WSDOT Traffic Forecasting Guide

Volume 2 — Forecasting Instructions

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16. ABSTRACT

The Washington State Department of Transportation has produced this guide to improve the development of traffic forecasts used by Department engineers and planners. The guide is intended to help standardize the methodology for developing forecasts, provide an "audit trail" of the steps and assumptions behind each forecast, and ensure that the assumptions underlying the forecasting process have been carefully considered.

The guide is split into two volumes. The first volume describes the forecasting process and reviews the issues that must be addressed. The second volume provides more detailed instructions for the forecasting process. Volume 2 assumes that the user is already familiar with the issues that affect traffic forecasts and understands why different inputs to the forecasting process are important. Persons new to traffic forecasting should read Volume 1 before continuing with this volume.

Volume 2 of the guide describes the steps required to perform a forecast for WSDOT. The guide assists planners in obtaining and organizing the information needed for a forecast, provides guidance on the factors to include in a forecast, and gives a consistent structure for analyzing those data and reporting results.

The appendices provide an extra set of worksheets and tables for the forecasting process, directions for using the Lotus spreadsheet templates that are discussed in Chapter 3, summary information on four-step computer models supported by WSDOT, a summary of data sources for the forecasting process, an example forecast, and a set of 3-1/2 inch, IBM PC compatible diskettes that contain the Lotus 1-2-3 templates discussed above.

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Traffic Forecasting Guide

WSDOT TRAFFIC FORECASTING GUIDE VOLUME 2 — FORECASTING INSTRUCTIONS

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DISCLAIMER

The contents of this report reflect the views of the author, who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Washington State Transportation Commission, Department of Transportation, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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CHAPTER 1

INTRODUCTION

This is Volume 2 of a guide produced by the Washington State Department of Transportation (also referred to as WSDOT or the Department) to aid in the development of traffic forecasts used by the Department. The guide is intended to help standardize the methodology for developing forecasts, provide an "audit trail" of the steps and assumptions behind each forecast, and ensure that the assumptions underlying the forecasting have been carefully considered and reviewed.

This volume of the guide describes the specific steps required to perform a forecast for WSDOT. It does not include descriptions of the related analyses that use traffic forecasts such as capacity analyses, pavement design, or geometric design. While these tasks are often an integral part of the work that includes traffic forecasting, they are presented in other WSDOT manuals or training courses.

This volume assumes that you already are familiar with the issues that affect traffic forecasts and understand why different inputs to the forecasting process are important. If you are new to traffic forecasting, please read Volume 1 before continuing with this volume.

It is important to point out that this guide does not perform traffic forecasting. It only assists you in obtaining and organizing the information for that process. The guide does include information about where additional training in the forecasting process can be obtained. It also provides a series of reminders about factors that you should be consider in the forecasting process.

LAYOUT OF VOLUME 2

The guide is separated into four chapters:

- Introduction,
- Preliminary Work

- Performing the Forecast, and
- Reviews and Presentation of the Forecast.

The following brief description of the layout of this Volume completes the first chapter.

Chapter 2 reviews the preliminary steps in the forecasting process. (These steps are discussed in more detail in chapters 3 and 4 of Volume 1.) It presents directions, tables, and references that will assist you in determining the scope of the effort required for a particular forecast, and help you identify and obtain the information you need to make the required estimates,. It also leads you through the steps necessary to select the appropriate tool(s) for performing the forecast.

Chapter 3 directs you through the forecasting process for each of the basic types of forecasts. It includes directions for estimating all traffic variables normally associated with a forecast. This chapter does not work through specific commands required to operate the various computer models you may use. Instead, it provides a generic guide covering the steps needed to estimate specific values (e.g., to estimate design hour volumes from daily estimates), regardless of the analysis tools you choose. To perform and document these tasks, a series of worksheets have been developed. The use of these worksheets in the forecasting process is also described.

Chapter 4 describes the external reviews that are necessary to ensure that the forecast estimates are reasonable. External reviews are important for reducing conflicts between the Department and other agencies and jurisdictions. This chapter also describes the format you should use to transmit the final forecast estimates.

In addition to these chapters, several appendices contain important references and additional information. Appendix A provides an extra set of the worksheets and referenced tables for you to use in the forecasting process. The worksheets should be copied and used for all forecasts. Appendix B contains directions for the use of the Lotus spreadsheet templates that are discussed in Chapter 3. Appendix C presents summary information on five four-step computer models that are supported by the Department.

Appendix D provides a summary of data sources that provide input to the traffic forecasting process. Appendix E presents an example forecast for your review. Finally, a set of 3 - 1/2 inch, IBM PC compatible diskettes, containing the Lotus 1-2-3 templates, are enclosed at the back of this volume.

CHAPTER 2

PRELIMINARY WORK

This chapter describes the initial steps in the forecasting process. These steps include the following:

- becoming familiar with the project area,
- understanding the scope, level of effort, and time frame of the project,
- determining the end results that are required from a specific forecast,
- identifying and requesting the data available for the forecast,
- making a preliminary selection of the forecasting technique to be used,
- collecting and reviewing the input information, and
- revising the selection of forecasting technique(s) as necessary.

Each of these topics is discussed briefly below. More detail on each of these steps can be found in Volume 1 of this guide.

BECOME FAMILIAR WITH THE PROJECT

While this portion of forecasting may seem obvious, the importance of familiarity with the project and the geographic area surrounding it cannot be understated. Because forecasting is an art as much as a science, you need to understand all of the factors that may influence how traffic along a road may change. Specific steps you should take as part of the process of becoming familiar with a project area are described below.

Determine What the Proposed Project Is Supposed to Accomplish

This information will help you understand what is required for the forecast, how much effort should be expended on the forecast, and what the basic forecast requirements will be.

Determine the Jurisdictions That Are Involved in the Project

This will provide you with a better understanding of potential data sources and which jurisdictions should be included in the review of the forecasts you produce.

Obtain a Map of the General Area Around the Project

A map will help you understand where potential traffic will come from, where congestion must be alleviated, how congestion could be reduced, and how the project facility fits into the surrounding area.

Become Familiar With Existing Roadway Conditions on the Project Facility and the Facilities Identified Above

To do this

- collect data on the existing traffic flows,
- review previous traffic studies performed either by or fore the WSDOT or local agencies, and
- discuss the current level of service with Departmental and local jurisdiction staff familiar with traffic flow in the area.

Investigate the Current Plans for The Project and Nearby Facilities

You should be able to describe

- what plans for major maintenance or roadway expansion the Department has made or is considering for the area impacted by your project, (both for the road being studied and roads that might either carry traffic to/from the road being studied or carry traffic parallel to the route being studied), and
- what roadway improvements other jurisdictions and agencies have planned for facilities they operate and maintain in the project area or in surrounding regions that might contribute traffic to the study area.

Determine the Expected Amount of Development in the Project Area

You should investigate expected growth in all areas which have the potential to feed traffic into the study area. This includes both expected population and economic changes in the area. If the project you are working on is small, you should concentrate on specific developments near the project location (e.g., the new factory proposed for this road). If your project is larger, you will more likely need general county- or region-wide estimates of growth.

UNDERSTAND THE SCOPE, LEVEL OF EFFORT, AND TIME FRAME

The general type of project you are working on usually determines the level of effort required to perform the forecast and the results that the forecast must provide. These in turn determine the tools you will need to use and the type of input data that are required to perform the forecast.

The project you are working on should fall into one of the following general categories of work.

- Project Scoping,
- Corridor Analyses,
- Design Analysis,
- Rehabilitation, Reconstruction and Restoration (3R),
- Signal Jobs,
- Pavement Only (i.e., a simple overlay project), and
- New Development Analysis and Review.

Each of these types of analyses has its own characteristics and common output requirements. (Note that 3R, Signal and Pavement jobs are really subsets of the more generic Design Analysis effort.) Table 2-1 summarizes the types of traffic data which must be forecast for each of these analyses, the issues that usually must be examined as part of each forecast, and the tools that are normally used to make the required estimates.

DETERMINE THE FORECAST REQUIREMENTS

Determining the information required for any given project is usually a simple matter of responding to the letter requesting assistance in performing a forecast. As part of familiarizing yourself with the forecast to be made, it may become apparent that the engineer may need more (or less) data than s/he requested. Consequently, it is important that you structure your forecasting efforts to supply the information needed, rather than just the information requested. It is often helpful to schedule a meeting with the project designer to discuss forecasting procedures and data requirements, particularly if the

TABLE 2-1

TYPES OF ANALYSES AND THEIR REQUIREMENTS

Type of Analysis	Required Output	Areas of Interest	Tools to Use
Project Scoping	Projected AADTs Projected peak hour volumes ESALs projected for the design life of the project.	Capacity constraints Impacts of parrallel facilities and predicted growth Impacts of new development Level of development designation	QRS II CINCH Highway Emulator Spreadsheet Calculator
Corridor Analysis (rural areas)	Projected AADT's Projected peak hour volumes	Capacity constraints Impacts of parallel facilities and predicted growth	QRS II Spreadsheet calculator Higway Emulator
Corridor Analysis (urban areas)	Projected AADT's Projected peak hour volumes	Capacity constraints Impacts of parallel facilities and predicted growth Impacts of new development Level of development designation	QRS II CINCH Highway Emulator TMODEL2 Traffic modeling software (TRANSYT-7, PASSER)
Design Analysis (rural and urban)	Current and projected AADT Current and projected annual truck traffic Current and projected design hour traffic (trucks and auto volumes ESALS projected for the design life of the pavement	Capacity constraints Impacts of parallel facilities Impacts of new development Level of development designation Impacts of alternative truck traffic predictions on pavement depth Shape of the growth curve	QRS II CINCH Highway Emulator Spreadsheet Calculator Traffic Modeling software (TRANSYT-7)

TABLE 2-1

TYPES OF ANALYSES AND THEIR REQUIREMENTS (Continued)

Type of Analysis	Required Output	Areas of Interest	Tools to Use
3R Work	ESALS projected for the design life of the pavement Current and projected peak hour traffic (trucks and auto volumes	Capacity constraints Impacts of parralel facilities and predicted growth Impacts of new development Level of development designation	
Pavement Only Projects	Current and projected AADT Current and projected annual truck traffic ESALS projected for the design life of the pavement	Level of development designation Impacts of alternative truck traffic predictions on pavement depth	Spreadsheet Calculator
Signalization Projects	Hourly Traffic Volumes	Impacts of new development	CINCH Highway Emulator Traffic Models (TRANSYT-7)
New Development Review	Current and projected peak hour traffic (trucks and auto volumes ESALS projected for the design life of the pavement	Capacity constraints Impacts of new development Level of development designation	

apparent needs are different from the original request. Table 2-2 outlines the data required to perform a variety of the common planning and design functions. This table can be used as a guide to the data that a forecast should provide for specific types of analyses.

You should also provide some explanation along with the traffic estimates that you supply. Supplying additional information is not limited to providing AADTs with a request for design hour traffic because the engineer forgot to request them. It is more important that you explain the sensitivity of the estimates you are providing. For example, if you are providing estimates of AADT and truck percentage, and those estimates almost exceed an LOD boundary, you must tell the engineer that with a slightly higher estimate of traffic (or truck) growth, this facility will warrant a higher LOD rating. The engineer/planner receiving this information can then include that additional information in his/her project design, and build the road appropriately.

IDENTIFY AND REQUEST THE AVAILABLE DATA

As you become familiar with the project area, request the traffic and socio-economic data that will be needed to perform the forecast. Table 2-3 provides a summary of some of the major types of data that are available and their sources. Essentially, all forecasting techniques require the following types of information:

- an estimate of current (or base year) traffic,
- an estimate of current socio-economic factors (e.g., land use), and
- an estimate of future growth or change.

The specific format of these estimates varies according to the size of the project, the forecasting technique to be used, and the availability of data. Each of these types of data are discussed briefly below.

TABLE 2-2

DATA REQUIRED TO PERFORM COMMON WSDOT DESIGN AND PLANNING FUNCTIONS[1]

Function	Data Required
Bridge Design	AADT Average Daily Truck Traffic
Long Range Planning	AADTs Peak Period Volumes or K and D factors
Noise Analysis	Peak Hour Volume Average Daily Volume of Heavy Trucks in the Traffic Stream Number of Heavy Trucks Over 10,000 pounds Vehicle Speeds
Project Level Forecasts	AADT Peak Hour Volumes K D T Design Hour Volume Directional Design Hour Volumes Volumes by Vehicle Classification
Resurfacing	Number of Vehicles by Vehicle Classification For Each Year of the Design Period. Damage Factor (ESAL) by Vehicle Classification
Signal Warrants	Hourly Traffic Volumes
System Level Bridge Design	AADT Average Daily Truck Traffic

[1] A definition of terms used in this table is presented in Appendix F of Volume 2 of this Guide.

TABLE 2-3

DATA AVAILABLE FOR USE IN FORECASTING*

Type of Data	Location(s)	Use For Data
Short Duration Traffic Volume Counts	TRIPS database Transportation Data Office Annual Traffic Report New data collection	Estimate current traffic volumes Review historical trends
Permanent Traffic Recorders	TRIPS database Annual Traffic Report	Examine seasonal changes Review historical trends
Vehicle Classification Counts	TRIPS database Transportation Data Office Annual Traffic Report New data collection	Estimate current traffic volumes Review historical trends
Truck Weight Surveys	Transportation Data Office	Examine pavement loading aspects of trucks using the project facilities.
Origin / Destination Surveys	Transportation Data Office MPOs New Data Collection	Input to model calibration process Examine impact of new roads on specific movements made by target areas of population and industry.
Turning Movement Counts	TRIPS database Transportation Data Office	Intersection analysis
Population Estimates	MPOs WSDOT Planning Office Transportation Data Office Census Bureau Local counties and cities OFM	Input to planning models Estimates of predicted growth and growth rates Estimating trip generation
Employment Estimates	MPOs WSDOT Planning Office Local counties and cities Employment Security Labor and Industries	Input to planning models Estimates of predicted growth and growth rates Estimating trip generation
Industrial / Agricultural Activity Estimates	County Offices Reebie Ass. Trans. Consultants Woods & Poole Economics, Inc. WSU (Casavant)	Input to planning models Estimates of predicted growth and growth rates Estimating trip generation
Transit / HOV Information	MPOs Local Transit authorities Transportation Planning Office	Estimating mode split Examining the impact of HOV incentives
Statewide Growth Estimates	TRIPS database Transportation Data Office OFM	Background (through) traffic growth estimates for rural roads

* The terms used in this table are defined in Appendix A of Volume 1 of this report.

Current Traffic Data

You should look for and request the following traffic information from TRIPS and/or the Transportation Data Office whenever possible:

- the most recent traffic count,
- any available vehicle classification counts and their dates,
- the availability of manual turning movement counts if one or more intersections are included within the project boundaries,
- the extent of the history of counts at that location or immediately up or downstream of the project, and
- the location of PTRs (permanent traffic recorders) on that same highway or on nearby roads.

Also check whether truck weight measurements have been made near the project on the state highway being examined. If hourly count information is available (and needed) but not contained within TRIPS, order the appropriate data from the Transportation Data Office.

Whenever possible, if traffic counts have not been made within the project boundaries in the past year, new counts should be requested for each forecast to be performed. At no time should a traffic forecast be based solely on traffic data over three years old, although data older than three years may be used within the forecasting process.

If trucks play an important part in the traffic analysis you are performing (e.g., the project includes laying new pavement), at least one 24- or 48-hour vehicle classification count should have been taken within the last 3 years on the road under study. (The 48-hour count is preferred.) That count must be sufficiently close to the project area that traffic mix does not significantly change between the count location and the project. (In rural areas where interchanges and truck traffic generators are widely spaced, this distance might be quite large; in industrial areas, it might only be to the next major freeway interchange.) As with volume data, a new count should be requested if one does not already exist.

These requests for data should be made as soon as a potential project is identified to allow the orderly scheduling of that count. Waiting until work on the project begins to request additional traffic counts may prevent those counts from occurring in time for them to be used in forecasting process.

Traffic count information can also be obtained from involved jurisdictions. This is especially true in urban areas. Traffic information is often needed for roads crossing state highways, in addition to volumes on the state routes themselves. When using data from local jurisdictions, determine the equipment and techniques used to provide those estimates, as the quality of the traffic data varies greatly between jurisdictions.

Obtain Current Non-Traffic Volume Information

Each analysis technique requires a slightly different mix of population, employment and land use data. The types of information that are normally required as inputs for each type of forecasting technique are shown in Table 2-4. Table 2-5 provides a list of questions to be answered as part of the data collection process. Non-traffic data can sometimes be obtained, already coded for use by a specific model, from the following sources:

- the MPO for an urban area,
- the WSDOT headquarters Transportation Planning Office,
- the WSDOT Transportation Data Office,
- a county transportation office, or
- the District office in charge of traffic forecasts.

More likely, you will obtain these data in some format other than what your model requires and you must convert them into the format desired.

TABLE 2-4

INPUT DATA NEEDED FOR FORECAST TECHNIQUES

Forecast Technique	Population/Employment Data	Traffic Estimates	Other Data
QRS II	Base year & forecast year estimates of average income or auto ownership, retail and non-retail employment and dwelling units by zone	None, except for calibration and comparison against base year estimates.	Map of the study area and/or coordinates of nodes in the transportation system. Minimum travel times between zones. Percent travel on arterials within zones.
SPF	Production and Attraction estimates by zone Population of urban area.	None, except for calibration and comparison against base year estimates.	Endpoint coordinates of project being analyzed.
MicroTRIPS	Base year & forecast year estimates of pop. and emp. by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.)
TModel2	Base year & forecast year estimates of pop. and emp. by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.)
EMME II	Base year & forecast year estimates by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.)
UTPS	Base year & forecast year estimates by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.) Trip generation rate equations Mode split model.
Spreadsheet Calculator	None, except for general consideration	Base year AADT Estimates Base year truck volumes by vehicle class	Estimated growth rate Type of growth expected (straight line, compound, etc.) Truck volumes
CINCH	None, except for general consideration	Base year hourly volumes Base year turning movements Number of Buses Percentage of heavy vehicles	Pedestrian Movements Signal Timing Plans Parking Movements Geometric Data
Highway Emulator	Number of Households By Income Range By Zone Rtail and Non-retail Employment By Zone	Base year hourly volumes Cordon line volumes	Link Distances and Speeds Hourly Capacity Any Additional Impedances

TABLE 2-5

QUESTIONS TO BE ANSWERED
AS PART OF THE DATA COLLECTION PROCESS

GENERAL CONSIDERATIONS
(To be asked of all projects.)

Are there significant changes to the road system planned in the area of the project? For example, are there new roads planned in the surrounding area? Is an existing road going to be closed?

Are there any "special circumstances" that you want to take into account during this forecast. For example, a doubling of the price of gasoline, or a new set of truck size and weight regulations?

PAVEMENT CONSIDERATIONS
(To be asked when new pavement will be placed on an existing road.)

Does the Pavement Management System show average, slow or fast deterioration of the previously laid pavement?

Are there railroad lines in the area whose abandonment might impact the level of truck traffic on the study facilities? If so, are the rail lines branch lines or trunk lines? How likely are those rail lines to be abandoned?

Are there new industrial or other facilities being built along or near the right-of-way of this road (including outside the project limits)? If so, how big are those facilities, and when will they be built?

Are there new industrial or other facilities being built in geographic areas served by this road or connected roads? If so, how big are those facilities, and when will they be built? What are the road connections to the project highway?

CAPACITY DESIGN CONSIDERATIONS
(To be asked when future conditions may result in traffic congestion.)

Is the existing road currently suffering congestion problems at some point during the day? If so, when, and at what level of service is it operating?

Is the traffic on the facility subject to large changes in volume as a result of seasonal fluctuations? (e.g., does the road provide access to a recreational area?)

Are there new industrial or other facilities or population centers being built along or near the right-of-way of this road (including outside the project limits)? If so, how big are those facilities, and when will they be built? Are these facilities likely to add truck traffic of a particular vehicle classification? Will this traffic occur at specific times of the day?

Are there new industrial or other facilities or population centers being built in geographic areas served by this road or connecting roads? If so, how big are those facilities, and when will they be built? Are these facilities likely to add truck traffic of a particular kind to the project? Will this traffic peak at specific times of the day?

OTHER CONSIDERATIONS
(To be asked to help determine the scope of the forecasting project.)

Does the project require an EIS?

Does the project require air or noise studies?

Has economic and/or traffic volume growth in the project area been increasing or decreasing over the last five years? Is the study area nearing maturity in terms of growth and available land?

The non-traffic information you collect must describe the current condition of factors that impact traffic generation and distribution. Some of this information, such as population estimates, may be used directly in a computerized model (to generate person trips). Other pieces of information simply serve as baselines against which future growth can be compared (e.g., a factory is not functioning at this time, but the local planners believe that it will re-open in two years).

