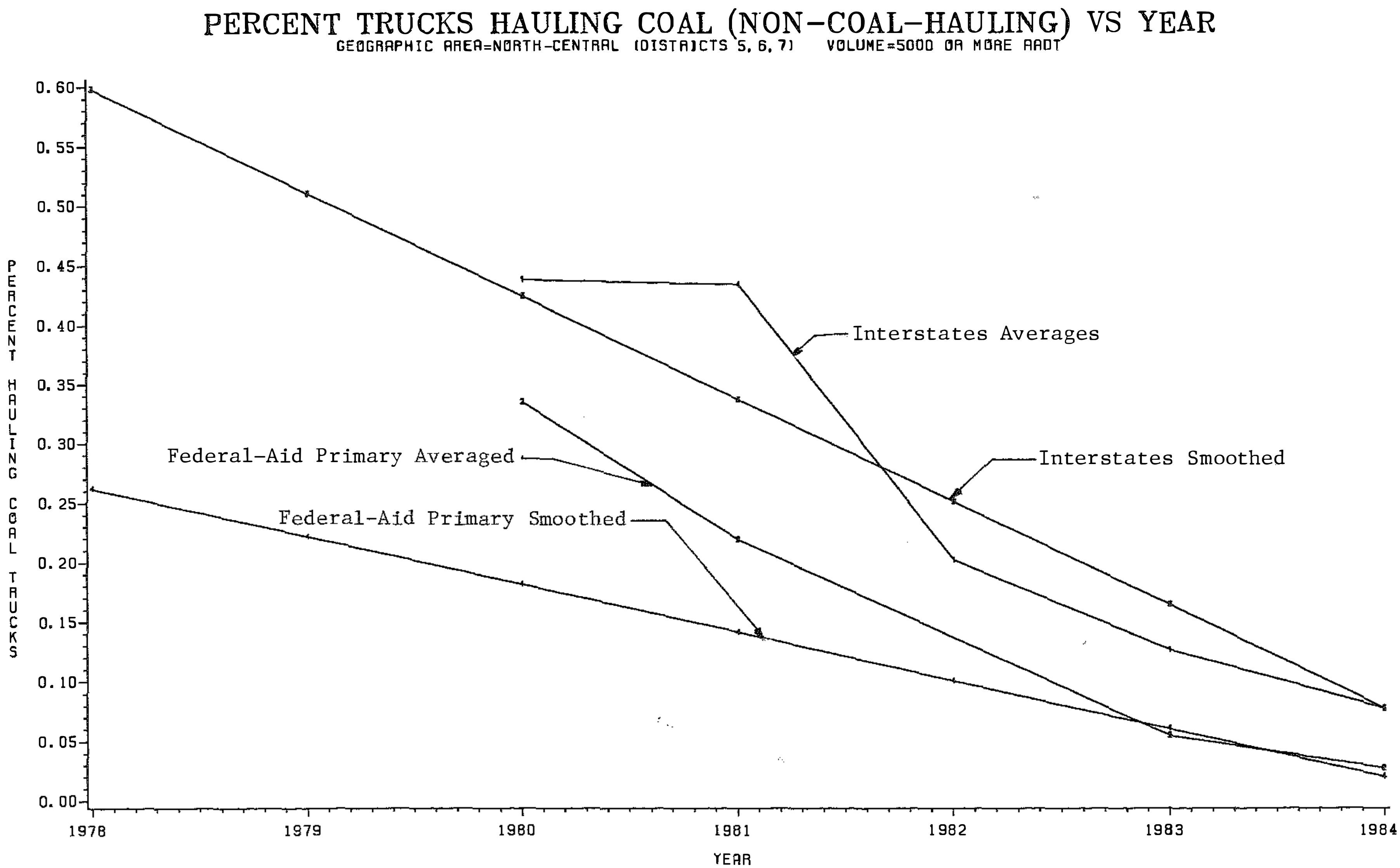

Figure H-3. Comparison of Percent Trucks Hauling Coal - Non-Coal-Haul (Averaged Versus Smoothed) for Interstates and Federal-Aid-Primary Routes