In addition, for larger projects you may have to perform one or more special studies to collect a variety of types of data that will improve the validity of the forecast. For example, you may have to perform an origin/destination study to determine the travel patterns within a study area. Table 2-6 lists other studies that might provide useful input to the forecasting project and the types of information gained from those studies. These studies can be costly, and their cost often precludes their use for most forecast efforts.

Future Growth Estimates

The third crucial data input to a forecast is some measure of the future. This estimate of the "future" can take many forms. It can be predicted levels of population and employment, or it can be the expectation that growth will continue in the same manner as it has in the past. It is also important to estimate how the envisioned future will happen. For example, will the anticipated changes occur constantly over time? Will the changes occur slowly at first and then accelerate? Will the changes occur rapidly in the beginning and then slow down?

As with the data required for input to the forecasting process, the estimates needed for predicting future year traffic vary, depending on the forecasting technique you select. Make sure you pick a forecasting process for which the necessary data are available, and then collect those data so that the forecasting process can be completed.

TABLE 2-6

STUDIES FOR COLLECTING FORECASTING INFORMATION

Origin/destination studies
MPO small area studies
Vehicle speed studies
Pedestrian studies
Special volume count studies (turning movement counts, cordon line counts, etc.)
Traffic delay studies
Vehicle classification studies
Truck weight studies
License plate study of on-ramp to exit ramp flows
Study of gasoline sales in a region
Travel time studies

It is important that you collect any "official" estimates of future growth that have been developed by impacted jurisdictions and agencies. For urban areas with a population of greater than 50,000 people it is important that you obtain these estimates from the designated agency (usually the MPO) which maintains one or more datasets with the "expected" future conditions. Unless further examination shows this data to be unreasonable, this data should serve as your starting point for the future year forecast. When "official" estimates are obviously unreasonable, collect the necessary data to improve on those estimates, and document the changes you made to those estimates and the reasons you made those changes.

MAKE A PRELIMINARY SELECTION OF THE FORECASTING TECHNIQUE TO BE USED

A variety of factors enter into the selection of a traffic forecasting technique for a specific project. The required forecast elements (i.e., the "answers" needed) and data available are the most important of these factors, because the forecast technique must be capable of producing the desired results, and no forecast can be made without the necessary input data. Once the available data have been determined, you should consider the other factors involved in this process. These other factors are as follows:

- the available budget,
- the available time frame,
- your knowledge of the alternative techniques (i.e., experience using specific techniques or computer programs),
- the importance of the project to political leaders and other decision makers, and
- the tools and equipment available to perform the forecast (e.g., access to computers and specific software).

SELECT THE FORECASTING TECHNIQUES

If you are unclear about which technique you should use for performing a forecast, use the chart in Figure 2-1 to help select the appropriate forecasting technique(s) for any given situation. Follow the steps listed below to use this chart.

- Select the techniques for which you have the necessary computer equipment (mark these with an "X" in Column 2).
- Select the techniques for which the required input data are available or can be obtained within the time frame of the project (mark these with an "X" in Column 3).
- Use Table 2-7 to examine whether each of the forecast techniques which have two "X's" can be used in the time frame available for the project. (Note that the time shown in Table 2-7 includes only the approximate time to operate the model, not the time required to attend meetings, wait for

FIGURE 2-1

SELECTING APPROPRIATE FORECASTING TECHNIQUES

Forecast Technique	Computer Equipment	Data Available	Time Frame	Area Size
QRS II				
SPF				
MicroTRIPS				
EMME II				
UTPS				
Spreadsheet Calculator				
CINCH				
Highway Emulator				

Directions
Place an "X" for those forecast techniques which are appropriate for this effort.
Place an "O" for those forecast techniques which might be useful for this effort.
Leave a blank for those forecast techniques which can not be used or are inappropriate.

TABLE 2-7

APPLICABILITY OF FORECASTING TECHNIQUES

Forecast Technique	Appropriate Area Size for Study	Urban/Rural	Time Frame For Use
QRS II	Small areas 10-50 streets	Urban/Rural	Week or more
SPF	Small areas 10-50 streets	Urban/Rural	Week or more
MicroTRIPS	Small to medium areas 50-100 streets	Urban	Month or more
TModel2	Small to medium areas 50-100 streets	Urban	Month or more
EMME II	Medium to large areas 50-200 streets	Urban	Month or more
UTPS	Large areas 50-500 streets	Urban	Month or more
Spreadsheet Calculator	Individual roads Small projects	Rural	Hours or Days
CINCH	Small networks 2-10 streets	Rural/Small Urban	Days
Highway Emulator	Small to Medium large Networks 5-1000 streets	Urban/Rural	Days or greater depending on network size

data to be collected, prepare documents, or perform other forecast related functions.)

- Place an "X" in column 4 for those tools which fit the time frame, and a "O" for those tools which you might not be able to use in the available time frame.
- Repeat this procedure for the appropriateness of forecasting tools for the evaluation area's size and rural/urban character. (Use Table 2-7 and Column 5 of Figure 2-1.)
- Select a tool with all "X's" from this chart, if possible, as your forecasting tool.
- If no tool has all "X's," arrange to collect additional input data, get additional training or assistance, or use one of the tools that might be

considered "marginally acceptable" (i.e., has one or more "O's" in columns 4 and 5.)

- Consider the need to defend the the final forecast estimates (i.e., is the likelihood that the project will be debated heavily by the public?). If any controversy is likely, examine whether the initially selected technique can adequately account for those factors that are important to the public debate.
- If the initially selected process is not sensitive to those parameters, select at least one additional technique that is sensitive to those parameters. Make forecasts using both selected techniques.

COLLECT THE INPUT INFORMATION

Gather any data not already collected and examine it for completeness and reasonability (i.e., Do the volumes estimated by the local agencies match the traffic counts made by the Department? Does the MPO dataset for 1990 show a development that was never built?).

If you have questions about the data collected, or if you were told that some data exist, but are unable to obtain it, you may have to either arrange to generate those data (i.e., arrange for traffic counts, or special surveys) or change the selected forecasting technique to reflect the data actually obtained.

REVISE THE SELECTION OF TECHNIQUE(S) AS NECESSARY

If the data required to use a specific forecasting technique are not available, return to the technique selection criteria (Figure 2-1) and select the appropriate tools on the basis of the revised input information. You may also need to pursue this same step if the model results produced with a selected forecasting technique do not appear to be reasonable or are not sufficiently sensitive to the necessary inputs.

CHAPTER 3

PERFORMING THE FORECAST

This chapter describes the specific steps that you must follow to perform a traffic forecast. The chapter is split into three sections. Each section describes a different type of analysis process. These analysis processes are

- trend analysis,
- rural growth analysis, and
- four-step modeling.

You should follow only one of these procedures for each forecast. The write-ups for these sections are independent of each other, and it is not necessary to read this entire chapter to use only one of the techniques described.

Each of the forecasting techniques described assumes that you have already selected the basic forecasting tools you wish to use and have collected the necessary data for input into the forecasting process. These data include estimates of mitigating circumstances and expected changes in the local factors which impact the forecast..

Trend analysis and rural growth analysis are both done manually or with Lotus 1-2-3 spreadsheet templates. Trend analysis is the use of historical traffic count information to predict future traffic volumes. It can be used when several traffic counts near or within a project are available over time at the same location. Rural growth analysis relies on default growth rates, plus site specific information. It is to be used when insufficient data are available to perform either the trend analysis process or the four-step modeling sequence.

The four-step modeling discussion describes the steps you should follow when using any one of the four-step computer models supported by the Department, regardless of which model you have selected. (Specific instructions for the individual models can be found in the User's Guides for the respective models.) It is the most complex of the forecasting techniques, and will be used the least often.

TREND ANALYSIS

This process is most appropriate for rural highways and older urban areas that are not expected to experience large changes in traffic or economic growth during the design period. These changes can be caused by both increased growth, and decreases in developable land. In addition, this procedure is to be followed only when a large number (five years or more) of traffic counts are available as a basis for a trend line. The trend line is estimated with a linear regression technique, and the corresponding growth rate is then applied to the base year traffic estimate. Any necessary adjustments are then added to this growth estimate to account for specific growth areas (new factories, sub-divisions, etc.) in or near the project. The vehicle mix is then adjusted to account for predicted changes in the state or local truck mix. Finally, the required design information (K, D, T) are updated to reflect the predicted traffic volumes.

The specific steps to be followed in this forecasting process are as follows:

- indicate the year for which the baseline traffic estimate is made,
- list the initial traffic conditions,
- indicate the length of the design period and the forecast year,
- calculate the historic growth patterns,
- determine any mitigating circumstances,
- forecast the traffic levels,
- adjust the forecast traffic on the basis of the mitigating circumstances,
- review the results,
- test the sensitivity of the forecast,
- adjust the mitigating circumstance assumptions that have been used,
- revise the forecast, and
- estimate the design traffic data.

These steps are described in more detail below. Use Worksheets 1 through 3 to keep track of the results of these steps and to document the assumptions and results of the forecast efforts.

<u>Indicate Base Year For Traffic</u>

On Worksheet 1, list the base year for the traffic forecast. This is the year in which the roadway will be opened for traffic after the project has been completed. It will either be the current year or a year in the near future. Also at this time, indicate the location of the project you are working on in the upper left-hand corner of the worksheet.

<u>List The Initial Traffic Conditions</u>

Next, place the base year traffic volumes for the project facility in Worksheet 1. These values should be the current year traffic volumes obtained from the TRIPS files or from special traffic counts performed to provide these data. If the project is not scheduled to be opened to traffic for more than one year, treat the baseline as this year and add the number of years left until the project opens to the design period. When calculating total traffic loadings for pavement design, only accumulate traffic loads from the date the project is scheduled for completion. (For example, if a project is a seven year design with an opening date of 1993 and the forecast will be made using 1990 data, treat the project as a ten year design with an opening date of 1990 when developing traffic volumes. Start accumulating ESALs in 1993. Figure 3-1 illustrates this concept.)

Use one worksheet for each traffic estimate to be made for the project. For example, if only one traffic estimate is to be made for the project, only one Worksheet 5-1 is needed. If traffic changes significantly three times within the project (see Figure 3-2 below), then three copies of Worksheet 1 are required.

Worksheet 1. Summary Traffic Information

SR# ____________ Beginning Milepost ____________ Ending Milepost ____________

Forecaster's Name: ______________________________

Base Year ____________ Forecast Year ____________ Duration ____________

BASE YEAR CONDITIONS

Automobile Volume = ________	Other 2-Tire, 4-Axle Veh. = ________	Other Vehicles (Specify type and vehicle): ________
Buses = ________	4-Axle Single Trailer ________	
2-Axle, 6-Tire SU ________	5-Axle Single Trailer ________	5-Axle Multi-Trailer ________
3-Axle Single Units ________	6+ Axle Single Trailer ________	6-Axle Multi-Trailer ________
4+ Axle Single Units ________		7+ Axle Multi-Trailer ________
Total Single Units ________	**Total Single Trailers** ________	**Total Multi-Trailers** ________

AADT = ________ Percent Trucks (Daily) = ________ K = ________

Percent Trucks (Pk. Hr.) = T = ________ D = ________

FORECAST YEAR CONDITIONS

Automobile Volume = ________	Other 2-Tire, 4-Axle Veh. = ________	Other Vehicles (Specify type and vehicle): ________
Buses = ________	4-Axle Single Trailer ________	
2-Axle, 6-Tire SU ________	5-Axle Single Trailer ________	5-Axle Multi-Trailer ________
3-Axle Single Units ________	6+ Axle Single Trailer ________	6-Axle Multi-Trailer ________
4+ Axle Single Units ________		7+ Axle Multi-Trailer ________
Total Single Units ________	**Total Single Trailers** ________	**Total Multi-Trailers** ________

AADT = ________ Percent Trucks (Daily) = ________ K = ________

Percent Trucks (Pk. Hr.) = T = ________ D = ________

WORKSHEET 2

VOLUMES AND ESALS BY PROJECT YEAR

Current Year: ____________   Design Year: ____________

Project Opens: ____________   Design Period ____________

Actual Forecast Duration ____________

Year	____	____	____	____	____	____	____	____	____	____
Forecast Volumes (AWDT)	____	____	____	____	____	____	____	____	____	____
Forecast Truck Volumes (AWDT)	____	____	____	____	____	____	____	____	____	____
Forecast ESALs (Annual, in 000)	____	____	____	____	____	____	____	____	____	____
Cumulative Project ESALs (Annual, in 000)	____	____	____	____	____	____	____	____	____	____
Year (continued)	____	____	____	____	____	____	____	____	____	____
Forecast Volumes (AWDT)	____	____	____	____	____	____	____	____	____	____
Forecast Truck Volumes (AWDT)	____	____	____	____	____	____	____	____	____	____
Forecast ESALs (000) (Annual, in 000)	____	____	____	____	____	____	____	____	____	____
Cumulative Project ESALs (Annual, in 000)	____	____	____	____	____	____	____	____	____	____

DESIGN ESAL ____________

WORKSHEET 3

ASSUMPTIONS USED IN THE FORECAST

Project SR ____________________ Forecasters Initials __________

Date Forecast Completed ____________

Major road system improvements included in the forecast

Special economic growth included in the forecast

Sources for land use, population and current year traffic estimates used in the forecast

Mitigating circumstances and growth rates assumed in the forecast

FIGURE 3-1

CALCULATING CUMULATIVE ESALS FOR PROJECTS NOT OPENING DURING THE CURRENT YEAR (USING WORKSHEET 2)

Current Year: 1990 — Design Year: 2000

Project Opens: 1993 — Design Period: 7 years

Actual Forecast Duration: 10 years

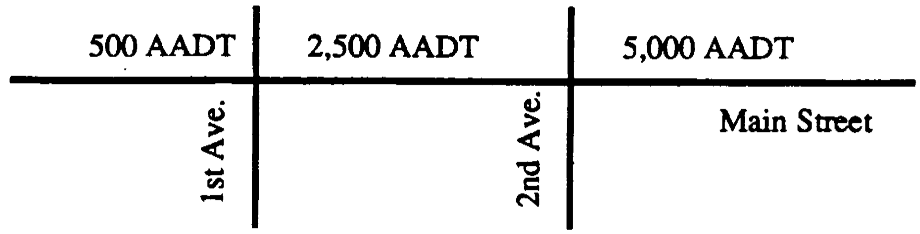
Year	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**
Forecast Volumes (AWDT)	10,700	11,020	11,350	11,690	12,040	12,400	12,780	13,160	13,550	13,690
Forecast Truck Volumes (AWDT)	700	720	740	760	790	810	840	860	890	910
Forecast ESALs (Annual, in 000)	210	216	222	229	236	243	250	258	266	273
Cumulative Project ESALs (Annual, in 000)				229	465	708	958	1,216	1,482	1,755

Year (continued)	----	----	----	----	----	----	----	----	----	----
Forecast Volumes (AWDT)	----	----	----	----	----	----	----	----	----	----
Forecast Truck Volumes (AWDT)	----	----	----	----	----	----	----	----	----	----
Forecast ESALs (000) (Annual, in 000)	----	----	----	----	----	----	----	----	----	----
Cumulative Project ESALs (Annual, in 000)	----	----	----	----	----	----	----	----	----	----

DESIGN ESAL 1,755,000

Figure 3-2

Variable AADTs Within a Project



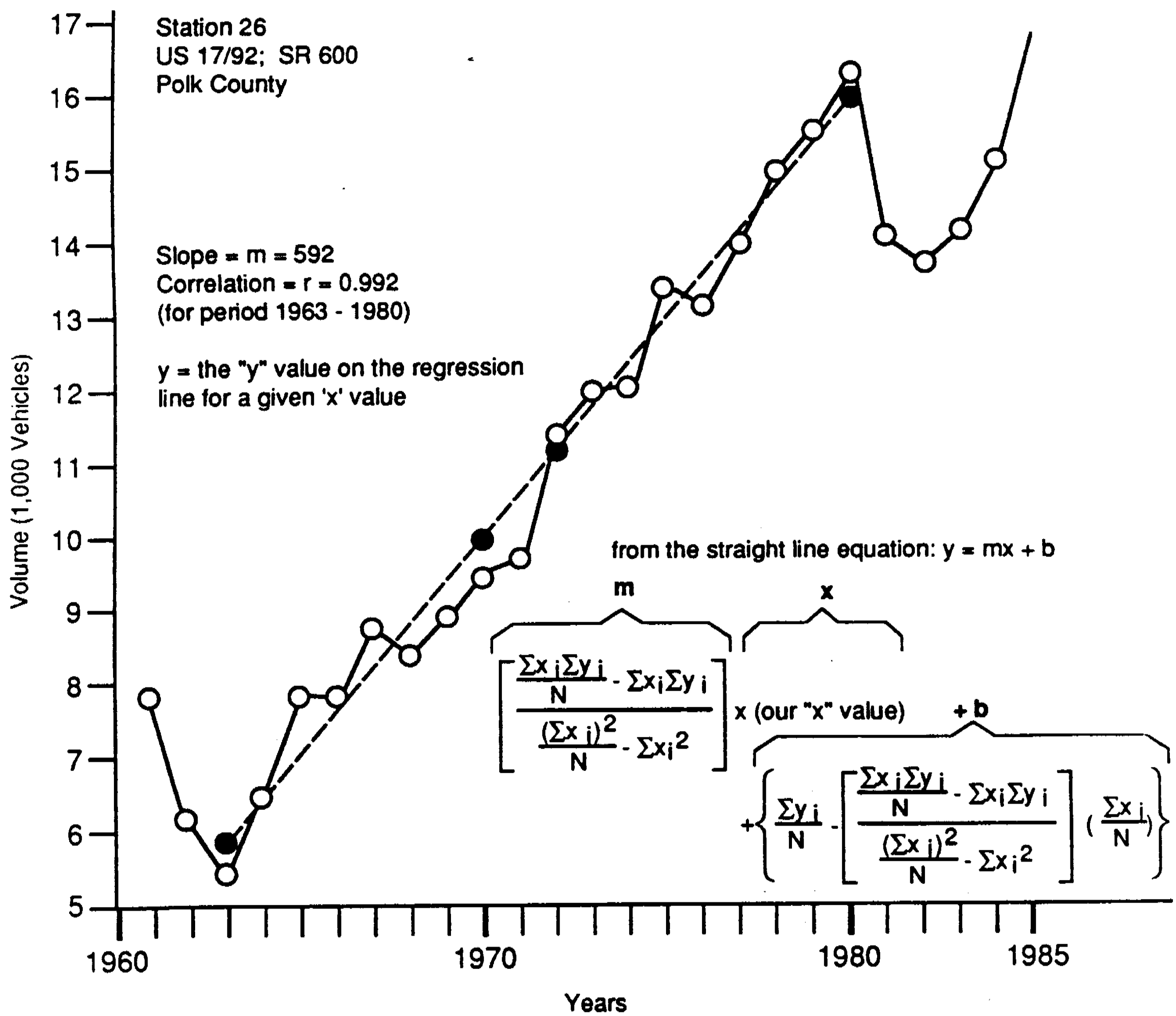
Indicate The Length Of The Design Period And Forecast Year

Indicate on Worksheet 1 the length of the forecast period and the actual forecast year. For overlays, the forecast period is usually ten years, and most projects forecast with this methodology will be overlay jobs. However, other forecast periods may be required, and information about these different design periods should be provided to you as part of the forecast request, or you should obtain them as part of the scoping process (See Chapter 3).

Calculate Historic Growth Patterns

One growth rate is required for each Worksheet 1 filled out above. In many cases, one growth calculation may be able to estimate growth rates for all sections of the highway. This occurs when data is available for only one section of the project, and when growth from other project generators is assumed to be consistent with growth within the area forecast. If only one growth rate assumption is made, this should be clearly described on the assumptions worksheet (Worksheet 3).

To calculate growth, a simple linear regression technique is used to fit a straight line through historical traffic volumes on roads containing projects that do not add lanes. A straight line has proven to be the best fit for predicting future volumes for areas not subject to significant changes in population or employment growth. To confirm that a linear growth should be used, the data are plotted on graph paper and examined for evidence of linear stability (see Figure 3-3). A straight line is then fitted to the stable



$$y = \left[\frac{\frac{\Sigma x_i \Sigma y_i}{N} - \Sigma x_i \Sigma y_i}{\frac{(\Sigma x_i)^2}{N} - \Sigma x_i^2}\right] x + \left\{\frac{\Sigma y_i}{N} - \left[\frac{\frac{\Sigma x_i \Sigma y_i}{N} - \Sigma x_i \Sigma y_i}{\frac{(\Sigma x_i)^2}{N} - \Sigma x_i^2}\right]\left(\frac{\Sigma x_i}{N}\right)\right\}$$

Figure 3-3. Example of Linear Regression Trend Analysis portion of the graph, and the slope is determined. A mathematical process using a hand-held calculator (or a microcomputer using a statistical program like SPSS or SAS) is usually used to determine the coefficients for the growth line, but in many cases, a simple, manual, graphic technique may be sufficient. Table 3-1 and Figure 3-3 illustrate this method and include the necessary formulas for calculating the regression line. While the formula in this exhibit looks complex, the use of modern computer programs and calculators makes this step fairly simple.

Determine The Mitigating Circumstances

Mitigating circumstances are expected changes that may cause the forecast traffic volumes to be different than historical trends indicate. These are the various factors you have explored as part of "becoming familiar with the project" in Chapter 3. They include the construction of new recreational, manufacturing, or industrial facilities along the highway, or along highways that intersect the project highway. These changes can also include the closing of these facilities, or even changes to the highway network itself (such as the opening of parallel roads or the abandonment of a rail line spur).

Use Worksheet 3 to list the mitigating circumstances that you expect to impact traffic on this facility during the forecast period. Also on this worksheet, write your estimate of the impact each expected change will have on the facility. Figure 3-4 provides an example of how to document these expected changes.

Forecast Traffic Levels

Using the historic growth rate calculated above, use the Lotus spreadsheet **TABLE1.WK1** to estimate the preliminary traffic levels on the project facility. One forecast is required for each Worksheet 1 you have developed. This forecast represents the amount of traffic expected without the "extenuating circumstances" listed on Worksheet 2.

TABLE 3-1. DATA FOR REGRESSION EXAMPLE

YEAR	AADT
1960	7,945
1961	7,908
1962	6,136
1963	5,553
1964	6,506
1965	7,860
1966	7,907
1967	8,743
1968	8,494
1969	8,952
1970	9,658
1971	9,834
1972	11,252
1973	11,980
1974	12,068
1975	13,503
1976	13,265
1977	14,066
1978	14,880
1979	15,414
1980	16,200
1981	14,051
1982	13,634
1983	14,152
1984	14,942
1985	16,842

Stable Growth Period (1964–1980)

Equation of line through stable growth period is

$$Y = 592\,X + 5{,}868$$

in which Y = AADT and

X = age (in years)

Slope = 592

Correlation (r) = 0.99

FIGURE 3-4

WORKSHEET 3
ASSUMPTIONS USED IN THE FORECAST

Project SR __________________ Forecasters Initials _________

Date Forecast Completed ___________

Major road system improvements included in the forecast

Special economic growth included in the forecast

Sources for land use, population and current year traffic estimates used in the forecast

Mitigating circumstances and growth rates assumed in the forecast

Adjust The Forecast Traffic On The Basis Of The Mitigating Circumstances

Apply the changes you expect from the "mitigating circumstances" to the preliminary traffic volume estimates. Use the same Lotus spreadsheet (TABLE1.WK1) to make these additions. Note that these adjustments can occur at any point in the forecast period.

For example, you may estimate that a new resort will open three years into the ten-year design period. This resort will generate 100 automobile trips and two trips by 3S2 trucks per day for its first year of operation, and twice that number every year thereafter. To account for this, you should add these estimates to the preliminary estimates in the Lotus spreadsheet, starting in the third year of the forecast. Each additional "mitigating circumstance" is added until all changes have been made. This process should be done for each Lotus 1-2-3 spreadsheet you have developed as part of the project.

By adding in the mitigating circumstances, you have now created the initial set of forecast estimates for this project.

Review The Results

The forecast estimates produced above must be reviewed before they are provided to the design engineers. This review must include both a check for "reasonableness" and a check for sensitivity.

If this is a pavement overlay project, one review should examine the forecast with respect to data from the pavement performance monitoring system (PMS). This review should be performed by the Materials Lab (or whoever else is performing the axle load calculation). The PMS tracks a pavement's condition and deterioration over time. If a pavement has deteriorated more quickly than it should have (i.e., the pavement has not reached its design life, in years), it is important for you and the pavement design engineer to look particularly carefully at truck volumes on that facility. If the truck volumes used for the last pavement design are available, compare those estimates with the current truck volume estimates. If they are the same, or nearly the same, you should consider increasing the estimated truck volumes. Essentially, you are using the unusually high rate of deterioration shown in the PMS as an additional mitigating circumstance. While many factors could cause premature pavement deterioration, under-estimated truck volumes and under-estimated truck weights are particularly common causes.

A review that should be performed for all projects is an examination of the Level of Development (LOD) category implied by a forecast. LOD impacts the design standards for a roadway, and you should not take lightly the shifting of a road from one LOD category to another. If a forecast does cause a change in a road's LOD categories, you should discuss this result with the project design engineer and examine whether small changes in the forecast alter this new LOD rating. Essentially, you want to know whether small errors in the forecast will cause you to incorrectly predict the proper LOD category for that road.

If small changes in the forecast assumptions cause changes in the future LOD category for a road, the uncertainties of the forecasting process may warrant a closer examination of the forecast estimate and the inputs used to make that estimate. In particular, you may also want to consider other factors, such as the availability of funds for increasing the size of that road, the public reaction to a change in the LOD designation for that road, and the desires of local jurisdictions to have that road change LOD categories.

In addition to the PMS and LOD reviews described above, you should also examine other aspects of the forecast's impact on the project. As part of this examination, you should be able to answer the following questions:

- Does the forecast level of traffic indicate congestion? If so what level of congestion? (Unless this project already includes a complete capacity analysis, this should be a cursory examination, intended to provide insight into whether capacity has unexpectedly become an important design issue.)

- Could part of that congestion be alleviated by other existing or planned roads?
- Does the predicted level of traffic make sense for the project?
- How does that level of traffic compare with traffic on other roads like that one?
- Do the sources for truck traffic appear to be large enough (or small enough) to generate the estimated level of truck traffic?
- Have you accounted for possible railroad branch line abandonments?

Any specific concerns should be noted and investigated more carefully.

Adjust Mitigating Circumstance Assumptions

If the sensitivity analysis and review of the project point out errors or areas of concern, adjust the assumptions and mitigating circumstances used in the initial forecast estimate. These adjustments can be made to the expected changes in total traffic volumes or the expected changes in particular vehicle types. They can occur over the length of the project or be restricted to one-year events. Make sure that you note any additions or deletions you make to your assumptions on Worksheet 3 so that reviewers have an accurate understanding of the final set of assumptions inherent in the forecast.

Revise The Forecast

Using the revised mitigating circumstance assumptions, revise the initial daily traffic forecasts for the project. This revision includes changing the assumptions you have listed on the worksheets and revising the Lotus 1-2-3 spreadsheet used to calculate the forecast traffic. Review these revised results in the same manner you reviewed the initial forecasts. Continue the review/revision process until you are satisfied with the results, and then record the tests you made, the reasons you made those tests, a brief explanation of the results of those tests, and the final assumptions used in the actual project forecasts.

Take the design loading results from the final Lotus 1-2-3 spreadsheet and place them on the bottom of Worksheet 2. As before, this must be done for each worksheet used for this project.

<u>Estimate Design Traffic Data</u>

In many cases, you must refine traffic forecasts to include design hour volumes, truck percentages and directional splits. (This forecasting technique already provides the required daily and annual estimates of trucks and ESALs.) To estimate these values, you should start with estimates of base year conditions, and then revise those estimates as a result of forecast conditions.

Information for estimating base year values for D and T can be obtained from TRIPS and through the state's PTR system. Base year traffic counts near the site will provide a good estimate of the directional distribution of traffic and (if vehicle classification counts have been performed) a reasonable estimate of the truck traffic present during the peak periods of the day. These measurements can be used to estimate both current and forecast D and T values, although you should take into account the fact that design hour conditions may be more extreme than the peak period conditions measured by the base year traffic counts. You should also take into account site specific changes which are expected to occur over the life of the project (such as the construction of a new industrial facility) that may change these values.

The K factor is more difficult to estimate than D and T. If a WSDOT PTR station is located near the project on the same road, the traffic data from that counter should provide a good estimate of the design hour traffic. (In most cases, the 30th highest hour of the year is used to compute the K factor for a project, although for partial recreational routes the 50th highest hour of the year may be used, and for very low volume roads that are exclusively recreational, the 200th highest hour may be used. These lower K factors are used when using the 30th highest hour volume would result in the construction of a large road which was unused for the majority of the year.)

Where a WSDOT PTR is not readily available, the estimation of the K factor becomes more subjective. Figures 3-5 and 3-6 show how hourly traffic volumes (and thus K factors) vary at different sites. Selecting from within these curves is mostly a judgement call based on the known characteristics of the site. To help select an appropriate K factor, look at the peaking characteristics of PTR sites that have similar traffic patterns and volumes to your project facility, also decide whether the project facility experiences heavy recreational traffic flows (and therefore has a large K factor), or whether the facility will be capacity constrained (as in many urban and suburban sites) and will thus have a lower value of K. It is also a good idea to discuss your selection of a K value with other persons involved in traffic forecasting, to gain their insight. In general, the greater the average daily traffic, the lower the K factor. In addition, the more urban the road and the less recreational the traffic the lower the K factor.

Once you have selected a K factor for current conditions, assume that this value will stay stable or decline slightly over time if volumes on the facility are increasing. Use the forecast AADT estimate and the K factor estimate and compare the predicted design hour volumes against the expected future roadway characteristics for the project. to determine if the K factor makes sense.

To do this, multiply the selected values for the current traffic conditions by the forecast daily AADT and compare the resulting traffic volume against the planned capacity of the roadway. (This should be a "quick and dirty" calculation.) If the volume to capacity ratio does not indicate a reduction in the level of service from current standards, assume that the baseline K, D, and T values will remain the same in forecast years.

FIGURE 3-5

RANGES OF DESIGN HOUR FACTORS[2]

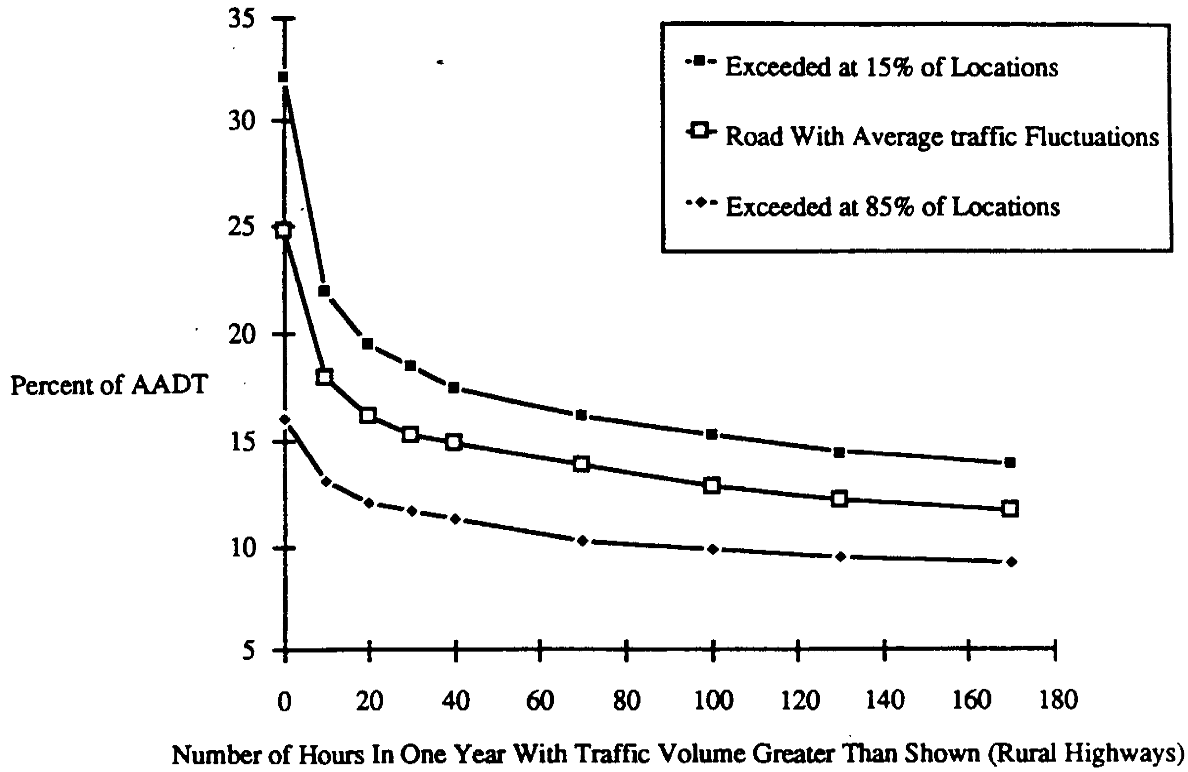
K-Factors By Highway Group

Highway Type		Two-Way	One-way
Large Urban:	Controlled access	.09 - .10	.06 - .07
	No access control	.08 - .12	.06 - .07
Small urban	Controlled access	.10 - .15[3]	.08 - .12
	No access control		.06 - .07
Rural	Controlled access	.15 - .20	.08 - .12
	No access control	.1 - .15	.06 - .08

If a reduction in the level of service will result from the new design hour volume, you must examine other facets of the project design before determining design hour factors. If the project is in an area of heavy recreational travel (where peak period volumes are very high), the Department may determine that some congestion during peak periods is more acceptable than building capacity that is unused for the majority of the year. In this case, a reduced design hour percentage will be used in the design process. It is also possible (particularly in urban and suburban areas) that general congestion on the facility, and an inability of the Department to expand roadway capacity will lead to a spreading of the peak traffic flows and a subsequent reduction in the design hour flow from that predicted. Selecting between these alternatives should be done after looking at the available data, and discussing the project with others who are used to performing traffic forecasting.

2 Sources: Highway Capacity Manual and New York State DOT, Traffic Forecasting Guide, Chapter 11

3 Factor for "suburban freeway"



Source: "Highway Engineering - 5th Edition, by Wright and Paquette

Figure 3-6. Alternative Design Hour Factor Ranges

Finally, additional guidance on design hour factors can be obtained from reports such as the New York State Traffic Forecasting Guide, and data on urban peak periods found in NCHRP reports 187 and 255.

Your selected design hour estimates should be placed in Worksheet 1 for each project section in the forecast.

RURAL GROWTH ANALYSIS

This procedure is to be followed when four-step planning models are not appropriate (for lack of data and/or time) and when the historical data at the project site are insufficient to allow the calculation of trends for that site. These problems usually occur on low volume, rural roads for pavement-only (resurfacing) projects. This methodology does not account well for major changes in traffic growth or changes in travel patterns resulting from expected geometric changes (i.e., new interchanges) to the project facility or surrounding facilities. It can do a reasonably good job of estimating growth due to new housing or industrial construction in the immediate vicinity. The following steps are to be followed when this type of forecast is performed:

- indicate the year for which the baseline traffic estimate is made,
- list the initial traffic conditions,
- indicate the length of the design period and the forecast year,
- determine the mitigating circumstances (local growth),
- forecast the background traffic growth,
- adjust the background traffic on the basis of the mitigating circumstances (local conditions),
- review the results and test their sensitivity,
- adjust the mitigating circumstance assumptions as necessary,
- revise the forecast as necessary, and
- estimate the design traffic data.

Worksheets 1 through 3 should be used to keep track of these estimates.

Indicate The Base Year For Traffic

On Worksheet 1, list the base year for the traffic forecast. This is the year in which the roadway will be opened for traffic after the project has been completed. This will either be the current year or a year in the near future. Also, you should indicate the location of the project you are working on in the upper left-hand corner of the worksheet.

List Initial Traffic Conditions

Next, place the base year traffic volumes for the project facility in Worksheet 1. These values should be the current year traffic volumes obtained from the TRIPS files or from special traffic counts performed to provide these data. If the project is not scheduled to be opened to traffic for more than one year, treat the baseline as this year and add the number of years left until the project opens to the design period. When calculating total traffic loadings for pavement design, only accumulate traffic loads from the date the project is scheduled for completion. (For example, if a project is a seven year design with an opening date of 1993 and the forecast will be made using 1990 data, treat the project as a ten year design with an opening date of 1990 when developing traffic volumes. Start accumulating ESALs in 1993. Figure 3-7 illustrates this concept.)

Use one worksheet for each traffic estimate to be made for the project. For example, if only one traffic estimate is to be made for the project, only one Worksheet 5-1 is needed. If traffic changes significantly three times within the project (see Figure 3-9 below) then three copies of Worksheet 1 are required.

Figure 3-8

Variable AADTs Within a Project

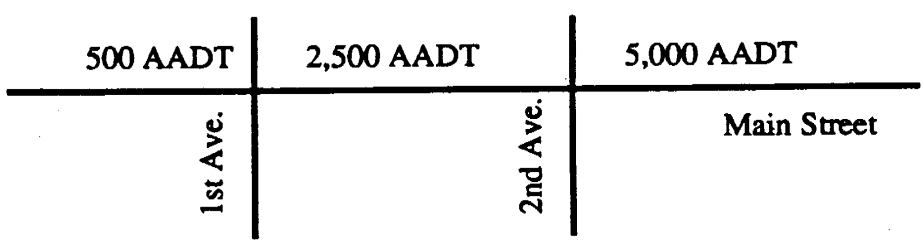


FIGURE 3-7

CALCULATING CUMULATIVE ESALS FOR PROJECTS NOT OPENING DURING THE CURRENT YEAR (USING WORKSHEET 2)

Current Year: 1990 | Design Year: 2000

Project Opens: 1993 | Design Period 7 years

Actual Forecast Duration 10 years

Year	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**
Forecast Volumes (AWDT)	10,700	11,020	11,350	11,690	12,040	12,400	12,780	13,160	13,550	13,690
Forecast Truck Volumes (AWDT)	700	720	740	760	790	810	840	860	890	910
Forecast ESALs (Annual, in 000)	210	216	222	229	236	243	250	258	266	273
Cumulative Project ESALs (Annual, in 000)				229	465	708	958	1,216	1,482	1,755

Year (continued)	____	____	____	____	____	____	____	____	____	____
Forecast Volumes (AWDT)	____	____	____	____	____	____	____	____	____	____
Forecast Truck Volumes (AWDT)	____	____	____	____	____	____	____	____	____	____
Forecast ESALs (000) (Annual, in 000)	____	____	____	____	____	____	____	____	____	____
Cumulative Project ESALs (Annual, in 000)	____	____	____	____	____	____	____	____	____	____

DESIGN ESAL 1,755,000

Indicate The Length Of The Design Period And Forecast Year

Indicate on Worksheet 1 the length of the forecast period and the actual forecast year. For overlays, the forecast period is usually ten years, and most projects forecast with this methodology will be overlay jobs. However, other forecast periods may be required, and information about these different design periods should be provided to you as part of the forecast request, or you should have obtained them as part of the scoping process (See Chapter 3).

Determine Mitigating Circumstances

Mitigating circumstances are expected changes that may cause the forecast traffic volumes to be different than statewide trends indicate. These are the various factors you have explored as part of "becoming familiar with the project" in Chapter 3. They include the construction of new recreational, manufacturing, or industrial facilities along the highway, or along highways that intersect the project highway. These changes can also include the closing of these facilities, or changes to the transportation network itself (such as the opening of parallel roads or the abandonment of a rail line spur.)

Use Worksheet 3 to list the mitigating circumstances that you expect to impact traffic on this facility during the forecast period. Also on this worksheet, write your estimate of the impact each expected change will have on the facility. Figure 3-9 provides an example of how to document these expected changes.

Forecast Background Traffic

This procedure forecasts expected background traffic levels on the basis of existing traffic volumes and a default estimate of growth available through the TRIPS database. To make this estimate, you should use the Lotus 1-2-3™ spreadsheet named **TABLE1.WK1**. You should use the spreadsheet once for each traffic volume forecast you need for this project.

FIGURE 3-9

WORKSHEET 3
ASSUMPTIONS USED IN THE FORECAST

Project SR ____________________ Forecasters Initials __________

Date Forecast Completed ____________

Major road system improvements included in the forecast

Special economic growth included in the forecast

Sources for land use, population and current year traffic estimates used in the forecast

Mitigating circumstances and growth rates assumed in the forecast

For input, this spreadsheet uses the baseline traffic information you have entered onto Worksheet 1. It then adjusts those estimates on the basis of the expected growth of automobile and truck traffic over the desired period. Specific directions for the spreadsheet are given in Appendix A. Enter the expected growth in truck traffic (obtained from TRIPS) into the appropriate cells in the spreadsheet. The spreadsheet then automatically computes the "background" traffic forecast.