AXLES PER TRUCK (NON-COAL-HAULING) VS YEAR

GEOGRAPHIC AREA=NORTH-CENTRAL (DISTRICTS 5,6,7)   VOLUME=5000 OR MORE AADT

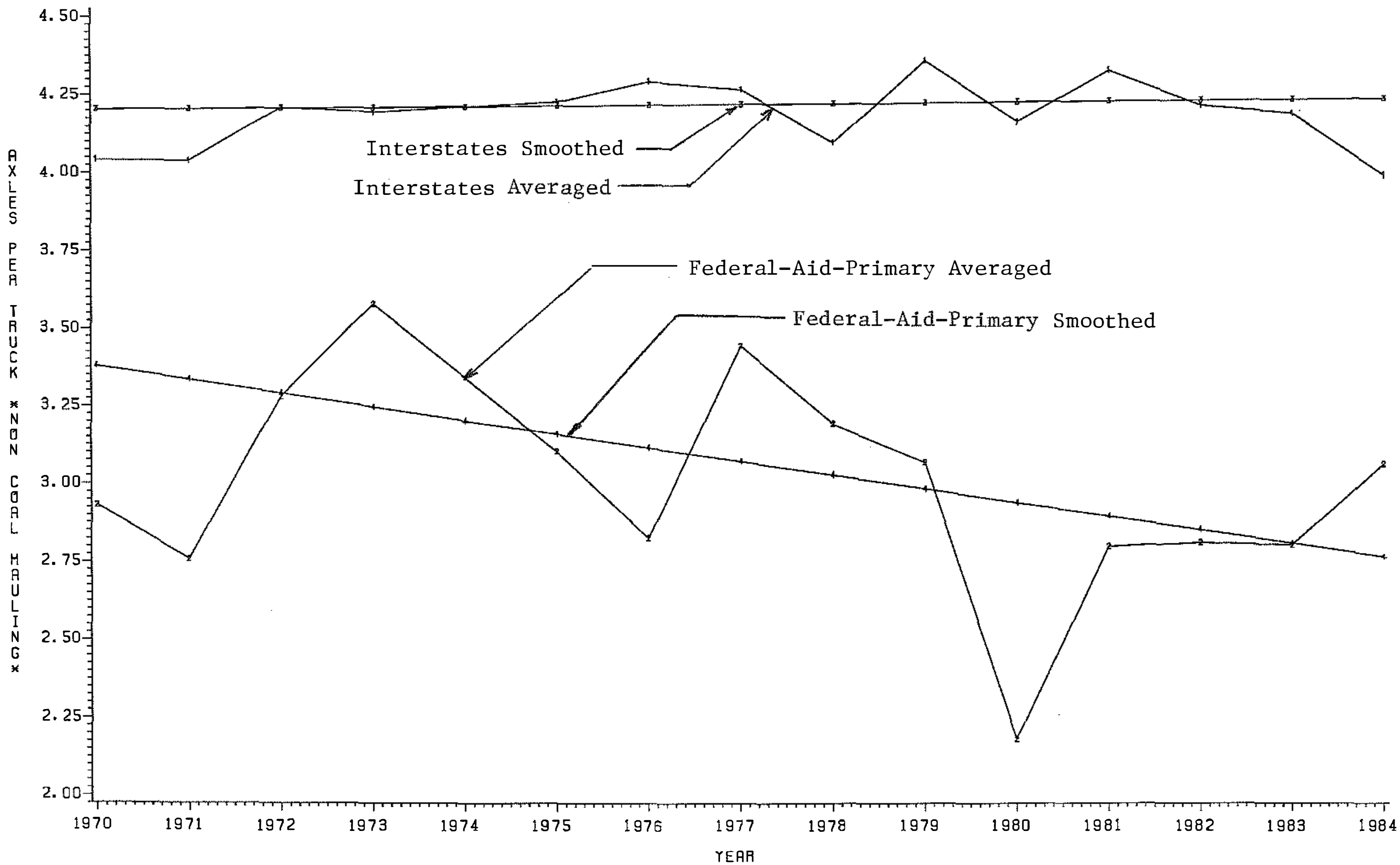

Figure H-4. Comparison of Axles per Truck - Non-Coal-Haul (Averaged Versus Smoothed) for Interstates and Federal-Aid-Primary Routes

AXLES PER TRUCK (COAL-HAULING) VS YEAR

GEOGRAPHIC AREA=NORTH-CENTRAL (DISTRICTS 5, 6, 7) VOLUME=5000 OR MORE AADT

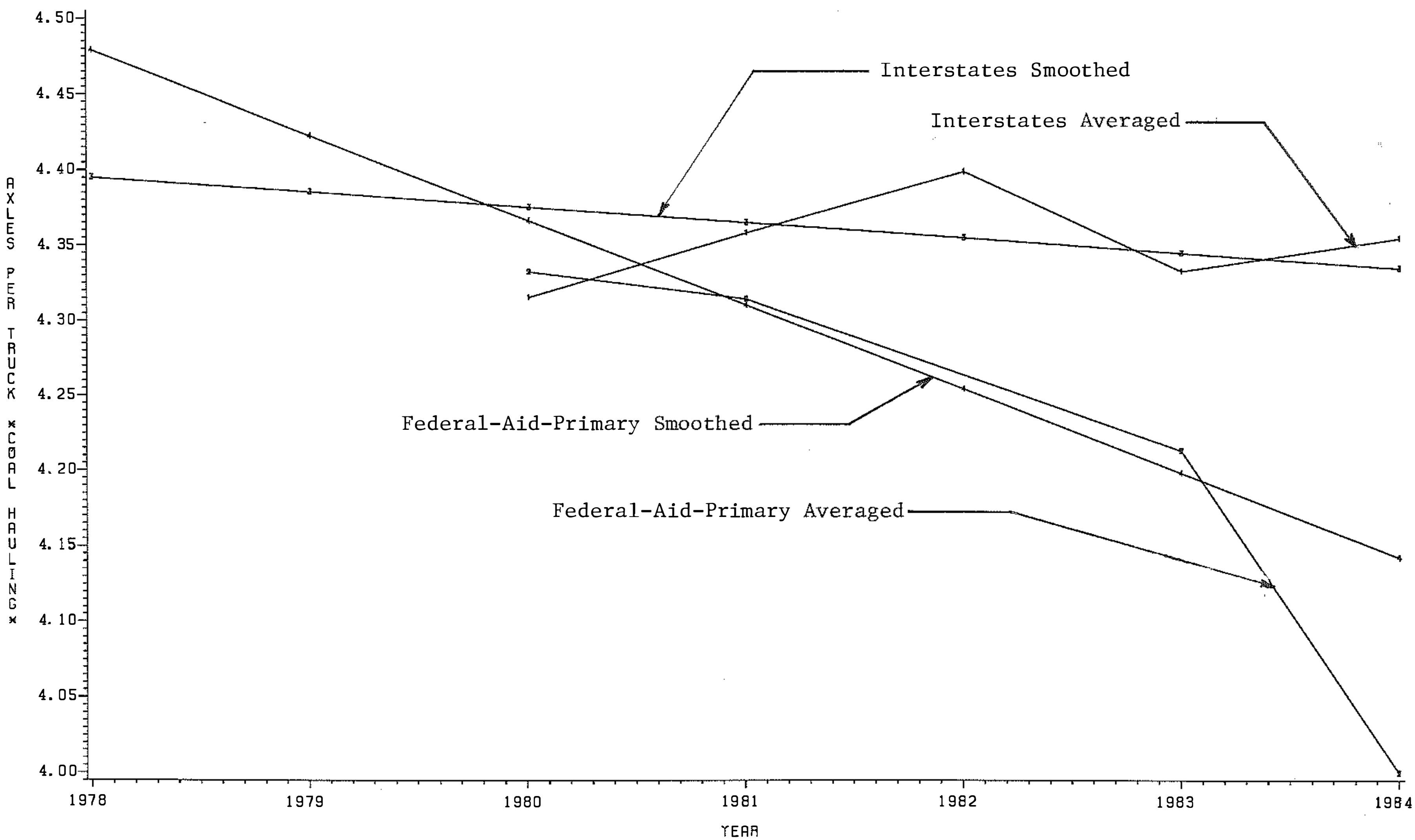

Figure H-5. Comparison of Axles per Truck - Coal-Haul (Averaged Versus Smoothed) for Interstates and Federal-Aid-Primary Routes

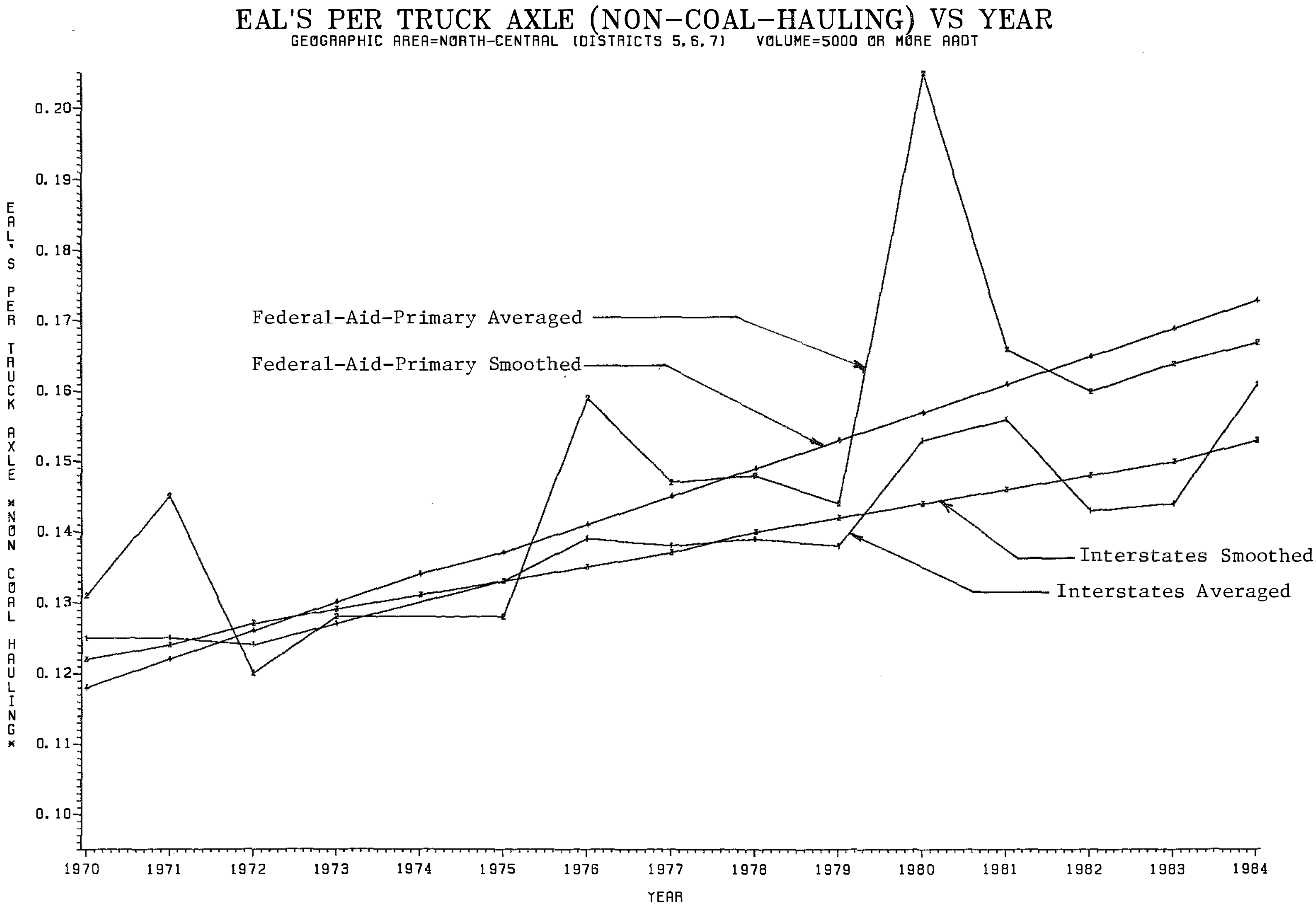

Figure H-6 Comparison of EAL's per Truck Axle - Non-Coal-Haul (Averaged Versus Smoothed) for Interstates and Federal-Aid-Primary Routes

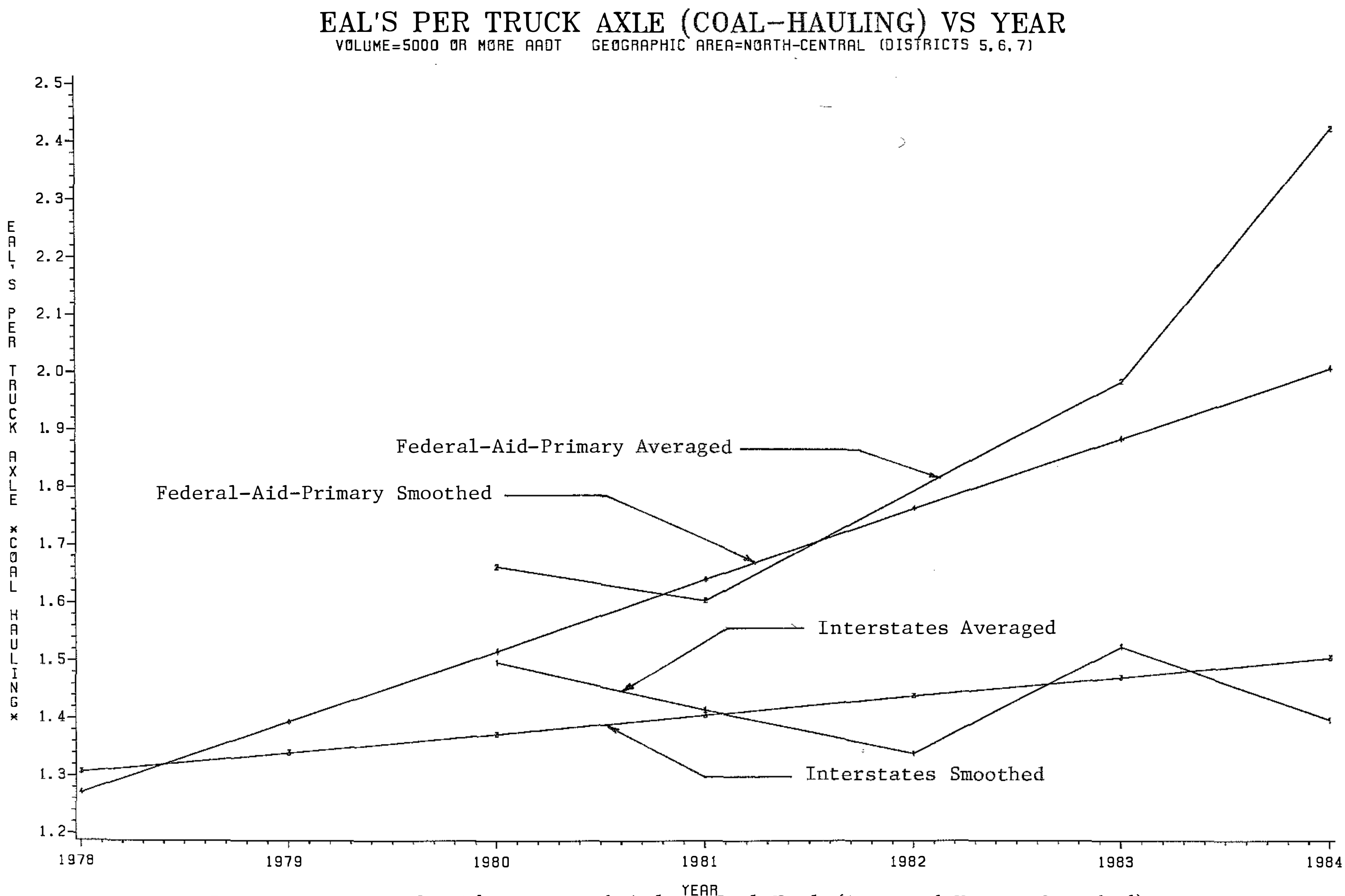

Figure H-7. Comparison of EAL's per Truck Axle - Coal-Haul (Averaged Versus Smoothed) for Interstates and Federal-Aid-Primary Routes