Adjust The Background Traffic On The Basis Of The Mitigating Circumstances

While still using the spreadsheet **TABLE1.WK1**, apply the changes you expect from the "mitigating circumstances" to the background traffic volume estimates calculated above. Note that these adjustments can occur at any point in the forecast period. For example, you may estimate that a new resort will open three years into the ten-year design period. This resort will generate 100 automobile trips and two trips by 3S2 trucks per day for its first year of operation, and twice that number every year thereafter.

To account for this, you should add these estimates to the background volume estimates in the Lotus spreadsheet, starting in the third year of the forecast. Traffic volumes (by class) for each additional "mitigating circumstance" are added to the spreadsheet until all expected changes have been made. This process should be done for each Lotus 1-2-3 spreadsheet you have developed as part of the project.

By adding in the mitigating circumstances, you have now created the initial set of forecast estimates for this project.

Review The Results And Test For Sensitivity

The forecast estimates produced above must be reviewed before they are provided to the design engineers. This review must include both a check for "reasonableness" and a check for sensitivity.

If this is a pavement overlay project, one review should examine the forecast with respect to data from the pavement performance monitoring system (PMS). This review should be performed by the Materials Lab (or whoever else is performing the axle load calculation). The PMS tracks a pavement's condition and deterioration over time. If an existing pavement has deteriorated more quickly than it should have (i.e., the pavement has not reached its design life, in years), it is important for you to look particularly carefully at truck volumes on that facility. If the truck volumes used for the last pavement design are available, compare those estimates with the current truck volume estimates. If they are the same, or nearly the same, you should consider increasing the estimated truck volumes. Essentially, in this case you are using the unusually high rate of deterioration shown in the PMS as an additional mitigating circumstance. While many factors could cause premature pavement deterioration, under-estimated truck volumes and under-estimated truck weights are particularly common causes.

A review that should be performed for all projects is an examination of the new Level of Development (LOD) category implied by a forecast. LOD affects the design standards for a roadway, and you should not take lightly the shifting of road from one LOD category to another. If a forecast does cause a change in LOD categories for a road, you should discuss this result with the design engineer and examine whether small changes in the forecast alter this new LOD rating. Essentially, you want to know whether small errors in the forecast will cause you to incorrectly predict the proper LOD category for that road.

If small changes in the forecast assumptions cause changes in the future LOD category for a road, the uncertainties of the forecasting process may warrant a closer examination of the forecast estimate and the inputs used to make that estimate. In particular, you may also want to consider other factors, such as the availability of funds for increasing the size of that road, the public reaction to a change in the LOD designation for that road, and the desires of local jurisdictions to have that road change LOD categories.

In addition to the PMS and LOD reviews described above, you should also examine other aspects of the forecast's impact on the project. As part of this examination, you should be able to answer the following questions:

- Does the forecast level of traffic indicate congestion? If so what level of congestion? (Unless this project already includes a complete capacity analysis, this should be a cursory examination, intended to provide insight into whether capacity has unexpectedly become an important design issue.)
- Could part of that congestion be alleviated by other existing or planned roads?
- Does the predicted level of traffic make sense for the project?
- How does that level of traffic compare with traffic on other roads like that one?
- Do the sources for truck traffic appear to be large enough (or small enough) to generate the estimated level of truck traffic?
- Have you accounted for possible railroad branch line abandonments?

Any specific concerns should be investigated more closely.

Adjust Mitigating Circumstance Assumptions

If the sensitivity analysis and review of the project point out errors or areas of concern, adjust the assumptions and mitigating circumstances used in the initial forecast estimate. These adjustments can be in the expected changes in total traffic volumes or the expected changes in particular vehicle types. They can occur over the length of the project or be restricted to one-year events. You may even change the expected background growth rates. Whatever changes you make, record them and the reason why you made them on Worksheet 3. This information can then be used by reviewers to understand the thinking behind the forecasting process.

Revise The Forecast

Using the revised mitigating circumstance assumptions, update the initial daily traffic forecasts for the project. This revision includes changing the assumptions you have listed on the worksheets, and revising the Lotus 1-2-3 spreadsheet used to calculate the forecast traffic. Review these revised results in the same manner you reviewed the initial forecasts. Continue the review/revision process until you are satisfied with the results, and then record the tests you made, the reasons you made them, a brief explanation of their results, and the final assumptions used in the actual project forecasts.

Take the results from the final Lotus 1-2-3 spreadsheet and place them on the bottom of Worksheet 1. As before, this must be done for each worksheet used for this project. Make sure that Worksheet 3 reflects the assumptions used in the final forecast.

Estimate Design Traffic Data

In many cases, you must refine traffic forecasts to include design hour volumes, truck percentages and directional splits. (This forecasting technique already provides the required daily and annual estimates of trucks and ESALs.) To estimate these values, you should start with estimates of base year conditions, and then revise those estimates as a result of forecast conditions.

Information for estimating base year values for D and T can be obtained from TRIPS and through the state's PTR system. Base year traffic counts near the site will provide a good estimate of the directional distribution of traffic and (if vehicle classification counts have been performed) a reasonable estimate of the truck traffic present during the peak periods of the day. These measurements can be used to estimate both current and forecast D and T values, although you should take into account the fact that design hour conditions may be more extreme than the peak period conditions measured by the base year traffic counts. You should also take into account site specific changes which are expected to occur over the life of the project (such as the construction of a new industrial facility) that may change these values.

The K factor is more difficult to estimate than D and T. If a WSDOT PTR station is located near the project on the same road, the traffic data from that counter should provide a good estimate of the design hour traffic. (In most cases, the 30th highest hour of the year is used to compute the K factor for a project, although for partial recreational routes the 50th highest hour of the year may be used, and for very low volume roads that are exclusively recreational, the 200th highest hour may be used. These lower K factors are used when using the 30th highest hour volume would result in the construction of a large road which was unused for the majority of the year.)

Where a WSDOT PTR is not readily available, the estimation of the K factor becomes more subjective. Figures 3-10 and 3-11 show how hourly traffic volumes (and thus K factors) vary at different sites. Selecting from within these curves is mostly a

FIGURE 3-10

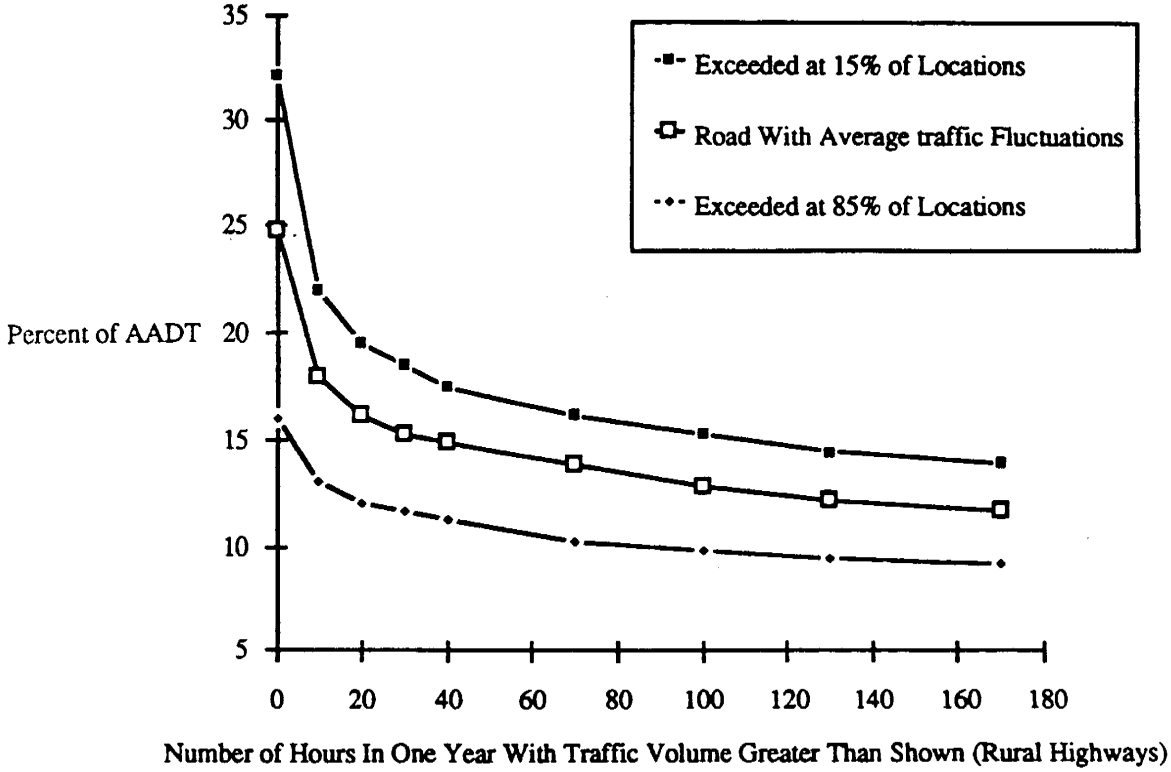
RANGES OF DESIGN HOUR FACTORS[4]

<u>**K-Factors By Highway Group**</u>

Highway Type		**Two-Way**	**One-way**
Large Urban:	Controlled access	.09 - .10	.06 - .07
	No access control	.08 - .12	.06 - .07
Small urban	Controlled access	.10 - .15[5]	.08 - .12
	No access control		.06 - .07
Rural	Controlled access	.15 - .20	.08 - .12
	No access control	.1 - .15	.06 - .08

4 Sources: Highway Capacity Manual and New York State DOT, Traffic Forecasting Guide, Chapter 11

5 Factor for "suburban freeway"



Source: "Highway Engineering - 5th Edition, by Wright and Paquette

Figure 3-11. Alternative Design Hour Factor Ranges judgment call based on the known characteristics of the site. To help select an appropriate K factor, look at the peaking characteristics of PTR sites that have similar traffic patterns and volumes to your project facility, also decide whether the project facility experiences heavy recreational traffic flows (and therefore has a large K factor), or whether the facility will be capacity constrained (as in many urban and suburban sites) and will thus have a lower value of K. It is also a good idea to discuss your selection of a K value with other persons involved in traffic forecasting, to gain their insight. In general, the greater the average daily traffic, the lower the K factor. In addition, the more urban the road and the less recreational the traffic the lower the K factor.

Once you have selected a K factor for current conditions, assume that this value will stay stable or decline slightly over time if volumes on the facility are increasing. Use the forecast AADT estimate and the K factor estimate and compare the predicted design hour volumes against the expected future roadway characteristics for the project. to determine if the K factor makes sense.

To do this, multiply the selected values for the current traffic conditions by the forecast daily AADT and compare the resulting traffic volume against the planned capacity of the roadway. (This should be a "quick and dirty" calculation.) If the volume to capacity ratio does not indicate a reduction in the level of service from current standards, assume that the baseline K, D, and T values will remain the same in forecast years.

If a reduction in the level of service will result from the new design hour volume, you must examine other facets of the project design before determining design hour factors. If the project is in an area of heavy recreational travel (where peak period volumes are very high), the Department may determine that some congestion during peak periods is more acceptable than building capacity that is unused for the majority of the year. In this case, a reduced design hour percentage will be used in the design process. It is also possible (particularly in urban and suburban areas) that general congestion on the facility, and an inability of the Department to expand roadway capacity will lead to a spreading of the peak traffic flows and a subsequent reduction in the design hour flow from that predicted. Selecting between these alternatives should be done after looking at the available data, and discussing the project with others who are used to performing traffic forecasting.

Finally, additional guidance on design hour factors can be obtained from reports such as the New York State Traffic Forecasting Guide, and data on urban peak periods found in NCHRP reports 187 and 255.

Your selected design hour estimates should be placed in Worksheet 1 for each project section in the forecast.

FOUR-STEP MODELING PROCESS

This procedure is to be followed when you select any of the four-step computer models. The basic steps involved in the modeling chain are similar for all of the models (notes are provided in the paragraphs below when these steps are not required for particular models). The primary differences among the models are in the specific input formats used for the data; the complexity of the input data; the complexity of the modeling sequence; the specific factors the models are sensitive to, and the manner in which information is input, manipulated, and extracted from the models. However, the basic steps you perform when using the models are the same. These steps include the following:

- indicate the year for which the baseline traffic estimate is made,
- list the initial traffic volumes,
- indicate the length of the design period and the forecast year,
- format the data for input to the base year model runs,
- calibrate the model,
- format the input data to be used for estimating future year predictions,
- apply the model to provide future year estimates,
- review the results,
- perform sensitivity analyses,
- revise the forecast (re-apply the model),
- refine the model estimates,
- determine the shape of the expected growth curve, and
- develop intermediate volume estimates as needed.

These steps are described in more detail below. Use Worksheet 1 to keep track of the results of these steps and to document the results of the forecast efforts.

Indicate The Base Year For Traffic

List the base year for the traffic forecast on the upper portion of Worksheet 1. The base year of the forecast is the year in which the roadway will be opened for traffic after the project has been completed. This will either be the current year or a year in the near future. Also at this time, indicate the location of the project you are working on in the upper left-hand corner of the worksheet.

List Initial Traffic Conditions

Next, place the base year traffic volumes for the project facility in Worksheet 1. These values should be either the current year traffic volumes obtained from the TRIPS files (or from special traffic counts) or these same values adjusted slightly to account for growth in the next year or two, if the project will not be opened until then. (This short-term growth should be a linear growth and can be estimated using the estimates stored in TRIPS or on the basis of conversations with District or local agency personnel.)

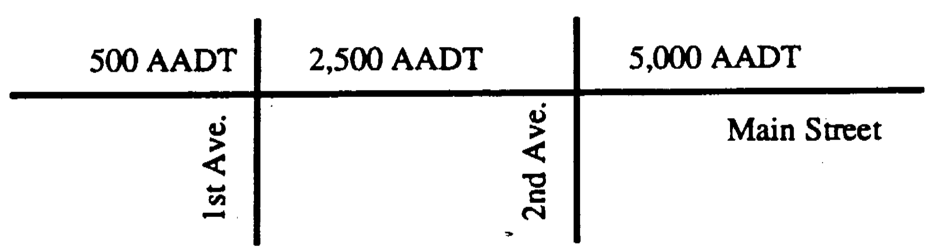
Use as many worksheets as necessary for the project. For example, if only one traffic estimate is to be made for the project, only one Worksheet is needed. If the traffic changes significantly three times along the route (See Figure 3-12 below) then three copies of Worksheet 1 are required.

Indicate The Length Of The Design Period And Forecast Year

Indicate on Worksheet 1 the length of the forecast period and the year for which the forecast is made. For new pavements, this is usually 20 or 30 years. For overlays, the

Figure 3-12

Variable AADTs Within a Project



forecast period is usually ten years. If a forecast period other than this is required, you should be informed of the desired time period in the forecast request or during the scoping process (See Chapter 3).

Format Data For Input To The Model

It is now time to begin working with the computer models. The first step in this process is to transform the data obtained in Chapters 3 and 4 into the format required by each model. (Specific model inputs are described in each model's User's Guide and summarized in Appendix D.) Data formatting usually requires the following steps:

- creating a highway network (link/node representation) in the appropriate model structure,
- developing the zone structure to be used by the model,
- aggregating the land use and population information obtained in Chapters 3 and 4 into the zone structure developed, and
- obtaining any mode split models that are required by the modeling chain (some models use them, some do not).

Create The Highway Network

All four-step models except SPF use a link/node highway network. In many cases an existing network can be obtained from one of the sources listed earlier in Table 2-3. If not, the network must be obtained from maps and translated into the appropriate link/node format for the selected model.

When you create (or obtain) a link/node highway network, it is important that you tailor the network to the project being performed. For example, you may obtain a regional highway network from an MPO. Your project may appropriately add detail to that network in the geographic area surrounding the project and reduce the detail of that network in areas far away from the project. This process is called "windowing," or "sub-area focusing." Windowing reduces the cost of required computer time while allowing a more precise look at traffic patterns near the points that are most important to the study.

It is also very important to compare the highway network given to you with the actual configuration of the street system. Networks can easily become out-of-date. They may include roads that were planned but never built. They may include "dummy" links that were added as part of another analysis and not removed. They may include links that represent a combination of several roads. For every analysis, you should review the network after coding has been completed to ensure that the modeled network contains all of the links that you desire, that you understand and want all of the links present in the network, and that no errors in the network are present as a result of the coding process.

Finally, when you create or review a network it is important that you check to ensure that the network contains the necessary provisions for examining all project proposals. This means that not only does the project street system need to be well represented in the network, but the network must be able to add new links or facility changes that need to be modeled as part of the forecasting alternatives.

For the more complex models (EMME II and UTPS), you must also often develop and code a transit network. The transit network should be developed in the same manner as the highway network and with the same amount of care applied.

Develop The Zone Structure

The zone structure is developed in tandem with the highway network. In most all cases, you will inherit an existing zone structure (census tracts or an existing model's Traffic Analysis Zones (TAZ)) from previous studies. You must refine these zone systems to fit your needs. Refinement entails aggregating zones where the existing zones provide more detail than you need, and splitting zones into finer geographic areas where you want to "window" and require a greater level of precision. Pay particular attention to the size of zones near your project and the number, location and potential impact of the zonal connectors that link those zones to the link/node highway network. These connections tend to overload the roads they join, and this overloading can seriously impact the accuracy of the traffic conditions predicted for your project.

Aggregate Zonal Data

Once the zone system has been established, you must transform the available data into the appropriate data entry format. This may mean the aggregation of some information and the disaggregation of others. Take care when you perform this task to ensure that the character of each zone is accurately reflected by the data for that geographic area. (In other words, make sure the aggregation/disaggregation process does not lead to modeling problems such as all trips to or from a zone using the same highway, when in reality they would use four different roads that are included in the network.)

Obtain Mode Split Models

With the more sophisticated modeling packages (EMME II and UTPS) a mode split model must be run as part of the modeling chain. The less complex models usually assume a mode split and auto occupancy rate and are not sensitive to transit characteristics or mode shifts caused by economic factors. The more complex programs apply mode split models developed as part of large survey efforts and other large studies.

If your model supplies a mode split model, make sure that you understand the assumptions that use of that model implies. (For example, does it assume everyone drives a car? Does it assume one person per car or does it assume some average vehicle occupancy per vehicle? Does vehicle occupancy vary among different trip types?) When you are supplying a mode split model, make sure that you understand the factors that model is sensitive to and under what conditions it should be used. For example, a model designed for use with bus transit may not be calibrated for use with heavy rail transit.

In congested urban areas carpooling and other non-transit high occupancy vehicle (HOV) incentives are a major subject of concern to forecasters. The more complex mode split models can directly forecast these characteristics, although you should pay a great deal of attention to such a model's inputs and assumptions, and review its output for "reasonableness." Where the available mode split model does not directly account for the the impacts of HOV incentives and those incentives may have an impact on the forecast volumes, you should use documents such as "Freeway and HOV Lane Mobility Estimation Methodology," by Tim Loman (FHWA/TX-88), and "High Occupancy Vehicle Facility Development, Operation and Enforcement," by D.R. Samdahl, et. al. as guides for estimating the impacts of those incentives on forecast volumes and traffic congestion.

When you have questions about using a particular mode split model, contact someone within the Headquarters staff assigned to assist with forecasting, and discuss the options that are available to you. Taking a little more time and making valid decisions when selecting mode split models will always provide you with a better end product than continuing without direction.

Calibrate The Model

Run the selected model through its modeling chain using the base year inputs you have just finished coding. Compare the traffic volumes output from the model with the traffic data that you entered or collected earlier in the forecasting process. Also compare the traffic volumes output from the model with existing volumes on other important roads in the network. Data on the actual traffic volumes on other roads in the network can be obtained from TRIPS, the jurisdictions responsible for those roads and a variety of other sources.

The model volumes on major roads and roads near your project should be within about 10 percent of the measured street volumes for the model to be considered calibrated. For larger corridor planning studies, you may also have to calibrate the model against screen lines in addition to specific roads. (For example, all volumes from the north past this line should total X, where X is the sum of volumes from the north as measured by a series of traffic counters.) Occasionally in regional applications you may calibrate a model so that it accurately represents corridor volumes but is not able to accurately duplicate flows on individual roads within the corridor. This problem is usually caused by insufficient detail in either the network itself (the network does not include all of the streets in the region) or the zone system (too many trips start out from one point on the road network and never distribute themselves correctly over the remainder of the network).

For corridor studies, you can often "make do" with a model that places too many vehicles on one road and too few vehicles on a parallel road, so long as the total volumes within the corridor are reasonable. However, it is important that you note the discrepancies between the model output and the ground counts and then examine the model's future year estimates to determine whether this poor distribution between parallel facilities is still apparent. If necessary, you can adjust these future year estimates to better estimate traffic on each facility. Such an adjustment can be done manually, through the use of a different traffic assignment model or through procedures described in the literature, such as NCHRP Report 255.