APPENDIX I

HISTORICAL TRENDS IN BIDIRECTIONAL EAL'S

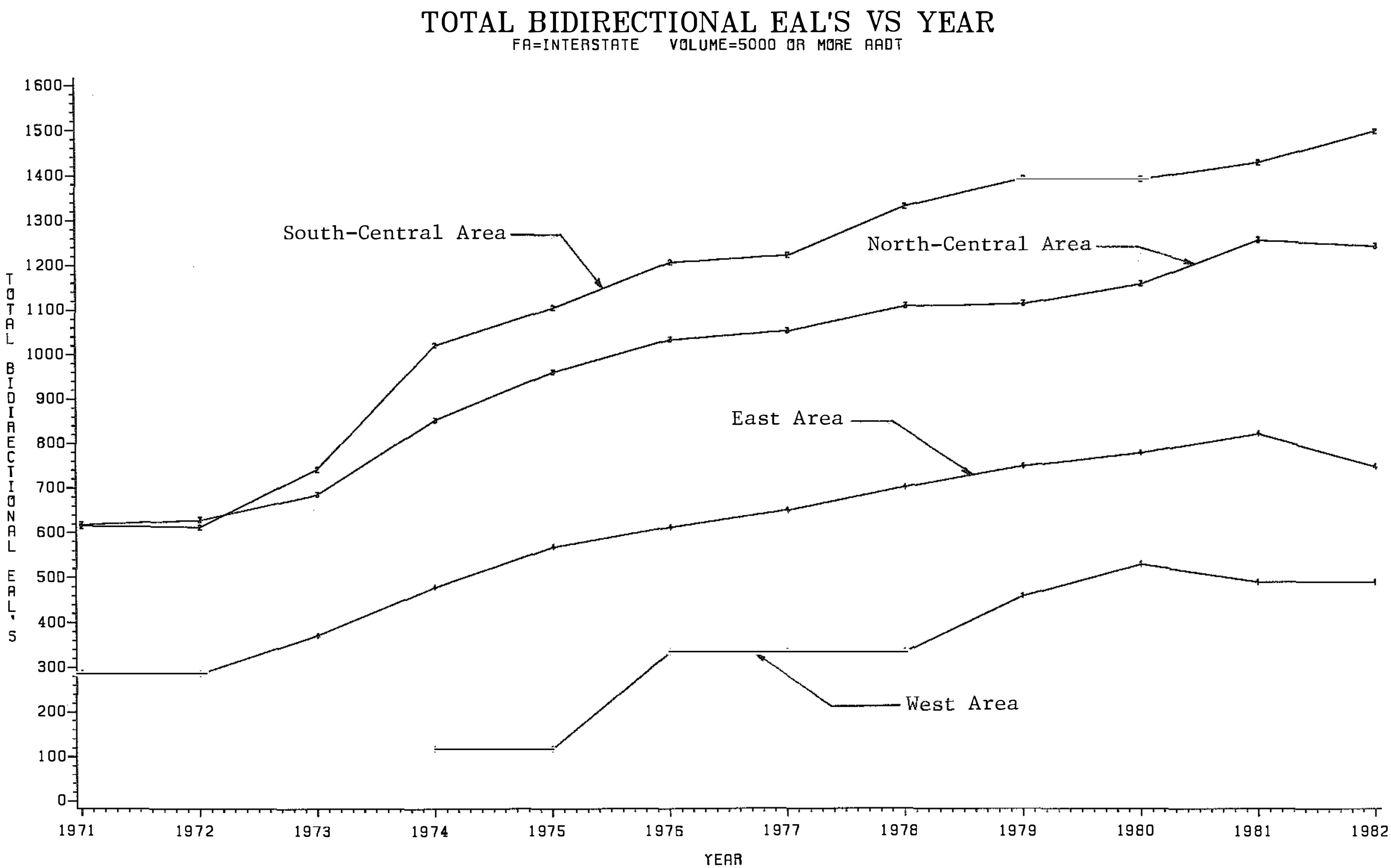

Figure I-1. Historical Trends in Two-Directional EAL's by Geographic Area for High-Volume Interstates

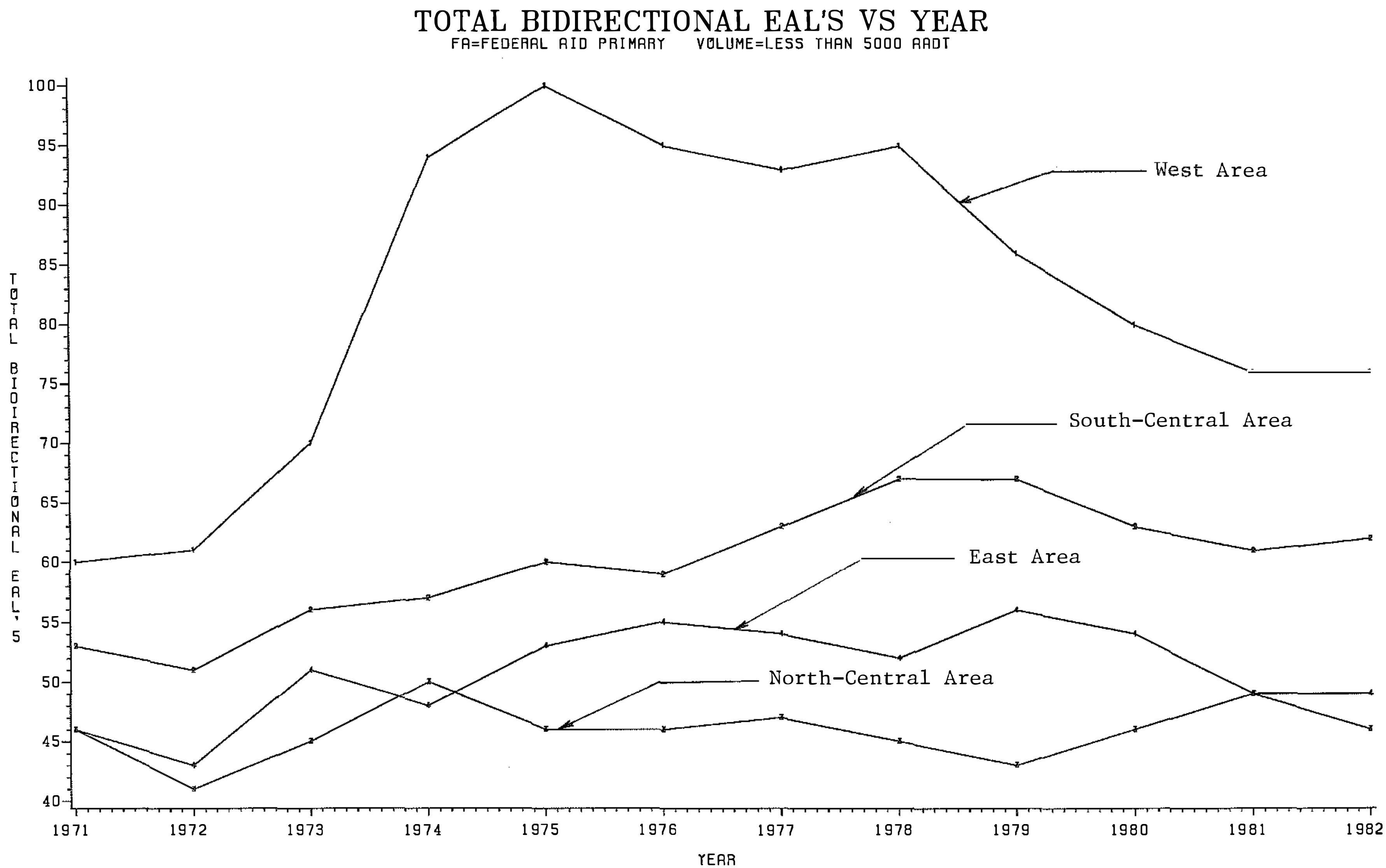

Figure I-2. Historical Trends in Two-Directional EAL's by Geographic Area for Low-Volume Federal-Aid-Primary Routes