For projects that look at specific roads, you may have to disaggregate the zone and highway information near the project to provide the detailed traffic volumes and movements your project requires. You may also have to use one model (an existing regional model) to estimate total volume on nearby roads and then use a different model with a smaller network to distribute those estimated vehicle trips over the roads adjacent to your project.

In general, if the model outputs do not match the existing traffic predictions, then you must make some type of adjustment to the network, zonal information, and/or model parameters to calibrate the model. Try a variety of different adjustments (e.g, friction factors or K factors in the gravity model) until the model outputs replicate the existing conditions or until it becomes clear that the input data and model can not replicate existing conditions. If radical adjustments are required to calibrate the model, consider using a different model or review the input assumptions to ensure that the model inputs actually reflect current conditions.

Format The Data For Future Year Predictions

After the model has been calibrated, you are ready to convert the future estimates of land use, population, and highway changes into the appropriate modeling format. Take care to use the same modeling conditions (except for planned network changes) in the forecast year that you used in the final calibration run.

Apply The Model For Future Years

After you have coded the input data, apply the models for the future year conditions. The different four-step models require different levels of effort to work through the modeling chain. UTPS can require as many as 14 separate program runs to complete all phases of trip generation, trip distribution, mode split, and assignment. Other models, such as SPF, require only two or three steps from data entry to model output. Specific directions for each model are given in each model's User Guide.

Review The Results

After the initial forecast model runs have been completed, you must examine the model outputs for reasonableness. Reasonableness is difficult to define, but the following questions are among those you should ask about the model output.

- Do vehicles follow logical travel paths through the network?
- Does traffic distribute itself between parallel routes, or is one route full and the other empty?
- Does the congestion present on roads in the network invalidate some of your input assumptions? (For example, if you assign a small percentage of daily trips to the design hour, expecting congestion, and congestion doesn't materialize, it may not mean that congestion won't occur but that you have selected too low a percentage of daily trips to assign during the design hour.)
- Does congestion appear at places where it logically should not appear?
- Does congestion appear in places where it logically should appear?

These types of review questions will allow you to gain confidence in, or recognize problems with, a model run. Problems apparent from the review can be investigated through revisions in the input data and the modeling assumptions. Investigation of the model output also provides you with the information necessary to answer questions about the model runs raised by the outside review process (See Chapter 6).

<u>Perform Sensitivity Analyses</u>

An important aspect of the computerized modeling efforts is testing the sensitivity of the model to changing input assumptions. The more complex the modeling sequence is, the more carefully you should test the input assumptions. For example, if you are using the UTPS modeling package and a complex mode split model, it is important to change some of the input assumptions used in that mode split model and rerun the modeling chain just to ensure that the model is producing reliable results and is not overly sensitive to particular assumptions. Input assumptions that might be examined for model sensitivity include the following:

- the parking costs,
- the value of time,
- the transit fares,
- the highway network configuration (what if some of the roads assumed in the future year network aren't built as planned?), and
- land use and population estimates.

The objective of the sensitivity analysis is to give you insight into what factors have the greatest impact on the model's output. For example, if doubling the downtown parking rates halves the model's estimates of the traffic volumes heading downtown, you may want to reexamine the rates you have predicted for the future year forecast before accepting the model's initial output as "accurate."

Even for models that are not complex, it is a good idea to make minor alterations to the basic modeling inputs to determine whether the accuracy of these inputs have a significant impact on the model outputs. If you have used input assumptions that differ from those used in other studies, apply those other assumptions and examine the changes that occur in the model output. Knowledge gained from this comparison will allow you to better defend your assumptions and will give you answers to questions that are likely to be raised during the review process. Finally, remember that most of the model inputs are forecasts themselves and are likely to contain their own errors. Therefore, it is important to determine the possible impact on the output that potential errors in the input will have.

If the model you are using is sensitive to the changes you make, discuss the implications of this sensitivity with other professionals involved in the project. Come to an agreement on how the sensitivity should be handled (average the estimates, accept one as the "correct" answer, or have the design engineers take into account the potential variability in the traffic as part of their design.) Again, remember that a forecast is an estimate and is never "correct." Your job is to produce the most likely estimate from the available information. Designs are based on the best available information, and knowledge of a model's sensitivity is one part of developing that information.

Revise The Forecast (Reapply The Model)

If concerns are found as a result of the review process or the sensitivity analyses, you should carefully construct a series of model runs that provide answers to the questions you identified. If necessary, create a final, "official" forecast using a revised set of inputs based on the insight you have gained from the review and sensitivity analyses.

Refine The Model Estimates

Four-step model output is generally not complete by itself. Four-step models usually require aggregated network descriptions (that is, all roads are not incorporated in the network because of space limitations) and deal only with passenger cars and transit vehicles. In many cases, you must refine model inputs to include estimates of truck traffic and additional detail on turning movements and other micro-scale traffic characteristics.

For truck volumes, the best alternative is to use the default TRIPS estimate of truck growth over time as the expected change in the percentage of truck traffic. Start with the volumes of each truck class obtained from the base year traffic counts . Adjust these volumes to reflect the growth in truck traffic estimated in TRIPS, and add any site specific changes caused by new land use. The results of this effort are placed at the bottom of Worksheet 1. (Several of the Lotus 1-2-3 worksheets described in Appendix A can be of assistance in performing these calculations.)

Peak hour or peak period volumes are usually a direct output of the four-step models. However, these estimates do not provide a measure of truck traffic in the peak period, nor do they usually yield an accurate picture of the peaking of volumes within the peak hour used to compute design hour traffic. To estimate peak period and design hour truck percentages, use data from the existing traffic counts as representative of the forecast year, unless other data (i.e., site specific impacts of new developments) allow you to make a better estimate.

Four-step models will also provide you with sufficient information to estimate directional splits (D) during the design hour. They do not give 30th highest hour estimates, but these can be estimated using the model's peak period traffic estimates, the estimated level of congestion, WSDOT PTR information for urban sites with similar congestion levels, and reports such as the New York State Traffic Forecasting Guide, and data on urban peak periods found in NCHRP reports 187 and 255.

Turning movements and other micro-scale traffic details must be estimated either by hand, through the use of techniques described in NCHRP 255, or through other standard documents.

All of the design values (K, D, and T) and volume estimates should be placed on Worksheet 1 and accompanying traffic flow maps.

Determine The Shape Of The Expected Growth Curve

In some cases (especially pavement design), it is necessary to know the expected yearly vehicle volumes for each vehicle class to estimate the total number of vehicles passing a section of road during the design life of that pavement. To make this calculation you must estimate the rate at which the forecast growth will occur. (You currently have the end points of this curve from the modeling process.)

You may reapply the selected four-step model for each year of the forecast if the input data are available, but usually they are not. Population and employment estimates are usually available only for five- or ten-year increments (i.e., 1990, 1995, 2000, etc.). Converting these to yearly figures and then re-running the modeling chain is slow and costly.

As a result, a series of Lotus 1-2-3 spreadsheets have been developed to help you estimate the intermediate years of traffic data. The spreadsheets are based on the base year and forecast year volume and truck estimates and a prediction about the shape of the growth curve. The spreadsheets can model any of four growth patterns,

- linear,
- exponential,
- increasing factorial, and
- decreasing factorial.

Linear growth assumes a constant increase or decrease (the same number of vehicles per year) in volume by vehicle class each year. It is also called straight line growth. This is the most commonly used growth pattern and is representative of slow, steady growth.

Exponential growth is used when growth occurs at a constant percentage rate over time. This pattern reflects the growth in newly developed areas (particularly new suburbs). The pattern provides an ever increasing growth in the number of additional cars added each year.

The increasing factorial pattern is similar to the exponential pattern. It causes growth to increase over time. For this pattern, growth starts more slowly than with the exponential pattern, but it increases at a faster rate towards the end of the design period.

The decreasing factorial pattern provides a method to model the growth in an area in which growth is slowing down. This occurs in older suburbs and urban areas where the land available for new construction is decreasing, and fewer new homes and businesses are being built each year.

You must select the growth pattern desired from your knowledge of the geographic area being modeled. In general,

- if little change is occurring, the straight line approach is best;
- if new roads are being built in the area, an exponential growth rate is probably the best choice;
- if the growth in an area has just started and the rate of growth is expected to rapidly increase, the increasing factorial is appropriate; and
- if the area is maturing and growth is slowing, the decreasing factorial is probably the best choice.

Develop Intermediate Traffic Estimates

The spreadsheets require as input the beginning and ending volumes (by vehicle classification) and the shape of the curve desired. They output the annual and average daily volume totals for each vehicle class, as well as the ESALs for each class and the total design ESAL for the project life. Results of the spreadsheet analysis can also be printed graphically. These estimates should be placed on Worksheet 2.

Directions for operating the spreadsheet model are included in Appendix A.

CHAPTER 4

REVIEWS AND PRESENTATION OF THE FORECAST

This chapter provides a description of the reviews that a forecast should undergo before being used as design information by the Department. It also describes how the forecast should be presented to the requesting party and stored in the project and TDO files.

The reviews that should be performed for all traffic forecasts include:

- reviews within the forecasting office,
- reviews within the Department, but outside of the office that creates the forecast, and
- reviews outside of the WSDOT.

Reviews within the forecasting office (reasonableness checks, sensitivity analysis, and review of basic assumptions) have already been discussed as part of the description of the actual forecasting process in Chapter 5. The two remaining categories of review are described below.

WSDOT REVIEWS

The primary reviews that need to be performed within the Department are consistency checks and examinations of the assumptions used in the forecasting process. The information necessary for the review is included on Worksheets 1 and 3. Specifically, the Department needs to review the following information:

- base year truck and total volume estimates for the project,
- forecast year truck and total volume estimates for the project,
- the growth assumptions (rate of growth) implied by the forecast, and
- the mitigating circumstances included as part of the forecast,

Each of these reviews are discussed below.

Base Year Truck and Total Volume Estimates

The reviewer should examine these values in light of their understanding of the current traffic conditions. Do the estimates used as the basis for the forecast make sense when compared to your understanding of the existing traffic conditions? If they don't, are the current estimates based on actual recent traffic counts, or extrapolated from older counts? If the counts do not seem to reflect what you feel are current conditions, discuss these differences with the individual making the forecast.

Under extreme circumstances, it may be necessary to schedule counts to confirm or revise the base year traffic estimate. The cost of a short duration count is very small in relation to the cost of any project which requires placement of pavement, however, the delay caused by having to schedule and perform such a count often makes requesting new counts impractical except for those cases where the accuracy of the traffic estimates (i.e., their importance in the design work being performed) warrants the additional delay to the design process.

In the end, the forecaster is responsible for his/her own work, but approval of the volume estimates should also be obtained from the district supervisor of traffic forecasting or the Transportation Data Office in Olympia. The forecaster should be sensitive to the review comments received. In addition to these reviews, the design engineer has the option of applying a reliability factor to the volume estimates as part of both the pavement and geometric design procedures.

Forecast Year Truck and Total Volume

The reviewer should examine the forecast results in a preliminary fashion to quickly understand the impact of those estimates. Do the new estimates mean additional lanes of highway construction are required? Do they indicate the need for a change in the scope of work for the project? Do the forecast numbers indicate a change in the pattern of traffic using the road (i.e., an increase of loss of some seasonal or other traffic pattern?)

Have these impacts been accounted for in the design process? Are changes in the project design required by as a result of the forecast traffic? Is the design of the project subject to change if the forecast traffic volumes are marginally different? (For example, is the project barely over the dividing line between level of development categories or is it well within the bounds of one specific category?)

If relatively small changes in the forecast traffic estimates will have major effects on the project design, the reviewer should sit down with the forecasting person, and discuss the nature of these design changes, and the assumptions made in the forecast. From this meeting should come a consensus about the assumptions that should be used in the forecast, and that these assumptions are consistent with the assumptions being used by the remainder of the Department for that location.

Growth Assumptions Used and Mitigating Circumstances

When reviewing growth assumptions, the primary area of concern is that the forecast reflect the expected conditions for that geographic area. Are the growth estimates consistent with those used by other agencies? If not, are the reasons for using different growth estimates valid and well documented? Is the shape of the growth curve realistic? (That is, is growth constant in this area? Accelerating? Declining?) Can the developments forecast actually be built in the time frame assumed? What are the chances that they will be built faster?)

Worksheet 3 should contain all of this information, or at least indicate where it can be obtained. The reviewer should ensure that this form is adequately filled out, and that the assumptions made by the forecaster are reasonable and well documented.

EXTERNAL REVIEWS

External reviews of the project should take place, whenever the project impacts another agency or jurisdiction. The intent of the external review is to share information about the project and diffuse any potential disagreements about the assumptions used in an analysis. In particular, the external review should allow the external agency to voice concerns over specific assumptions used by the Department which do not coincide with assumptions made by that agency. (For example the agency might assume that a new county road is not being built and the Department might assume that road will be built. The existence of that road may have a significant impact on the traffic volumes forecast for the project.)

In some cases, the Department may want to make different assumptions than used by the local agency. If this is the case, the Department needs to be able to explain (and defend) the use of those assumptions in place of other alternatives. Providing for external review brings the important parts of the forecast to light, and allows a straight forward discussion of the issues, before significant design work begins. This allows potential differences to be straightened out before early in the design process, and should produce a smoother, more timely design.

PRESENTATION OF THE FINAL FORECASTING RESULTS

The final forecast results should be submitted to the requesting office on Worksheets 1, 2 and 3. These estimates should be accompanied by a hand-drawn flow map (or maps) of the roads included in the forecast, listing the appropriate daily and design hour volumes and turning movement estimates. These estimates should be included in the project design documentation, and stored for later review. A copy of each of these documents should also be maintained at the Transportation Data Office.

A brief transmittal letter should accompany the Worksheets and traffic sketches. The transmittal letter should highlight any concerns the forecaster has, and summarize the forecast results. If external review of the forecast provided dissenting opinions to the forecast estimates and revisions were not made to the forecast as a result of these disagreements, information describing the reasons behind the dispute, the reasons why the assumptions used in forecast were selected, and the reasons why the objections of the external agency were not accepted or agreed with should also be included in the transmittal letter. This letter should also be included in the permanent design record.

APPENDIX B

USERS' INSTRUCTIONS FOR LOTUS 1-2-3 TRAFFIC FORECAST TEMPLATES

APPENDIX B

USERS' INSTRUCTIONS FOR LOTUS 1-2-3 TRAFFIC FORECAST TEMPLATES

This appendix provides a brief description of the Lotus 1-2-3 worksheets developed to help you forecast traffic volumes and calculate ESAL loadings for pavement design. The spreadsheets are simple templates designed to let you easily examine the impacts of alternative truck growth rates on ESAL loadings. If the templates are missing from Volume 2 of the Washington State Department of Transportation's Forecasting Guide, you can obtain copies from the Traffic Data Office of WSDOT in Olympia at (206) 753 - 3210, (SCAN 234-3210).

BASIC OPERATION

Six templates have been designed to assist you in estimating and analyzing forecast traffic and ESALs. Each of the templates is a Lotus 1-2-3 spreadsheet that WSDOT personnel can reuse as necessary. The six templates each represent a different type of forecast analysis. These analyses include

- a straight line forecast given a known rate of growth,
- a straight line forecast with known beginning and ending volumes,
- a compound rate of growth given a known rate of growth,
- a compound rate of growth with known beginning and ending volumes,
- a declining growth function for a 20-year forecast, and
- an increasing growth function for a 20-year forecast.

You can use the first four templates for any length of forecast growth period up to 20 years. The last two templates are only valid for 20-year periods.

To use these templates, you should be familiar with Lotus 1-2-3 commands and be able to navigate around the spreadsheet. You do not have to be familiar with the more complex Lotus functions (such as macros or formulas) to use this software.

The structure and design are similar for all six templates. Each template is write protected, so you can not revise the template (except to enter volume and growth estimates) or save it without assigning a new name to the computer file. Thus, when you use a template to perform a forecast, you must give the Lotus 1-2-3 spreadsheet a name other than the name of the template to save your new computer file. This precaution was taken to prevent the accidental destruction of the basic template. (You may make copies of the templates using the DOS **COPY** command.)

You will load the templates in the same manner that you load any Lotus 1-2-3 spreadsheet, using the keyboard commands **/ F R** *templatename*, where *templatename* is the name of the template you wish to use (see Table B-1). At the top of each of the spreadsheets is a brief description of the functions that template will perform and instructions on the information you should provide.

Table B-1

Template Name	Function
TABLE1.WK1	Straight line growth rate with known rate of growth
TABLE2.WK1	Straight line growth rate with known beginning and ending volumes
TABLE3.WK1	Compound growth rate given a known rate of growth
TABLE4.WK1	Compound growth rate with known beginning and ending volumes
TABLE5.WK1	Declining growth rate for a 20 year forecast
TABLE6.WK1	Increasing growth rate for a 20 year forecast

Below the introductory information are located the volume and growth information, the heart of the template. This portion of the spreadsheet contains the cells into which you will enter volume data and basic growth information. The template calculates annual vehicle volumes by class on the basis of your inputs and places the estimated daily traffic volumes for each of the years in the forecast on the right side of this level of the template.

Space is provided in each template so that you can input traffic data in three formats:

- automobiles and trucks,
- automobiles and three classes of trucks (singles, doubles and trains), and
- the 13 FHWA vehicle classifications.

You may enter data in one or more of the formats on any spreadsheet. You may wish to use multiple formats to examine the differences in volumes or ESAL calculations that result from different aggregations of truck volumes and for the ESALs that are associated with those truck estimates.

All the information needed to perform the forecast is entered into this upper portion of the template. This information will either be beginning and ending volumes by vehicle class (within a design period), or beginning volumes and a growth rate along with the design period. Specific instructions on how and where to enter this information appear later in this appendix.

After entering the basic volume and growth information, you then have the opportunity to add "mitigating circumstances" to the forecast estimate. That is, you can enter expected deviations in the forecast volumes for specific vehicle types. These additions can be positive (more vehicles will be on the road) or negative (the number of vehicles will decline). These additions are meant to represent expected changes to the growth rate from point sources that are not included in basic growth rate associated with that forecast. (For example, a new factory may open on that road.) "Mitigating circumstances" will not always be necessary, and even when you use them they may not impact all vehicle types in a forecast.

"Mitigating circumstances" can be added for each or any year of the forecast and for any vehicle category. As many "mitigating circumstances" as you need may be added to each template. Once entered into the spreadsheet, the volumes added (or subtracted) from that year's forecast are carried into future year volume estimates. "Mitigating circumstances" can have a significant impact on the total volume estimates predicted for the design year for those vehicle classes.

A second portion of the template is the ESAL loadings assumed per truck for each of the vehicle classes. ESAL calculations are performed automatically by the spreadsheet. Changes to the ESAL estimates may be made, but only with the concurrence of the materials laboratory or the project's design engineer. The current default for ESALs per truck is supplied in column A of each template.

Once all volume data have been entered into the template, you can move to the last part of the spreadsheet. This summary area is located below the volume input section and contains statistics for estimated total volumes per day for each year in the forecast, ESAL loads applied each year, and cumulative annual ESALs for each year in the forecast.

These summary statistics are provided for each of the three truck classification methods available to you (auto/truck, auto/three truck classes, and FHWA's 13 categories). For cases in which you enter volume estimates for more than one type of classification scheme, summary statistics are available for each of the categories for which you provided volumes. (The one exception to this is the estimate provided for <u>total volume</u> per day for each year. This estimate in the spreadsheet will be the <u>largest</u> of the volume estimates provided by any of the three classification schemes.)

From the summary statistics area of the template you can select the traffic estimates your forecasting work requires.

Specific instructions for using each of the six templates are provided below.

TEMPLATE 1 — STRAIGHT LINE GROWTH (KNOWN GROWTH RATE)

This template forecasts traffic for up to 20 years, given starting volumes by vehicle classification and a user supplied growth rate. It assumes the rate of growth to be constant in terms of vehicle volumes per year, with the exception of mitigating circumstances. (That is, truck volumes grow by some number of vehicles per day per year.) You supply the actual growth rate it uses in terms of a percentage of the base year traffic volumes. You may even enter a negative growth. Volumes for all vehicle classes grow (or decline) at the same rate, unless that rate is altered as a result of "mitigating circumstances."

Specific instructions for using this template are as follows:

- Load the template entitled TABLE1.WK1.
- Enter the anticipated growth rate (in percent) in cell D11.
- Enter the Base Year volumes for automobiles and trucks (by selected class) in column D, rows 16 through 39. (If you have only autos and trucks, use rows 16 and 17. If you have three truck classes, use rows 19 through 22, and use rows 24 through 39 for the FHWA 13-category scheme.)
- Enter the calendar year that serves as the base year in cell D14.
- Enter any mitigating circumstances (revisions to the straight line growth) in the columns with the heading "MITI. CIR." Place these changes in the column appropriate for the year in which those changes will take place.
- After completing your data entry, you will find the summary statistics you need in the following areas:
  - Total vehicles per day for each forecast year, row 43.
  - Total ESALs per day for each forecast year, rows 45 through 47.
  - Cumulative ESALs at the end of the stated year, rows 49 through 51.