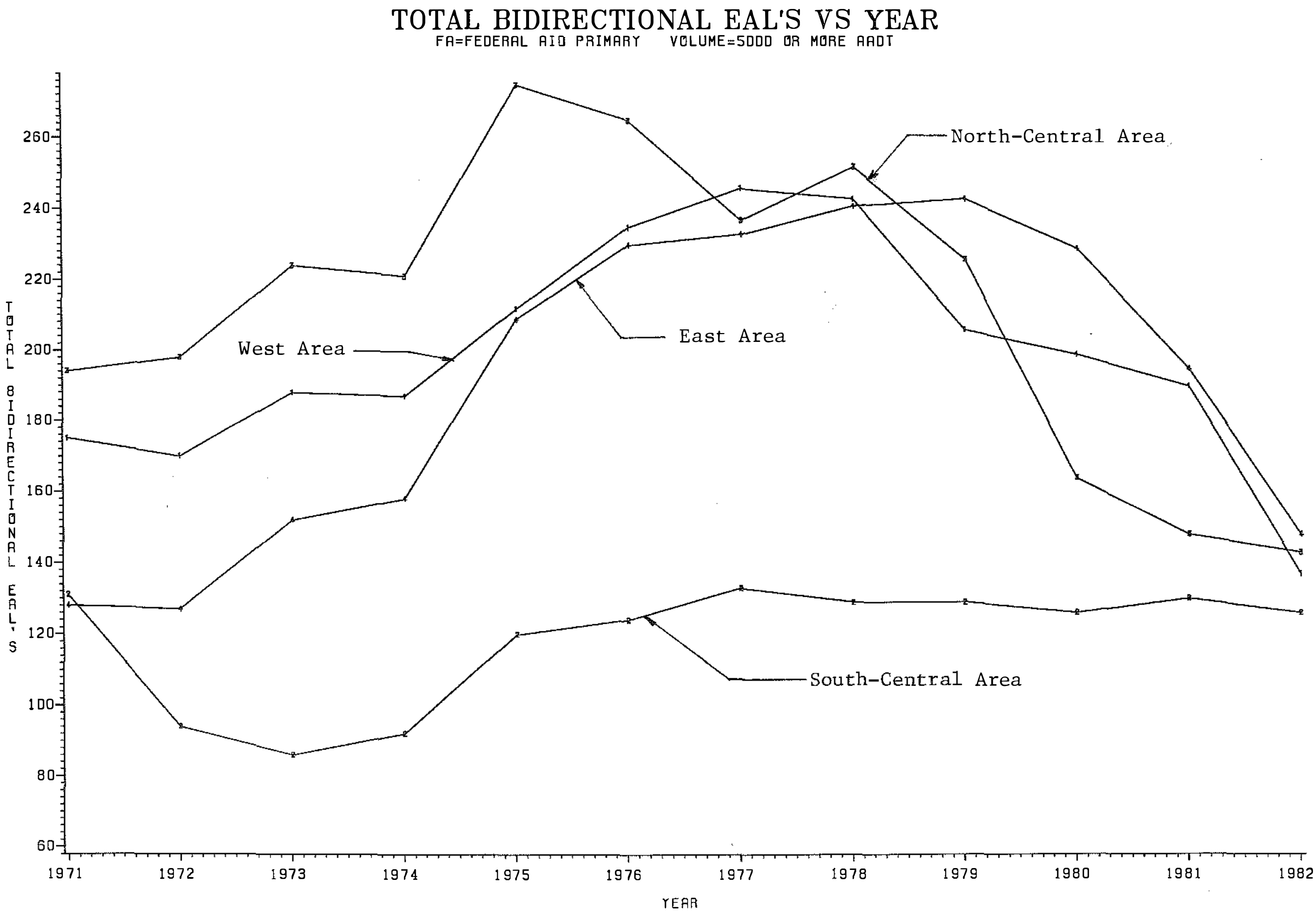

Figure I-3. Historical Trends in Two-Directional EAL's by Geographic Area for High-Volume Federal-Aid-Primary Routes

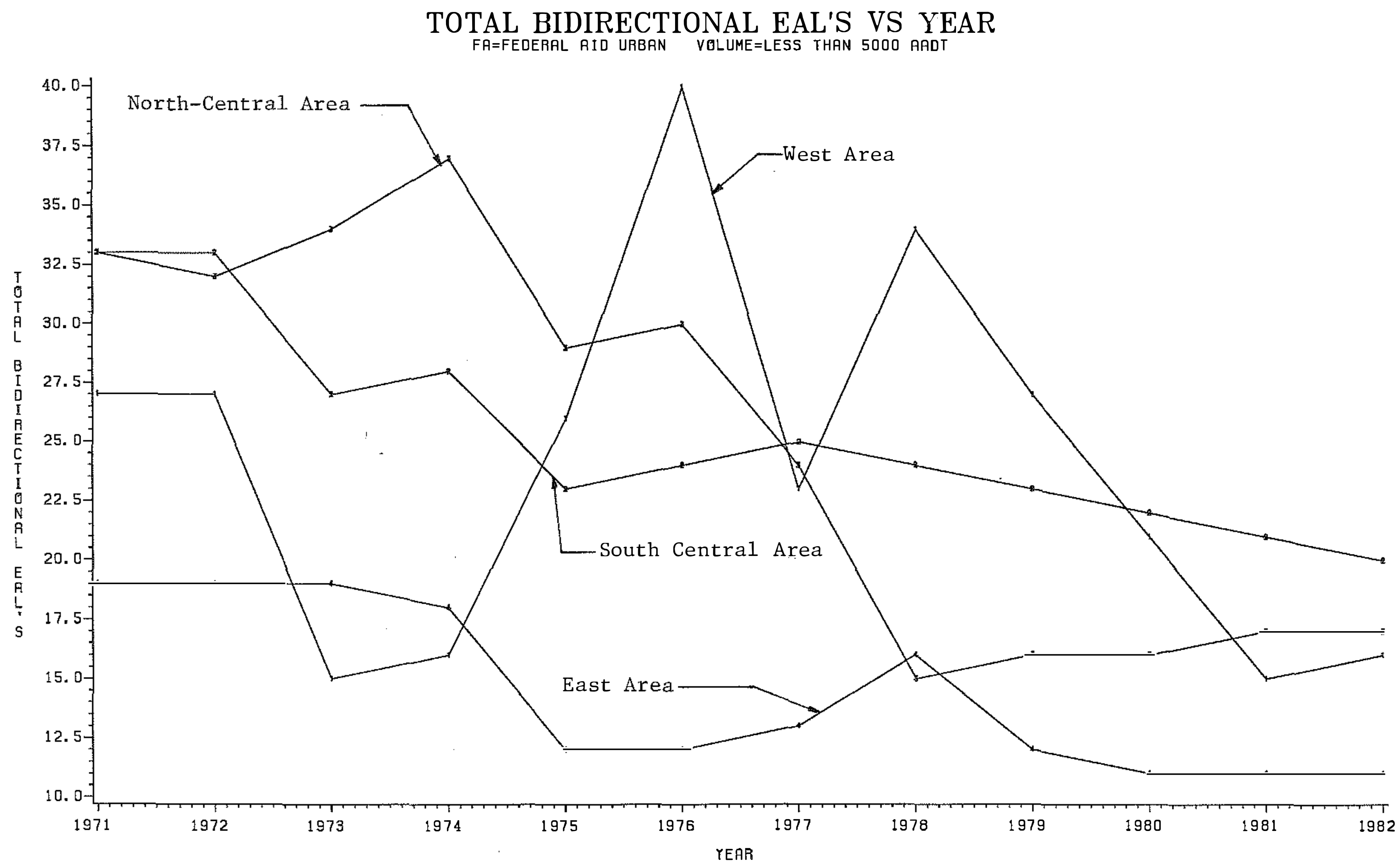

Figure I-4. Historical Trends in Two-Directional EAL's by Geographic Area for Low-Volume Federal-Aid-Urban Routes

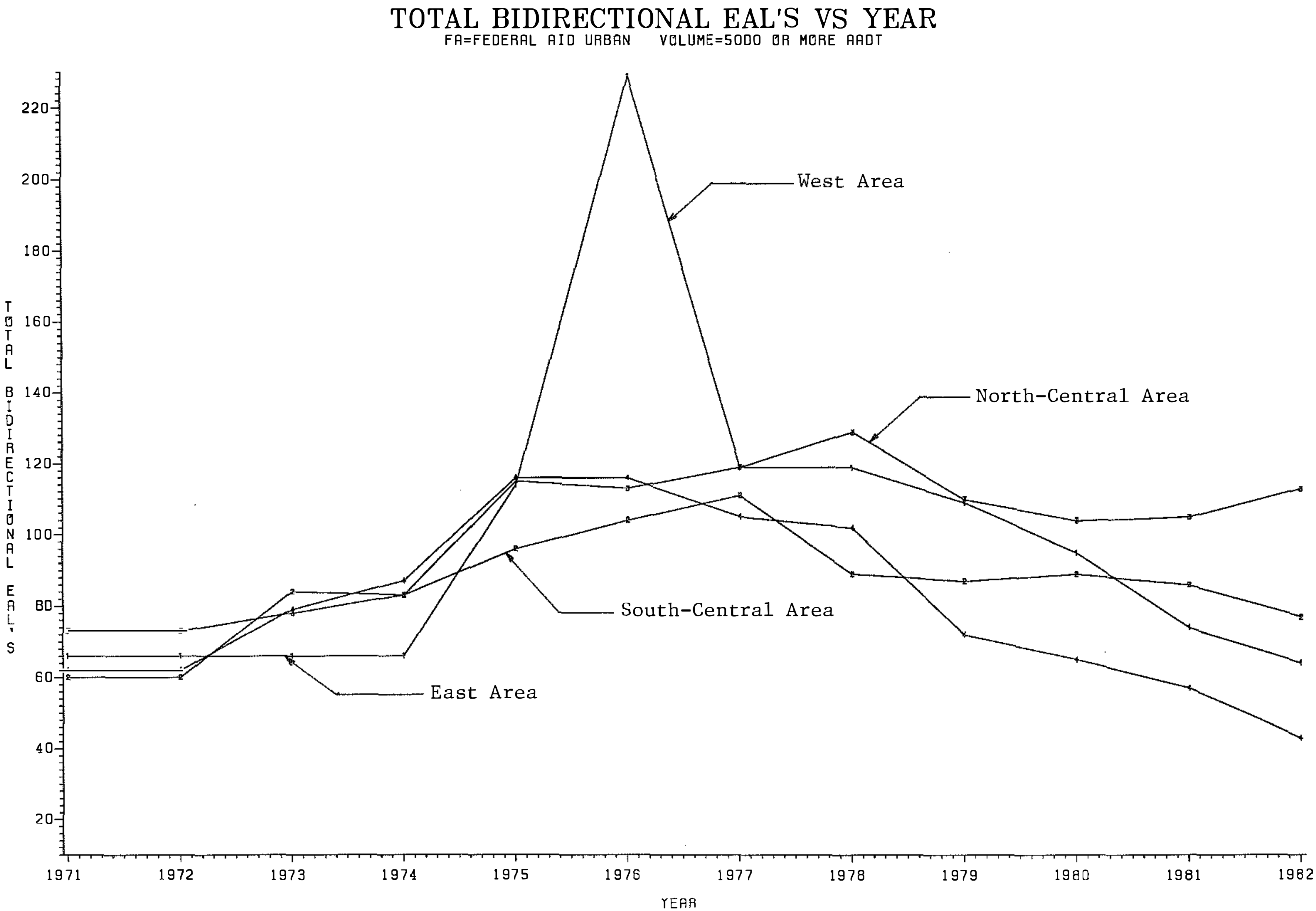

Figure I-5. Historical Trends in Two-Directional EAL's by Geographic Area for High-Volume Federal-Aid-Urban Routes