- The Design Year ESAL you need is the Cumulative Total ESAL estimate for the "nth" year, where "n" is the design life of the project being designed.

Please note that row 45 contains ESAL estimates based only on the volumes present in rows 16 and 17 (auto/truck), and that it will contain a zero if you have not used that particular classification scheme. The same is true for data in rows 46 (auto/three truck classes) and 47 (13 FHWA categories) and the rows maintaining cumulative ESAL values.

TEMPLATE 2 — STRAIGHT LINE GROWTH (BEGINNING/ENDING YEAR VOLUMES)

This template forecasts traffic for up to 20 years, given user supplied starting and design year volumes by vehicle classification, as well as the starting and design years. As with Template 1, you may model both increases and decreases in traffic volumes. However, with this template, the rate of increase or decrease of individual vehicle classes may differ by class because the rate of growth for each vehicle type is controlled by the base year and forecast year differences you enter in columns D and E. (For example, you may input that small trucks will grow from 100 to 150 vehicles per day, while large trucks grow from 100 to 300 trucks per day during the same time span.) In addition to these linear changes, your "mitigating circumstance" estimates also affect the volumes predicted by the spreadsheet. However, note that use of "mitigating circumstances" results in final design volumes that are different than those specified in column E of the template. (The final forecast volume is equal to the value in column E for each vehicle classification plus the sum of the "mitigating circumstances" entered for that vehicle type.

The spreadsheet automatically computes the straight line growth rate by evenly allocating the required changes in vehicle volumes over the design period you specified. As indicated above, "mitigating circumstances" are external to this calculation.

As with the first template, this template calculates 20 years of growth, regardless of the design period you specify. Growth beyond the desired design period occurs at the same rate as during the design period, and you may ignore it. Because growth is linear and summary statistics are provided for all years, you can select the appropriate volumes and ESALs for your Design Year by simply reading the appropriate column of the summary statistics.

To use this template, follow the steps listed below.

- Load the template entitled TABLE2.WK1.
- Enter the Base Year volumes for automobiles and trucks (by selected class) in column D, rows 20 through 43. (If you have only autos and trucks, use rows 20 and 21. If you have three truck classes, use rows 23 through 26, and use rows 28 through 43 for the FHWA 13-category scheme.)
- Enter the Design Year volumes for automobiles and trucks (by selected class) in column E, rows 20 through 43. (If you have only autos and trucks, use rows 20 and 21. If you have three truck classes, use rows 23 through 26, and use rows 28 through 43 for the FHWA 13-category scheme.)
- Enter the calendar year that serves as the base year in cell D18.
- Enter the calendar year that serves as the forecast year in cell E18.
- Enter any mitigating circumstances (revisions to the straight line growth) in the columns with the heading "MITI. CIR." Place these changes in the column appropriate for the year in which those changes will take place.
- After completing your data entry, you may find the summary statistics you need in the following areas:
  - Total vehicles per day for each forecast year, row 47.
  - Total ESALs per day for each forecast year, rows 49 through 51.

- Cumulative ESALs at the end of the stated year, rows 57 through 59.

- The Design Year ESAL is the Cumulative ESAL estimate for the "nth" year, where "n" is the design life for the project being designed.

Please note that row 49 contains ESAL estimates based only on the volumes present in rows 20 and 21 (auto/truck), and that it will contain a zero if you have not used that particular classification scheme. The same is true for data in rows 50 (auto/three truck classes) and 51 (13 FHWA categories) and the corresponding rows containing cumulative ESAL values.

TEMPLATE 3 — COMPOUND GROWTH (KNOWN GROWTH RATE)

This template forecasts traffic for up to 20 years, given starting volumes by vehicle classification and a user supplied growth rate. The template assumes the rate of growth to be constant in terms of a percentage increase each year over the previous year. That is, the absolute volume increase (or decrease) grows with time.

Mitigating circumstances are treated differently in this template than in the straight line template. In this template, they are included in the compound growth calculation. For example, if the base volume in year X is 1,000 vehicles and the growth is 3 percent, the volume in year X+1 is 1,030. If you add 100 vehicles in year X with the mitigating circumstances option, the volume in year X+1 becomes 1,133.

You supply the growth rate in units of percentage. You may enter a negative growth rate. As with the first straight line template, volumes for all vehicle classes grow (or decline) at the same rate (except this time in percentage terms), unless you alter them by entering a "mitigating circumstances" volume estimate within the template.

Specific instructions for using this template are given below.

- Load the template entitled TABLE3.WK1.
- Enter the anticipated growth rate (in percent) in cell D13.

- Enter the Base Year volumes for automobiles and trucks (by selected class) in column D, rows 19 through 42. (If you have only autos and trucks, use rows 19 and 20. If you have three truck classes, use rows 22 through 25, and use rows 27 through 42 for the FHWA 13-category scheme.)
- Enter the calendar year that serves as the base year in cell D17.
- Enter any mitigating circumstances (revisions to the compound growth) in the columns with the heading "MITIGAT. CIRCUM." Place these changes in the column appropriate for the year in which those changes will take place.
- After completing your data entry, find the summary statistics you need in the following areas:
  - Total vehicles per day for each forecast year, row 46.
  - Total ESALs per day for each forecast year, rows 48 through 50.
  - Cumulative ESALs at the end of the stated year, rows 55 through 57.
- The Design Year ESAL you need is the Cumulative ESAL estimate for the "nth" year, where "n" is the design life used for the project being designed.

Please note that row 48 contains ESAL estimates based only on the volumes present in rows 19 and 20 (auto/truck), and that it will contain a zero if you have not used that particular classification scheme. The same is true for data in rows 49 (auto/three truck classes) and 50 (13 FHWA categories) and the corresponding rows containing cumulative ESAL values.

TEMPLATE 4 — COMPOUND GROWTH (BEGINNING/ENDING YEAR VOLUMES)

This template forecasts traffic for up to 20 years by using a compound interest equation, given user supplied starting and design year volumes by vehicle classification, as well as the starting and design years. As with the previous templates, you may model both increases and decreases in traffic volumes. Similar to the second template, volumes for all vehicle classes grow (or decline) at their own compounding rates on the basis of the base and forecast year estimates you enter in columns D and E. The template computes these rates automatically by using a compound interest formula to allocate the required changes in vehicle volumes over the design period you have specified. However, please note the following.

1. The spreadsheet does not include "mitigating measures" when calculating the compound growth, but simply adds these changes to the volumes that would have been present without the mitigating circumstances.
2. The use of "mitigating circumstances" causes a forecast volume in the final year to be different than that input in column E. This is because the "mitigating circumstances" are external to the calculation of the compound interest rate.
3. The template calculates 20 years of growth, regardless of the design period you specify. Growth beyond the desired design period occurs at the same percentage rate as that during the design period.

To use this template, follow the steps listed below.

- Load the template entitled TABLE4.WK1.
- Enter the Base Year volumes for automobiles and trucks (by selected class) in column D, rows 14 through 37. (If you have only autos and trucks, use rows 14 and 15. If you have three truck classes, use rows 17 through 20, and use rows 22 through 37 for the FHWA 13-category scheme.)
- Enter the Design Year volumes for automobiles and trucks (by selected class) in column E, rows 14 through 37. (If you have only autos and trucks, use rows 14 and 15. If you have three truck classes, use rows 17

through 20, and use rows 22 through 37 for the FHWA 13-category scheme.)

- Enter the calendar year that serves as the base year in cell D12.
- Enter the calendar year that serves as the forecast year in cell E12.
- Enter any mitigating circumstances (revisions to the straight line growth) in the columns with the heading "MITIGAT. CIRCUM." Place these changes in the column appropriate for the year in which those changes will take place.
- After completing your data entry, find the summary statistics you need found in the following areas:
  - Total vehicles per day for each forecast year, row 41.
  - Total ESALs per day for each forecast year, rows 43 through 45.
  - Cumulative ESALs at the end of the stated year, rows 50 through 52.
- The Design Year ESAL is the Cumulative ESAL estimate for the "nth" year, where "n" is the design life used for the project being designed.

Note that row 43 contains ESAL estimates based only on the volumes present in rows 14 and 15 (auto/truck), and that it will contain a zero or error message if you have not used that particular classification scheme. The same is true for data in rows 44 (auto/three truck classes) and 45 (13 FHWA categories) and the corresponding rows containing cumulative ESAL values.

TEMPLATE 5 — DECLINING GROWTH (20-YEAR FUNCTION)

This template forecasts traffic for 20 years by using a declining growth rate function, given user supplied starting and design year volumes by vehicle classification. The template assumes that the rate of change slows over the 20-year design period, so that no growth occurs during the last year of the project. The template is only valid for 20-year periods, since the formula used to apportion traffic between forecast years is based on a 20-year cycle. As with the previous templates, both increases and decreases in traffic volumes may be modeled. As with templates 2 and 4, volumes for all vehicle classes grow (or decline) at their own rates on the basis of the base and forecast year estimates you enter in columns E and F.

The template computes the growth rate automatically by using a declining, additive factorial (i.e., 19/190 of the growth occurs in the first year, 18/190 occurs in the second, etc.) to allocate the required changes in vehicle volumes over the design period you specified. However, please note the following:

1. The spreadsheet does not include "mitigating measures" when calculating the change in volume per year, but simply adds these changes to the volumes that would have been present without the mitigating circumstances.
2. The template does not accurately calculate growth for periods other than 20 years.
3. The use of "mitigating circumstances" causes a forecast volume estimated in the final year of the spreadsheet to differ from that input in column E. This is because the "mitigating circumstances" are external to the calculation of the growth rate.

To use this template, follow the steps listed below.

- Load the template entitled TABLE5.WK1.
- Enter the Base Year volumes for automobiles and trucks (by selected class) in column E, rows 17 through 40. (If you have only autos and trucks, use rows 17 and 18. If you have three truck classes, use rows 20 through 23, and use rows 25 through 40 for the FHWA 13-category scheme.)
- Enter the Design Year volumes for automobiles and trucks (by selected class) in column F, rows 17 through 40. (If you have only autos and

trucks, use rows 17 and 18. If you have three truck classes, use rows 20 through 23, and use rows 25 through 40 for the FHWA 13-category scheme.)

- Enter the calendar year that serves as the base year in cell E15.
- Enter any mitigating circumstances (revisions to the straight line growth) in the columns with the heading "MIT. CIR." Place these changes in the column appropriate for the year in which those changes will take place.
- After completing your data entry, find the summary statistics you need in the following areas:
    - Total vehicles per day for each forecast year, row 44.
    - Total ESALs per day for each forecast year, rows 46 through 48.
    - Cumulative ESALs at the end of the stated year, rows 52 through 54.
- The last figure in the row containing the cumulative ESAL is the design ESAL to be used for the project being evaluated.

Please note that row 46 contains ESAL estimates based only on the volumes present in rows 17 and 18 (auto/truck), and that it will contain a zero if you have not used that particular classification scheme. The same is true for data in rows 47 (auto/three truck classes) and 48 (13 FHWA categories) and the corresponding rows containing cumulative ESAL values.

TEMPLATE 6 — INCREASING GROWTH (20-YEAR FUNCTION)

This template forecasts traffic for 20 years by using an increasing growth rate, given a user supplied starting and design year volumes by vehicle classification. The template assumes that the rate of change increases over the 20-year design period, so that no growth occurs during the first year of the project, but growth increases after that.

The growth rate in this template is steeper than that used in the compound function in Template 3 (i.e., the growth is slower at the beginning of the design period and faster at the end of the design period). The template is only valid for 20-year periods, since the formula used to apportion traffic between forecast years is based on a 20-year cycle. As with the previous templates, you may model both increases and decreases in traffic volumes. As with templates 2, 4, and 5, volumes for all vehicle classes grow (or decline) at their own rates on the basis of the base and forecast year estimates you enter in columns E and F.

The template computes this growth rate automatically by using an increasing additive factorial (i.e., 0/190 of the growth occurs in the first year, 1/190 occurs in the second, etc.) to allocate the required changes in vehicle volumes over the design period you specified. However, please note the following:

1. The spreadsheet does not include "mitigating measures" when calculating the change in volume per year, but simply adds these changes to the volumes that would have been present without the mitigating circumstances.
2. The template does not accurately calculate growth for periods other than 20 years.
3. The use of "mitigating circumstances" causes the forecast volumes in the final year to differ from those input in column E. This is because the "mitigating circumstances" are external to the calculation of the growth rate.

To use this template, follow the steps listed below.

- Load the template entitled TABLE6.WK1.
- Enter the Base Year volumes for automobiles and trucks (by selected class) in column E, rows 17 through 40. (If you have only autos and trucks, use rows 17 and 18. If you have three truck classes, use rows 20 through 23, and use rows 25 through 40 for the FHWA 13-category scheme.)

- Enter the Design Year volumes for automobiles and trucks (by selected class) in column F, rows 17 through 40. (If you have only autos and trucks, use rows 17 and 18. If you have three truck classes, use rows 20 through 23, and use rows 25 through 40 for the FHWA 13-category scheme.)
- Enter the calendar year that serves as the base year in cell E15.
- Enter any mitigating circumstances (revisions to the straight line growth) in the columns with the heading "MIT. CIR." Place these changes in the column appropriate for the year in which those changes will take place.
- After completing your data entry, find the summary statistics you need in the following areas:
  - Total vehicles per day for each forecast year, row 44.
  - Total ESALs per day for each forecast year, rows 46 through 48.
  - Cumulative ESALs at the end of the stated year, rows 52 through 54.
- The last figure in the row containing the Cumulative Total ESAL is the design ESAL to be used for the project being designed.

Please note that row 46 contains ESAL estimates based only on the volumes present in rows 17 and 18 (auto/truck), and that it will contain a zero if you have not used that particular classification scheme. The same is true for data in rows 47 (auto/three truck classes) and 48 (13 FHWA categories) and the corresponding rows containing cumulative ESAL values.

APPENDIX C

DESCRIPTIONS OF MODELS COMMONLY USED IN TRAFFIC FORECASTING

APPENDIX C

DESCRIPTIONS OF MODELS COMMONLY USED IN TRAFFIC FORECASTING

This appendix provides brief descriptions of several computer models commonly used as part of the traffic forecasting process. The Department actively supports many computer packages, both by providing training courses for those packages and by designating individuals as technical experts who can provide assistance in working with specific programs. All software described in this section are available for microcomputers (although some are also available through the Department's mainframe).

The descriptions are intended to provide you with a better understanding of the needs and capabilities of these models. Five of the models which are often used directly in the forecasting process are reviewed in more detail. The other models mentioned in this appendix are also very useful, but they usually play a more peripheral role in the forecasting process.

The detailed reviews presented later are intended to help you select the appropriate model for the forecasting needs you have. These reviews should not be viewed as a substitute for the user's manuals for the various software packages. The reviews do not contain complete user instructions and are not sufficiently detailed to act as stand alone documents. The reviews cover the following five models:

- QRS II (The Quick Response System, version II),
- CINCH,
- SPF (Simplified Project Forecasting),
- THE (The Highway Emulator), and
- TMODEL2.

In addition, a brief summary of the USDOT Urban Transportation Planning System (UTPS) is provided.

Available computer software can be divided into categories on the basis of the primary emphasis of the program. The categories most appropriate to traffic forecasting are

- four-step planning models,
- traffic flow and evaluation models, and
- miscellaneous spreadsheets and computational aids.

Four-step Planning Models

Four-step planning models (i.e., those that perform trip generation, distribution, mode split and assignment) are at the high end of the traffic modeling process. That is, these models are complex and time consuming. They require a reasonable amount of user training to be accessible, but they perform a type of analysis that is often impossible to perform by hand. These models are best for examining expected growth in traffic levels based on predicted growth in population and economic variables. Traffic estimates produced by these models are usually assigned to "high level" representations of the actual street network (i.e., these networks often do not include all of the streets that actually exist, and the networks do not accurately model factors such as signal timing or turning movements), and these estimates must usually be refined before they can be used for design computations.

In general, the four-step planning models start with inputs in the form of zonal (socio-economic) and highway network information and produce estimates of traffic volumes. These relationships are fairly complex and inexact, and the model outputs must be carefully reviewed to ensure "reasonable" results. Four-step models are generally useful for larger projects and planning studies, particularly projects that occur in urban areas.

Among the four-step planning models the Department supports are

- QRS II,
- TModel 2
- MicroTRIPS,
- EMME II, and
- UTPS.

These models are listed in increasing order of their complexity and capabilities. QRS II is the simplest of the models but also has the fewest capabilities. EMME II and UTPS are the most complex and have the greatest capabilities. UTPS contains more complete transit modeling capabilities than EMME II, but EMME II allows graphical input (not possible with UTPS) and has considerably better graphics output than UTPS.

Within this guide, four-step planning models are differentiated primarily by the amount of effort required to operate each model, the number of default parameters each model provides (or allows to be over-written), and the detail each model allows when it electronically represents the city and highway being analyzed. In general, the more capable the four-step model is, the more difficult it is to use, and the more time it requires to operate.

Traffic Flow and Evaluation Models

The second category of microcomputer models are the traffic models. These models are concerned with specific roadway operations. They generally use a more sophisticated and precise model of the study area's highways than the four-step models do, but they usually cover a much smaller geographic area.

Models within the "traffic" category are differentiated from each other by the specific task each was designed to perform. While all four-step models perform the basic functions of trip generation, distribution, mode split and assignment, the traffic models tend to fulfill very different technical and functional needs.

The traffic models whose use the Department encourages are listed below.

- The Highway Emulator (THE) is a new model that combines the capabilities of the four-step models with the basic data requirements of the traffic models. It can create origin/destination tables from ground counts and then examine the impacts of roadway changes on the trips made using that O/D table.

- FREQ — This is a freeway simulation model used to examine the impacts of forecast traffic volumes on alternative freeway configurations.
- FRESIM — This is a detailed microscopic simulation model for analyzing the operation of freeway sections. It is more of an analysis tool than a forecast tool.
- NETSIM — This is a detailed microscopic simulation model for analyzing the operation of arterial signal networks. Like FRESIM, it is more of an analysis tool than a forecast tool. Recent work by FHWA has provided NETSIM with a graphic simulation component that can be useful in studying signal operation.
- HCS — The Highway Capacity Manual Software automates the analyses included in the 1985 upgrade to the Highway Capacity Manual.
- SOAP 84 — This is a program for designing isolated intersection signal timing plans for both actuated and semi-actuated controllers.
- TRANSYT-7F — This is a program for developing optimized traffic signal control plans for networked traffic signal systems.
- AAP — AAP is a modeling package that includes the TRANSYT-7F and PASSER II modeling programs. It is designed to allow the user to develop one database but use either or both of the modeling packages to examine alternative signal timing algorithms.
- PASSER III — This program is designed to assist in the development for signal timing plans for diamond interchanges.

Not all of the models listed above are used as part of the "forecasting" process (that is, the actual prediction of future traffic volumes). They are, however, part of the analysis process that parallels and impacts the forecasting effort and are often part of the design effort that includes the forecast volumes. Therefore, they are discussed in this guide to encourage their use and to help those in charge of forecasting future traffic levels investigate the "reasonableness" of specific traffic estimates and become aware of how those estimates will be used when they have been completed.

Other Models and Computational Aids

A number of the techniques used to develop forecasts require the application of reasonably simple mathematical procedures or the solving of various equations. As part of this project, several of these procedures and formulae have been converted into Lotus 1-2-3 spreadsheets. These spreadsheets are available through the Transportation Data Office. The capabilities and operation of these worksheets are described in Appendix A of this guide.

In addition to computer models, a number of other forecasting techniques exist. Most of these techniques were formalized prior to the advent of microcomputers, but they are still very valuable resources for obtaining initial forecasting assumptions, performing simple analyses, and learning about the factors which impact forecasts. Foremost among these resources are the NCHRP reports 187 (Quick Response Urban Travel Estimation Techniques and Transferable Parameters) and 255 (Highway Traffic Data For Urbanized Area Project Planning and Design), which are available in the WSDOT library.

DETAILED MODEL DESCRIPTIONS

The Quick Response System (QRS) Model

Quick Response System II (QRS II) is a set of computerized procedures for forecasting impacts of urban developments on highway traffic and for forecasting impacts of highway projects on travel patterns. It can also do complete transit ridership forecasts. Depending on the level of detail with which the network is described, QRS II can perform sketch planning or rigorous analysis. QRS II requires that the user draw the network with a program called General Network Editor (GNE). All data are entered through GNE.

Input Data Requirements

The following data are required if the user wants to develop project level traffic volumes, although the user may also input locally defined parameters at each step.

Table C-1. Input Data Requirements

- Map of study area including zone structure and highway links
- Zonal average income or average auto ownership
- Zonal retail and non-retail employment
- Zonal dwelling units
- Zone x - y coordinates
- Zone location type (CBD, center city, suburb);
- Percentage of travel on arterials within a zone
- Minimum travel time paths between zones

Output Generated By The Model

QRS II produces numerous reports and output files, which are listed below.

Table C-2. Output Data

- All assigned traffic volumes
- Shortest highway path from one origin to all destinations
- Transit loads
- Highway volumes and transit loads tabulated for specifically requested links
- Turning movements for specifically requested intersections
- Transfer volumes for requested transfer points
- Ridership levels for all transit routes
- Number of vehicle trips that go to, come from, or stay within every zone

Steps To Be Followed To Use The Model

The following steps may be used to complete a traffic simulation with QRS. More steps may be required, but these are the minimum number of steps.

Table C-3. Application Steps

1.	Establish base maps; trace zone boundaries; establish zone numbers
2.	Describe Highway link structure
3.	Develop zone data
4.	Calculate trip production and attractions
5.	Distribute trips using the gravity model
6.	Assign trips

The Cinch Model

The CINCH model will perform intersection capacity analysis and turning movement estimation. If the user chooses to perform an intersection capacity analysis, the model first performs volume and saturation flow rate adjustments for the specific geometric, traffic, and signalization conditions. It then provides a capacity analysis and indicates the level of service based on average delay per vehicle for the intersection and each approach.

This menu-controlled software is the equivalent of the intersection capacity analysis methods for signalized and unsignalized intersections described in the 1985 Highway Capacity Manual (HCM) and Circular 212. Data may be entered interactively at the keyboard or from files. The latter method alleviates the use of the forms supplied in the 1985 HCM. The model is iterative and allows quick revisions and changes to signal timing plans to provide rapid evaluation of alternatives.

The CINCH model will also estimate turning movements for three- and four-legged intersections according to the methods outlined in TRR #795, "Estimation of Turning Flows from Automatic Counts." The computer software acts as a "seed" program. It takes old turning movement data and new approach counts and rebalances the turning movements. The data for estimating turning movements must be entered manually.

Input Data Requirements

Intersection Capacity Analysis

The following chart lists the input data required to use CINCH for intersection capacity analysis. Remember that these data can be entered interactively at the keyboard and then stored in a file, or they can be retrieved from a file.

Three types of data (volume, geometric, and signal) are required.

Table C-4. Input Data for Intersection Capacity Analysis

Volume Data	Geometric Data	Signal Data
Left, right and through volumes by approach in vph	The location (CBD or non-CBD)	Number of phases
Number of buses stopping by approach	Number and average width (in feet) by approach for through/general purpose and exclusive left turns	Movements allowed by the phase
Number of pedestrians crossing by approach	Curb-to-curb distance (in feet) that pedestrians have to cross by approach	Green time by phase in seconds
Peak hour factor by approach	Grade (in %) by approach	Yellow and red clear times (change interval) by phase in seconds
Percentage of heavy vehicles by approach	Presence of parking or pedestrian actuation buttons	
Number of parking moves by approach		
Arrival type by approach		

Turning Movement Estimation Input

Three types of turning movement estimation may be performed:

- four-legged intersection- existing turns and future ins and outs known,
- three-legged intersection — existing turns and future ins and outs known, and
- three- or four-legged intersection — only ins and outs known.

Table C-5. Input Data for Turning Movement Estimation

Four-legged intersection	Three-legged intersection	Three- or four-legged intersection
• existing turns • future ins and outs	• existing turns • future ins and outs	• only ins and outs known

Output Generated By The Model

Intersection Capacity Analysis

While the format of the output data is similar to the ten worksheets at the end of Chapter 9 in the 1985 HCM, some exceptions are listed on page 23 of the user's manual. The first five charts summarize the output of the intersection capacity analysis program and the next lists the relatively simple output from the turning movement estimation program.

Table C-6 — Output Data from Intersection Capacity Analysis

Input Summary — all the required information on which subsequent computations are based	• Geometric conditions • Traffic conditions • Signalization conditions
Volume Adjustment	• Adjustment of movement volumes to reflect peak flow rates • Determination of lane groups for analysis • Adjustment for lane distribution
Saturation Flow Rate Adjustment	• Adjusted saturation flow rate to account for prevailing conditions that are not ideal
Capacity Analysis	• Flow ratio for each lane group • Capacity of each lane group • V/c ratio of each lane group • Critical v/c ratio for the overall intersection
Level-of-Service	• Average stopped-time delay per vehicle for each lane group, approach, and intersection • Level-of-service for each lane group, approach, and intersection • Average queue and 95th percentile queue for each lane group

Turning Movement Estimation Output

The turning movement estimation program simply provides estimates of the number of left and right turns, through movements, and exiting vehicles for each approach.

Steps To Be Followed To Use The Model

Because the program is menu-controlled and interactive, it is very simple to use, and repeating the steps here is unnecessary.

The Simplified Project Forecasting (SPF) Model

Simplified project forecasting serves as a quick alternative to the traditional four-step travel simulation forecasting process. The traffic forecasts provided for the design year are link specific and similar to the four-step process, except that SPF does not require large amounts of data and time.

To provide a forecast, SPF develops a growth factor for traffic on specific links as a function of growth in trips between any two zones in the area. The growth in trips is estimated with the gravity model, while the percentage total trips between zones using a specific link is estimated with a usage factor.

Input Data Required

The input data should give a representation of travel at the zonal level.

Table C-7. Input Data Requirements

• Productions and attractions (or surrogates) by zone for both base year and forecast year
• Zone centroid coordinates
• Endpoint coordinates of project being analyzed
• Population of urban area
• Functional class of highway containing project

Output Generated By SPF

The default destination for the program output is the terminal screen, but output may also be directed to the printer or to a user-named disk file.

Table C-8. Output from SPF

• Base year and future year predictions and attractions by zone with associated growth rates
• Growth and weighting factors at project level for six trip types

•	Overall traffic growth rate

Steps To Be Followed To Use The Model

The model comprises six modules, which may be selected from the main menu and executed sequentially.

Table C-9. Application Steps

1.	Establish project zonal system (24 districts).
2.	Compute productions and attractions (or, for example, population and employment) for each district.
3.	Determine zonal movements that will use or affect the project location (usage factors).
4.	Determine travel time and friction factors for each district movement.
5.	Apply growth factor equations to determine future growth.

The Highway Emulator Model

The Highway Emulator (THE) is a microcomputer-based highway traffic simulation model developed to model individual communities, corridors, sections of counties, or to analyze small sections of major cities. Based on trip generation equations from the Transportation Research Board report #187, the model can generate estimates of productions and attractions for three types of trips in each zone (home based work, home based non-work, and non-home based) and for external trips at the cordon line. After a preliminary assignment of these trip tables to a highway network, THE uses the initial trip table, a gravity model, and a "representative set of network traffic counts" (measured, actual counts) to adjust the trip table incrementally until it produces traffic volumes consistent with those observed counts.

THE comprises 11 separate programs in addition to a menu program that allows the user to move between the programs. Each of these programs may be run independently if the required data are accessible.

Input Data Requirements

The following two programs in THE require input from the user. Output from these models is used in later stages by the model. For instance, the assignment program uses the information from the network program to assign traffic volumes to particular links.

Table C-10. Input Data Required by THE Model

Network Coding	Node numbers at each end of the link Length of the link in miles Free flow speed on the link Whether link is one or two way Any additional impedances Hourly capacity for each link direction Traffic volume for each direction if THE will be used for calibration
Trip generation phase	External traffic zones Internal traffic zones The number of households by income range for each internal traffic zones The retail and non-retail employment for each internal traffic zone External zone cordon line volume

Output Generated By The Model

The information used to generate the output is stored in a traffic volume file. The output can be reported in two ways: as roadway segment volume information (speeds, capacities, assigned volumes, etc.) or as intersection turning movement information.

Table C-11. Output from The Highway Emulator

Summary page	• name of network file used • trip table used • number of traffic zones • hours for which the trip table applies • vehicle miles traveled for entire system • vehicle hours traveled for entire system
Report #1 Output	• information concerning the total volume of traffic assigned to each link by direction
Report #2 Output	• volume, speed, and capacity information

Steps To Be Followed To Use The Model

The following steps should be followed to develop a trip origin/destination table. If only traffic count information is used, then

1. Identify the area to be modeled and balanced.
2. Define a coded network.
3. Key the network attribute data and volumes into THE model.
4. Use the trip table program to create a trip table with a uniform value in every cell.
5. Run the trip table estimation program to develop a calibrated trip table.
6. Output the calibrated trip table.
7. Output traffic volumes from the assignment of a calibrated table

THE can also be used for site analysis by showing the change in traffic volume as a result of development.

1. Define the area to be modeled and the AM peak hour traffic counts.
2. Code the highway network.
3. Input data to THE.
4. Create a trip table matrix of uniform values.
5. Use the trip table estimation program to estimate the trip origin destination table.
6. Print out the calibrated trip table.

7. Perform a traffic assignment.
8. Print out the traffic assignment
9. Edit the trip table to include trips to and from the development site.
10. Perform a traffic assignment.
11. Print out the traffic assignment

TMODEL2

TMODEL2 is a microcomputer version of a classic 4-step planning model. It uses a convenient menu driven structure and contains batch processing options to speed up processing for users familiar with the program. The model was designed with the PCs graphics capabilities in mind, and is a good choice for medium large modeling efforts.

TMODEL2 provides a reasonable level of flexibility in the analysis process by providing both defaults for most modeling parameters and the option to change those defaults where such information is available. TMODEL2 follows the classic modeling procedure of network and zone construction, trip generation, trip distribution, mode split and assignment. The model does give the option of using either pre- or post-distribution mode split procedures, and provides some flexibility for the user to define the mode split model to be used. However, the model does set limits on the form these models can take.

TMODEL2 is primarily designed to model automobile traffic. It can be used to generate transit networks, but it is not intended as a transit analysis tool, and does not contain the techniques necessary to evaluate transit operations.

The model does have a number of utilities which allow for manipulation of trip tables, and zonal and network attributes. These utilities allow graphic review and manipulation of data files where appropriate. However, X/Y coordinate information must be included in the databases to be used if the graphics portions of TMODEL2 are to be used.

Input data Requirements

The following data are required if the user wants to use the model in its intended fashion.

Table C-12. Input Data Required by TModel2

Network Data	Consecutive Zone and Node numbers. Length of the link in hundredths of miles Free flow speed on the link One-way capacity Optional area types and facility types, extra impedances Intersection capacity, turning movement restrictions and penalties
Zonal Data	Population and employment data for up to 10 land use categories Trip generation rates

Output Generated by the Model

TMODEL2 produces a variety of outputs, including link volumes, estimated speeds and volume/capacity ratios. This information can be viewed in either graphic or tabular formats. Output can be directed to the computer screen, standard printers, or to multi-pen plotters. The model also has the ability to output specialized analyzes such as selected link or selected zone statistics, and turning movement analyses.

The Urban Transportation Planning System (UTPS)

The Urban Transportation Planning System was developed by the U.S. Department of Transportation between the late 1960s and the early 1980s. It is a mainframe computer package that runs only on IBM 370 and compatible computer systems.

UTPS is the most complete and flexible of the available four-step modeling packages. However, it is old, runs on a limited number of computers, and is the least "user friendly" of the models currently available. UTPS can explicitly model both automobiles and up to eight additional modes of travel.

The user can adjust almost all parameters used in the model and perform a wide variety of data manipulations with utility programs supplied with the transportation modeling software. The documentation supplied with the model is very complete, but it is quite voluminous, requiring ten megabytes of computer disk space, or roughly one entire drawer of a standard file cabinet if printed on paper.

Input Data Requirements

UTPS requires a large quantity of information. It can handle any number of socio-economic variables attributable to zones; complete traffic networks, including turn penalties, toll facilities, and HOV facilities; as well as complete descriptions of transit networks, including walk movements, park and rides, transit lines for a variety of modes, transit fares, transfer parameters, and other transit inputs.

The greatest advantage of UTPS is that the modeler has control over the vast majority of data items and processing procedures used to estimate forecasted traffic levels. The disadvantage of UTPS is that the forecaster must often also supply many parameters that are unimportant to the forecaster, whereas these values are provided as defaults in other modeling packages. Secondary disadvantages to the new user are the lack of a menu driven system for implementing UTPS runs and the amount of training required to operate the mainframe computers that maintain the system.

Output Generated By The Model

UTPS produces a wide variety of output reports. However, with the exception of large traffic flow maps produced on a mainframe plotter, it lacks graphical output capabilities. Most UTPS reports are tabular reports that provide almost all the information desired by a traffic forecaster, including traffic volumes, v/c ratios, air pollution estimates, travel times between specified points, trip interchange matrices, and various selected link statistics. However, the tabular format used to print this information tends to be cumbersome to read and often contains a large number of data not desired by the user. These data must be skipped over to get the desired figures.

Steps To Be Followed To Use The Model

The steps involved in running UTPS are too involved to discuss here. UTPS contains over 20 specific programs to perform the wide variety of tasks built into the package. The specific set of programs required to progress from network development through the four-step process varies depending on the complexity of analysis performed and the types of output information are desired. A typical flowchart of a UTPS process is shown in Figure C-1.

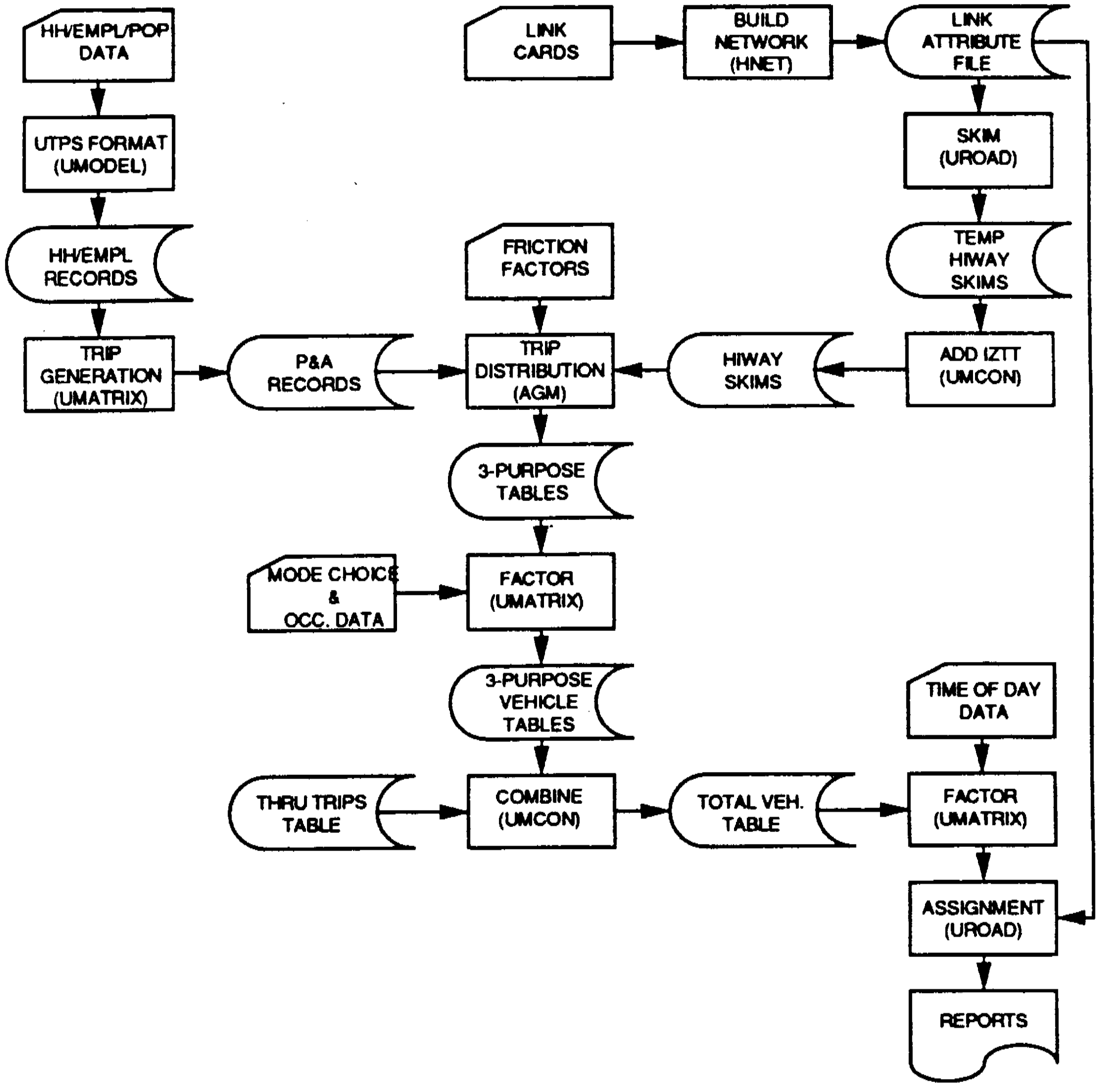


Figure C-1. Typical UTPS Modeling Sequence

APPENDIX D

DATA REQUIREMENTS AND SOURCES

TABLE D-1

DATA AVAILABLE FOR USE IN FORECASTING

Type of Data	Location(s)	Use For Data
Short Duration Traffic Volume Counts	TRIPS database Transportation Data Office Annual Traffic Report New data collection	Estimate current traffic volumes Review historical trends
Permanent Traffic Recorders	TRIPS database Annual Traffic Report	Examine seasonal changes Review historical trends
Vehicle Classification Counts	TRIPS database Transportation Data Office Annual Traffic Report New data collection	Estimate current traffic volumes Review historical trends
Truck Weight Surveys	TRIPS database Transportation Data Office	Examine pavement loading aspects of trucks using the project facilities.
Origin / Destination Surveys	Transportation Data Office MPOs	Input to model calibration process Examine impact of new roads on specific movements made by target areas of population and industry.
Turning Movement Counts	TRIPS database Transportation Data Office	Intersection analysis
Population Estimates	MPOs WSDOT Planning Office Transportation Data Office Census Bureau Local counties and cities OFM	Input to planning models Estimates of predicted growth and growth rates Estimating trip generation
Employment Estimates	MPOs WSDOT Planning Office Local counties and cities Employment Security Labor and Industries	Input to planning models Estimates of predicted growth and growth rates Estimating trip generation
Industrial / Agricultural Activity Estimates	County Offices Reebie Ass. Trans. Consultants Woods & Poole Economics, Inc. WSU (Casavant)	Input to planning models Estimates of predicted growth and growth rates Estimating trip generation
Transit / HOV Information	MPOs Local Transit authorities Transportation Planning Office	Estimating mode split Examining the impact of HOV incentives
Statewide Growth Esitmates	TRIPS database Transportation Data Office OFM	Background (through) traffic growth estimates for rural roads

TABLE D-2

INPUT DATA NEEDED FOR FORECAST TECHNIQUES

Forecast Technique	Population / Employment Data	Traffic Estimates	Other Data
QRS II	Base year & forecast year estimates of average income or auto ownership, retail and non-retail employment and dwelling units by zone	None, except for calibration and comparison against base year estimates.	Map of the study area and/or coordinates of nodes in the transportation system. Min. travel times between zones. Percent travel on arterials within zones.
SPF	Production and Attraction estimates by zone Pop. of urban area.	None, except for calibration and comparison against base year estimates.	Endpoint coordinates of project being analyzed.
MicroTRIPS	Base year & forecast year estimates of pop. and emp. by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.)
TModel2	Base year & forecast year estimates of pop. and emp. by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.)
EMME II	Base year & forecast year estimates by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.)
UTPS	Base year & forecast year estimates by zone	None, except for calibration and comparison against base year estimates.	Highway network file or highway description (distances, number of lanes, etc.) Trip generation rate equations Mode split model.
Spreadsheet Calculator	None, except for general consideration	Base year AADT Estimates Base year truck volumes by vehicle class	Estimated growth rate Type of growth expected (straight line, compound, etc.) Truck volumes
CINCH	None, except for general consideration	Base year hourly volumes Base year turning movements Number of Buses Percentage of heavy vehicles	Pedestrian Movements Signal Timing Plans Parking Movements Geometric Data
Highway Emulator	Number of Households By Income Range By Zone Rtail and Non-retail Employment By Zone	Base year hourly volumes Cordon line volumes	Link Distances and Speeds Hourly Capacity Any Additional Impedances

APPENDIX E

EXAMPLE FORECAST

APPENDIX E

EXAMPLE FORECAST

This appendix takes a real WSDOT forecast effort and shows how it would be conducted using the approach presented in the main body of this document. Included in the appendix are copies of transmittal letters, maps and forms that should be provided to both the requesting engineer and stored in the project files. This example includes some traffic analysis work that is not apart of the "forecasting" effort, but that must usually be performed as part of the effort to develop base year estimates. Additional examples of traffic forecasts and traffic analyses are presented as part of the traffic analysis class taught by the Department.