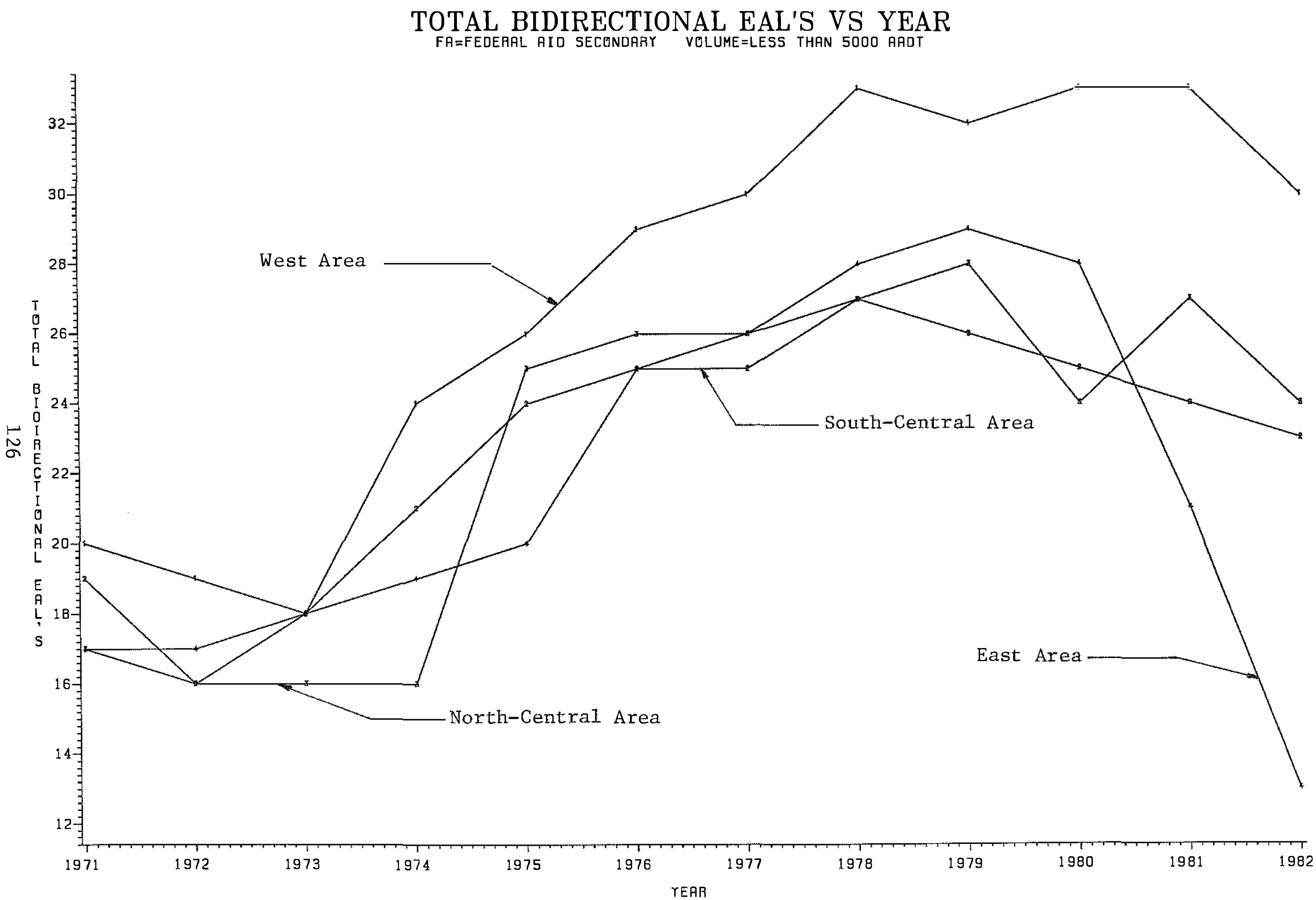

Figure I-6. Historical Trends in Two-Directional EAL's by Geographic Area for Low-Volume Federal-Aid-Secondary Routes

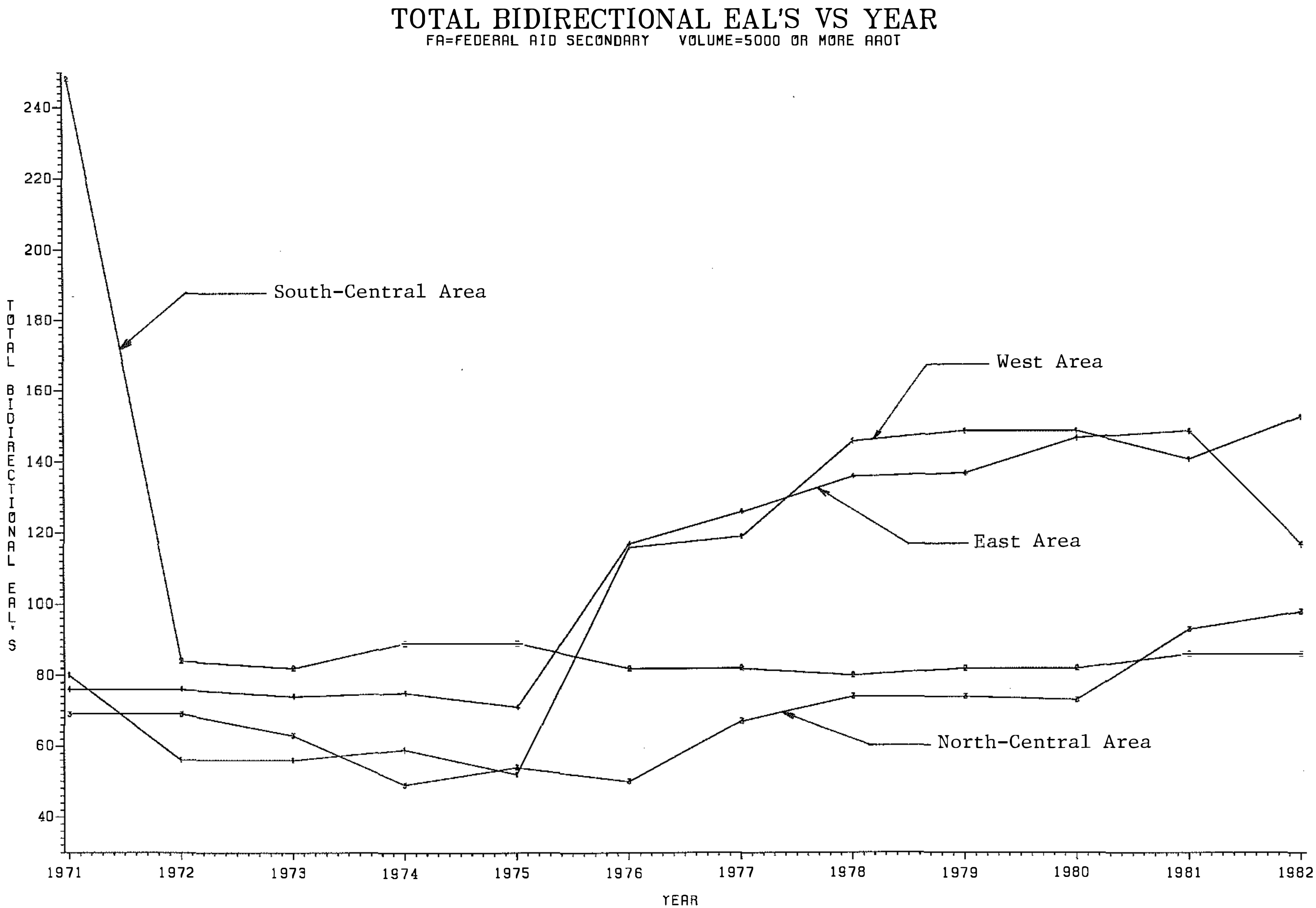

Figure I-7. Historical Trends in Two-Directional EAL's by Geographic Area for High-Volume Federal-Aid-Secondary Routes

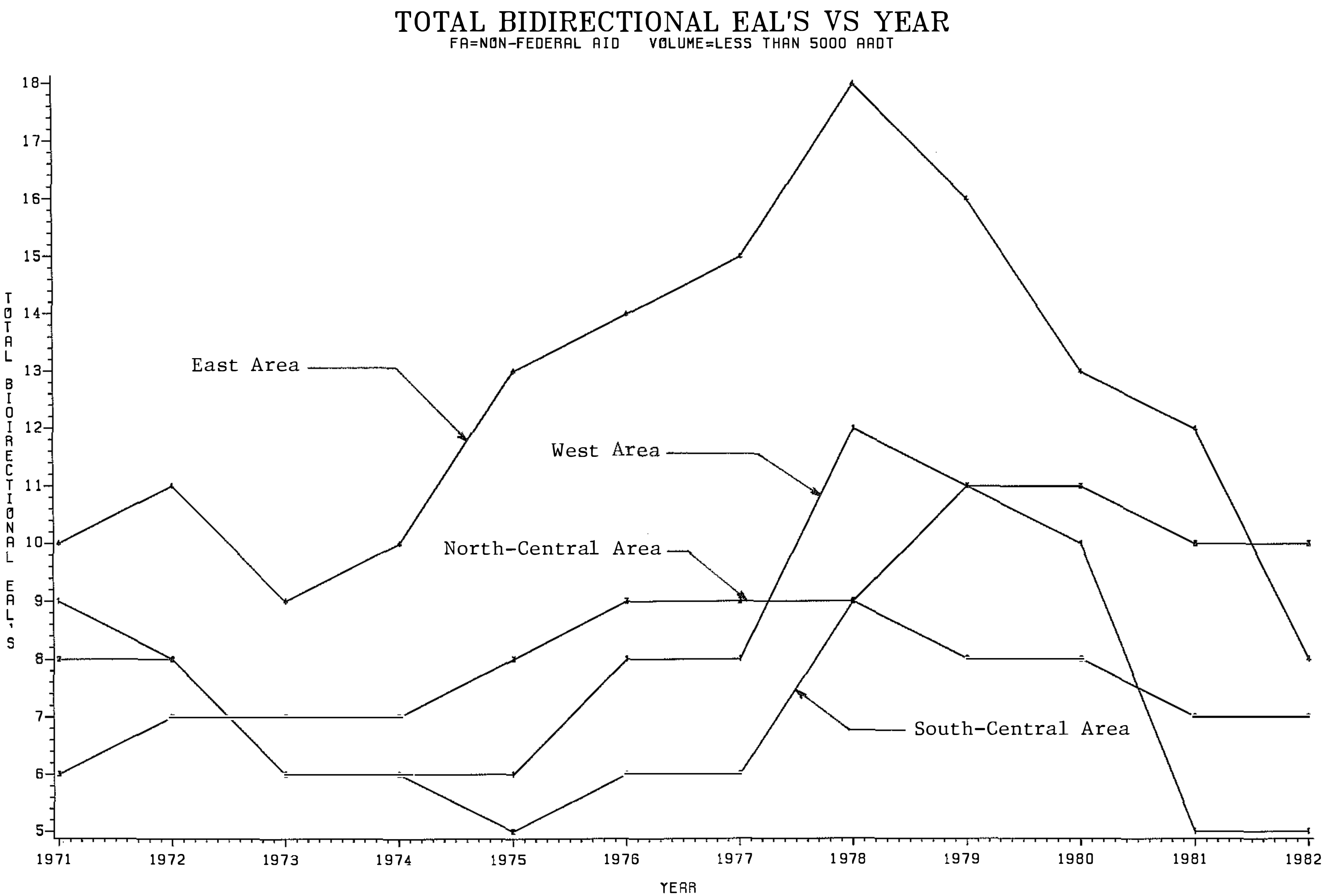

Figure I-8. Historical Trends in Two-Directional EAL's by Geographic Area for Low-Volume Non-Federal-Aid Routes

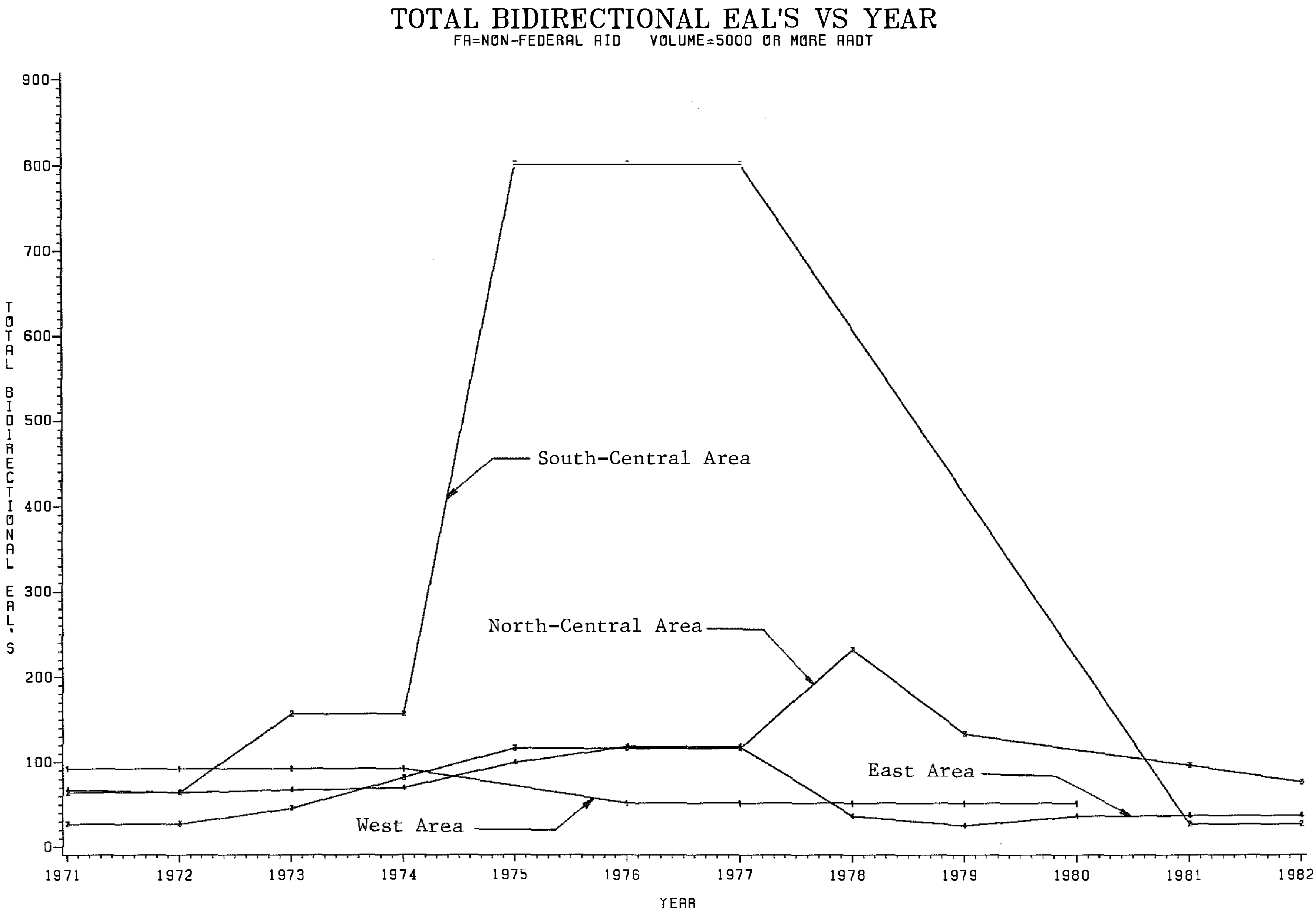

Figure I-9. Historical Trends in Two-Directional EAL's by Geographic Area for High-Volume Non-Federal-Aid Routes