Page E-3 contains the traffic forecast request submitted to the transportation Data Office. Page E-4 shows the project prospectus. As part of becoming familiar with the project and surrounding area, it is apparent that this project falls under the "Design Analysis" category. (Note that under current procedures, the Materials Lab will also receive a request for load estimates for the subject section of roadway, if pavement is to be laid as part of this project. The traffic forecaster and the Materials Lab should work together to produce these estimates.) Page E-5 is a vicinity map showing the location of the project.

Pages E-6 and E-7 show the available information that was obtained from the existing traffic database (this was done before TRIPS). The information included on these pages plays an important role in the assumptions made as part of the forecast. Note that the available truck data (from 1986 on page E-7) is at the extreme edge of the "acceptable" range. In future years, this information should be more up-to-date. Depending upon the sensitivity of this project to truck volumes, and to the time frame between receipt of the request, it might also be worthwhile arranging for additional vehicle classification data to be taken on the weekend for this project. If this can not be arranged, the procedures followed here are correct.

Page E-8 shows a worksheet used to compare the traffic volume estimates provided by the counts identified on page E-6. Pages E-10 through E-14 show sketches and worksheets used to estimate base year traffic volumes. Page E-15 shows PTR data used to estimate the design hour (K) and direction (D) factors used in the forecast. Pages E-16 through E-19 show Highway Capacity Manual Software output which was used to compare the capacity of the road against estimated 2009 design hour volumes.

Average daily truck percentages were taken from the 1989 Annual Traffic Report (5 percent singles, 6 percent combinations). This data should be available from TRIPS soon. The six percent figure for combinations was split into 3 percent double units and 3 percent multi-unit vehicles. These estimates were then multiplied by estimated AADT for the section to estimate total traffic volume by vehicle class (autos, light trucks, doubles and multi-trailers).

These values were then placed in the straight line forecasting worksheet TABLE1.WK1, along with the design year of 2009 (20 year forecast) and the estimated 5 percent growth rate. For this example, ESALS for the four vehicle class types were estimated (0.001 for cars, 0.5 for light trucks, 1.0 for doubles and 1.25 for multi-trailers), and the results from the spreadsheet placed on worksheets 5-1 and 5-2. This work would normally be done by the materials lab.

Assumptions used in the forecast are shown in worksheet 5-3. All three worksheets are shown on pages E-20 through E-22.

Finally, a submittal letter and flow maps are provided along with the three worksheets to the requesting engineer. The transmittal letter and flow maps are shown on pages E-23 through E-25.

WASHINGTON STATE TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
REQUEST FOR TRAFFIC ANALYSIS

DATE: July 12, 1989

FROM J. Doe

TO: D. Thompson
GF-11

C.S. 1630 **SR** 104 **XL** 0396

Project Name: Quilcene Center Rd to So. Point Rd

Project No. 310402A

Dear Sir:

Please prepare and forward to this office, traffic data for the above referenced project and as described below;

PURPOSE OF TRAFFIC DATA:

[X] Design Report Details
[ ] Collect Field Data
[ ] Determine Warrants for Traffic Control Device
[ ] Other (Explain)

ATTACHMENTS

[X] Vicinity Map
[ ] Traffic Diagram
[ ] Other (Explain)

SCHEDULED TIME FOR DISTRICT RECEIPT OF TRAFFIC DATA:

September 15, 1989

DESIGN YEAR: 2009

COMMENTS (List Special Details of Requirements)
Please provide present day and design year ADT's, peak hour volumes, and turning movements for the intersection of Beaver Valley Road and SR 104. this traffic will be used to determine channelization warrants.

MDM
JRA
Attachments
cc: J. Smith
D. Brown

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

PROJECT PROSPECTUS

PROGRAM ITEM NUMBER 310402A	SR No. 104	Date: 04/10/89

TERMINI: S.R.M.P. From 4.39	To 10.78	Length 6.39 (Miles)	Paving Length 6.39 (Miles)

TITLE: Quilcene Center Rd. to So. Point Rd. Vicinity

Level of Development Plan: ( ) Maintain ( ) 3R Standards (X) Design Standards

Master Plan for Access Control:
Implementation Status (X) Existing ( ) Proposed ( ) Defer

Roadway Geometric Data	Existing	Proposed	Standards
Total Number Through Lanes	2	2	
Number of Lanes This Proposal	*************	0	
Lane Width	11'	12'	12'
Shoulder Width Left (feet)	3'	3'	6'
Shoulder Width Right (feet)	3'	3'	6'
Roadway Width (feet)	42'	42'	36'
Auxiliary Lane Length (miles)	---	---	
Auxiliary Lane Width (feet)	---	---	

Project Type

1R ____
2R ____
3R X
4R ____
DS ____
N/A ____

(4,300 - 7,000) ADT (7%) Truck Percentage (89 - 91) Funding Biennium
(N) To Be Considered For Value Engineering (Y) Project Eligible For Federal Aid

STATEMENT OF PROBLEM AND PROPOSED SOLUTION:

1988 Priority Array:	MP 4.44 to MP 6.20	PMS = 822A	Rank = 74	Level = P2
	MP 6.20 to MP 8.20	PMS = 1486A	Rank = 127	Level = P3
	MP 8.20 to MP 10.78	PMS = 341A	Rank = 34	Level = P1

Preliminary engineering, right of way and construction for a 0.12' ACP wearing course plus 0.02' prelevel. Included in construction are digouts, crack sealing, installing guardrail and guideposts, slope flattening, beveling and installing culverts, widening for channelization at Beaver Valley Road and shoulder driving areas, striping and signing.

Environmental Considerations

1. Is this project controversial? No X Yes ____ Maybe ____
   Why? ____
2. Are permits or approvals from other agencies likely to be required? No ____ Yes ____ Maybe X
3. Is additional Right of Way required? No ____ Yes X Maybe ____
4. Indicate where applicable if any of the property involved is known to be or proposed as (____) a public park, (____) a recreation area, (____) a wildlife or waterfowl refuge, (____) a historic site, or (____) an archaeological site
5. Indicate where applicable if there is a potential to impact or for encroachment on (X) any wetlands, (____) any floodplains, (____) any bodies of water, (____) a hazard waste/materials site, or (____) any farmlands.

Probable SEPA Classification

SEPA-Categorical Exemption. Specify applicable WAC category ____
SEPA-EIS ____ SEPA-DNS Checklist X Other ____

Probable NEPA Classification

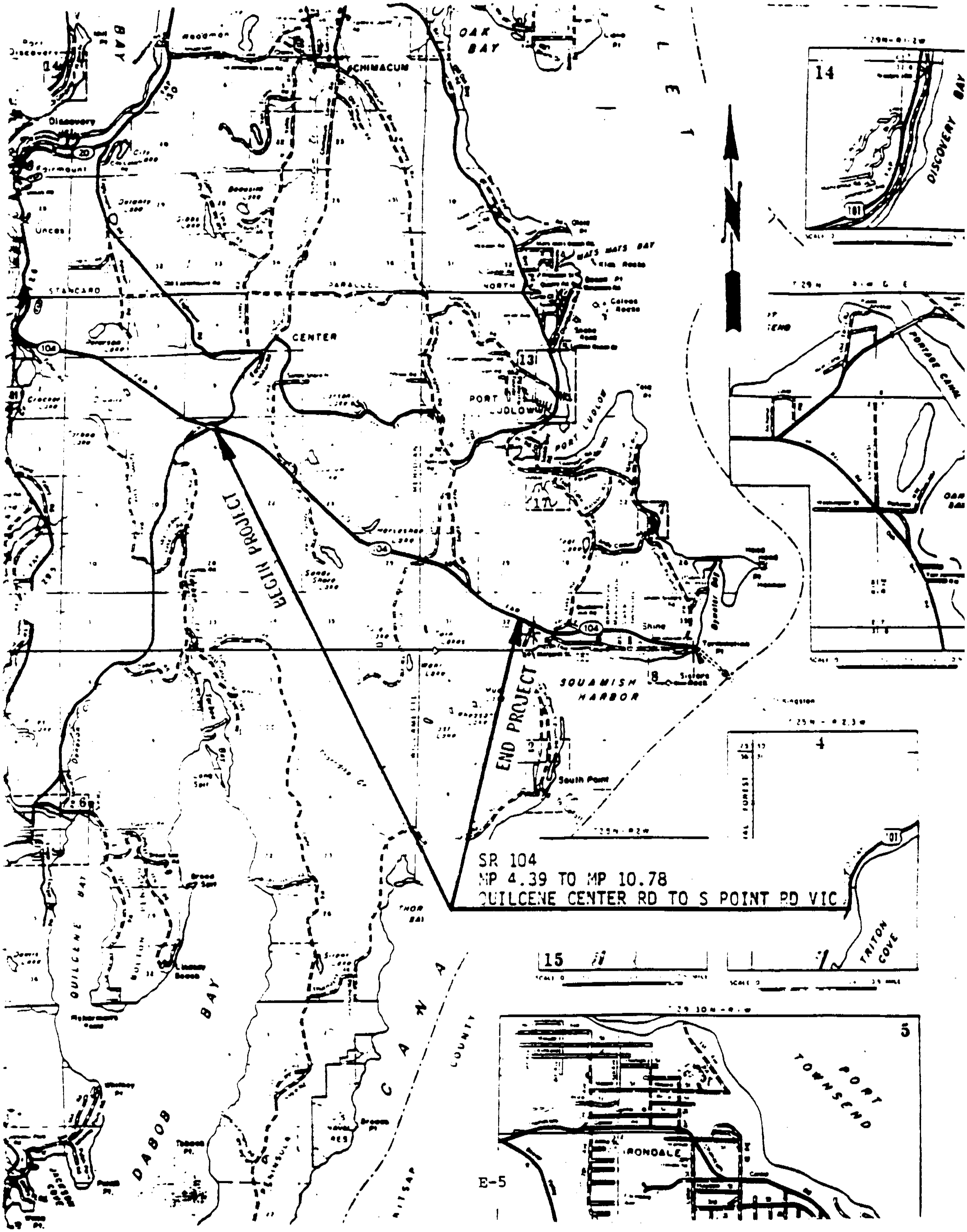
NEPA-Fixed List Categorical exclusion. Specify category CFR771.117(c) ____ CFR771.117(D) (1)
NEPA-EIS ____ NEPA-EA ____

HQ Location-Design Concurrence Date: ____

Date: 4-14-89 District Administrator: [signature]

Headquarters Comments:

Date: ____ HQ Approval: ____



SR 104
MP 4.39 TO MP 10.78
QUILCENE CENTER RD TO S POINT RD VIC
BEGIN PROJECT
END PROJECT
CHIMACUM
CENTER
PORT LUDLOW
SQUAMISH HARBOR
OAK BAY
DISCOVERY BAY
PORT TOWNSEND
IRONDALE
TRITON COVE
QUILCENE BAY
DABOB BAY
South Point
Discovery
Fairmount
Uncas
Shine

TRAFFIC ANALYSIS WORK FILE — C.S. 1630

PROJECT: SR 104 - QUILCENE CENTER ROAD TO SOUTH POINT ROAD

DATE: NOVEMBER 1989 — ANALYST: T. SMITH

PROJECT SCOPE: OVERLAY PLUS CHANNELIZATION AT BEAVER VALLEY ROAD
AND SHOULDER DRIVING AREAS
1989 AND 2009 ADT - K - D - T

PREVIOUS ANALYSIS

SR 104 - SR 101 TO QUILCENE/CENTER ROAD
MP 0.2 TO MP 4.39 — AUGUST 28, 1986
1986/2006 ADT-K-D-T — N. BANICK

SR 104 - SOUTH POINT ROAD TO JCT SR 3
MP 10.78 TO MP 15.54 — MARCH 12, 1986
1986/1991/2006 ADT-K-D-T — J. HAHN

SR 104 - HOOD CANAL BRIDGE
(TRIP TABLES, FLOW DIAGRAMS, GROWTH RATES)
THIS WAS INFORMATION FROM THE LATE 1970'S AND EARLY 1980'S FOR THE HOOD CANAL BRIDGE REPLACEMENT. IT DOES NOT REFLECT THE CHANGES IN TRAFFIC DUE TO THE REMOVAL OF TOLLS.

SR 104 - HOOD CANAL BRIDGE TRAFFIC - MONTHLY REPORTS
TRAFFIC AND CORRESPONDENCE REGARDING THE REOPENING OF THE BRIDGE IN 1982

HOOD CANAL BRIDGE TIME LINE:

OPENED	8/12/61
SANK	2/13/79
REOPENED	10/24/82
TOLLS REMOVED	8/29/85

COUNTS REVIEWED:

89-057 — SR 104 JCT. BEAVER VALLEY ROAD 9/19 - 22/89
DIRECTIONAL RECORDING COUNTERS
MANUAL COUNTS 0700 - 1100 & 1400 - 1800
G.K. CLASSIFIERS W/O BEAVER VALLEY ROAD

85-073 — SR 101 TO QUILCENE/CENTER ROAD 8/19 - 23/85
RECORDING COUNTERS, MANUAL COUNTS

SR 104 — MP 0.00 TO MP 13.91
RECORDING COUNTERS, MANUAL COUNTS & GK CLASSIFIERS

PTR-085 — SR 1-4 AT HOOD CANAL BRIDGE

AXLE CORRECTION INFO: INCLUDED

SPECIAL CONDITIONS & ASSUMPTIONS:

ADT

THE TRAFFIC COUNT FROM 89-056 WEST LEG OF JCT SR 104 AND BEAVER VALLEY ROAD WAS UNUSABLE (BAD COUNT). ADT FOR THIS LEG WAS FROM THE CLASSIFIERS. OTHERWISE NO PROBLEMS WITH 1989 ADT. THE SR 104 (MP 0.00 TO MP 13.91) COUNT FILE CONTAINED RECORDING COUNTS AND A MANUAL (NOT DONE AT THE SAME TIME) AT JCT. SR 104 / BEAVER VALLEY ROAD DONE IN OCTOBER 1987 BY DISTRICT #3. THE SIX HOUR MANUAL COUNT SHOWED 40 VEHICLES USING THE SOUTH APPROACH. AFTER CONSULTING WITH DISTRICT #3 IT WAS DETERMINED THAT THIS WAS NOT NORMAL TRAFFIC AND PROBABLY THE RESULT OF VEHICLES PULLING OFF THE MAINLINE FOR A REST STOP AS OPPOSED TO TRAFFIC GENERATED BY THE APPROACH.

K & D

AFTER A REVIEW OF PREVIOUS ANALYSES IT WAS DETERMINED THAT TRAFFIC HAS CHANGED AND CONTINUES TO CHANGE DUE TO THE REMOVAL OF TOLLS FROM THE HOOD CANAL BRIDGE. THE PEAK HOUR REPORT FROM PTR-085 ALSO SHOWS THAT THE "K" AND "D" HAVE CHANGED EACH YEAR SINCE THE TOLLS WERE REMOVED. (SEE SHEET WITH "K" AND "D" INFORMATION). FROM PTR-085 USED 50TH PEAK HOUR DATA. USED K = 12.5% D=65/35

"T"

WE HAVE NO CURRENT WEEKEND COUNTS FROM THIS VICINITY. FROM PREVIOUS ANALYSIS ON SR 104 IN THIS VICINITY (DONE 1986), WE HAD "T" OF 9.0% AND 19.0%. ACTUAL "T" ASSUMED TO BE CLOSER TO AN AVERAGE OF THE TWO. SEE IDC FOR ACTUAL "T" USED.

GROWTH FACTORS

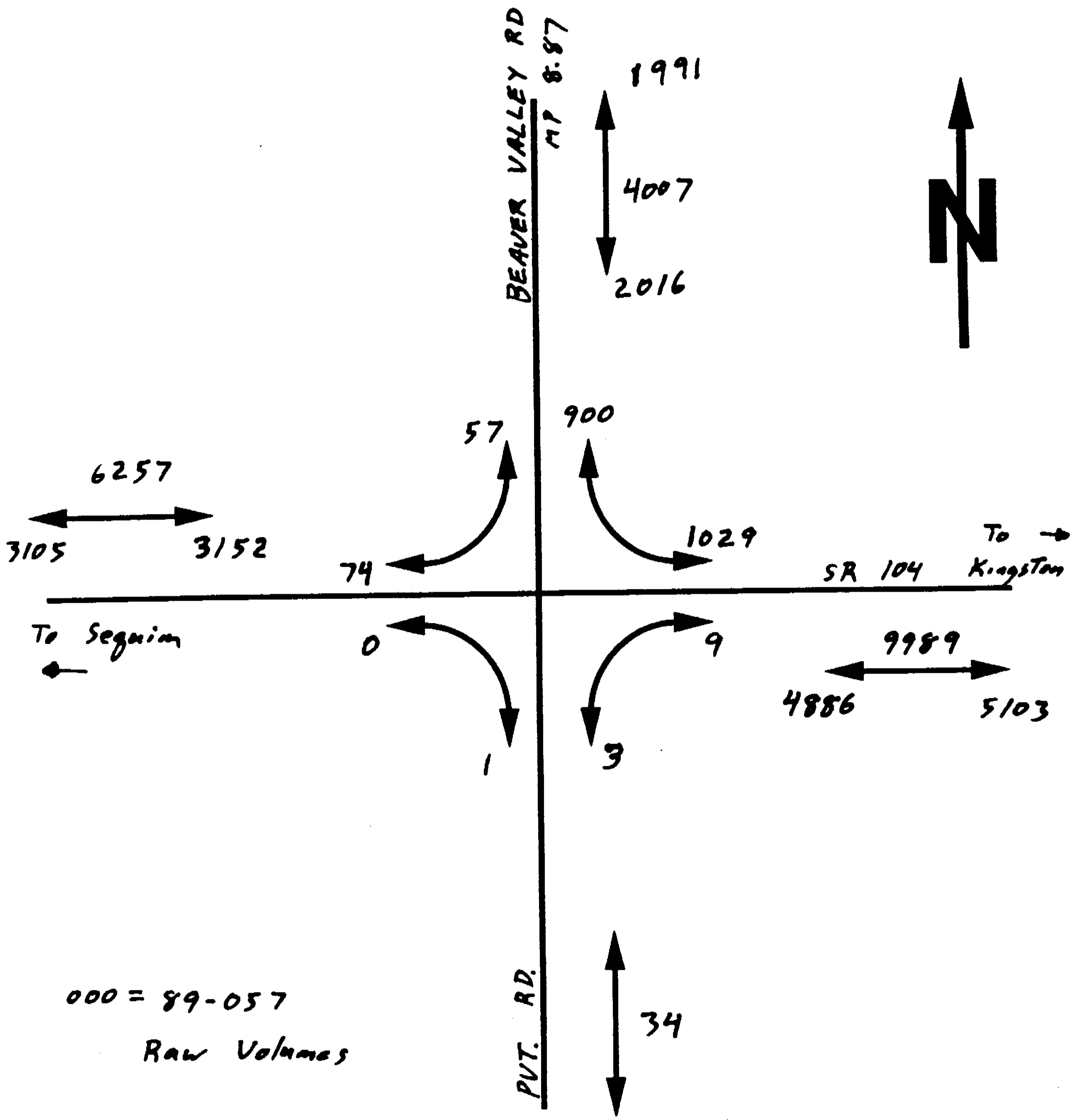
PREVIOUS ANALYSIS WERE STUDIED AND A CALL WAS MADE TO THE JEFFERSON COUNTY PLANNING DEPARTMENT. THE PLANNERS I SPOKE WITH INDICATED NO DEVELOPMENTS WERE PLANNED FOR THIS AREA. IT IS TO BE LEFT AS RESOURCE PRODUCTION AREA (I.E., TIMBERLAND). THE GROWTH RATES FOR SR 104 IN THIS AREA HAVE BEEN IN EXCESS OF 6.0%/YEAR 1978-1988. THIS INCLUDES THE EFFECT OF THE BRIDGE SINKING. LONG TERM - 1968 TO 1988 IS 14.7%/YEAR. IT WAS ASSUMED THAT THE GROWTH WILL CONTINUE AT APPROXIMATELY 6.0%/YEAR FOR THE NEAR TERM, SLOWING TO 4.0%/YEAR. AN AVERAGE OF 5.0%/YEAR WAS ASSUMED FOR THE DESIGN YEAR.

LOCATION: 89-057 SR104 Jct. Beaver Valley Road 9/19-22/89

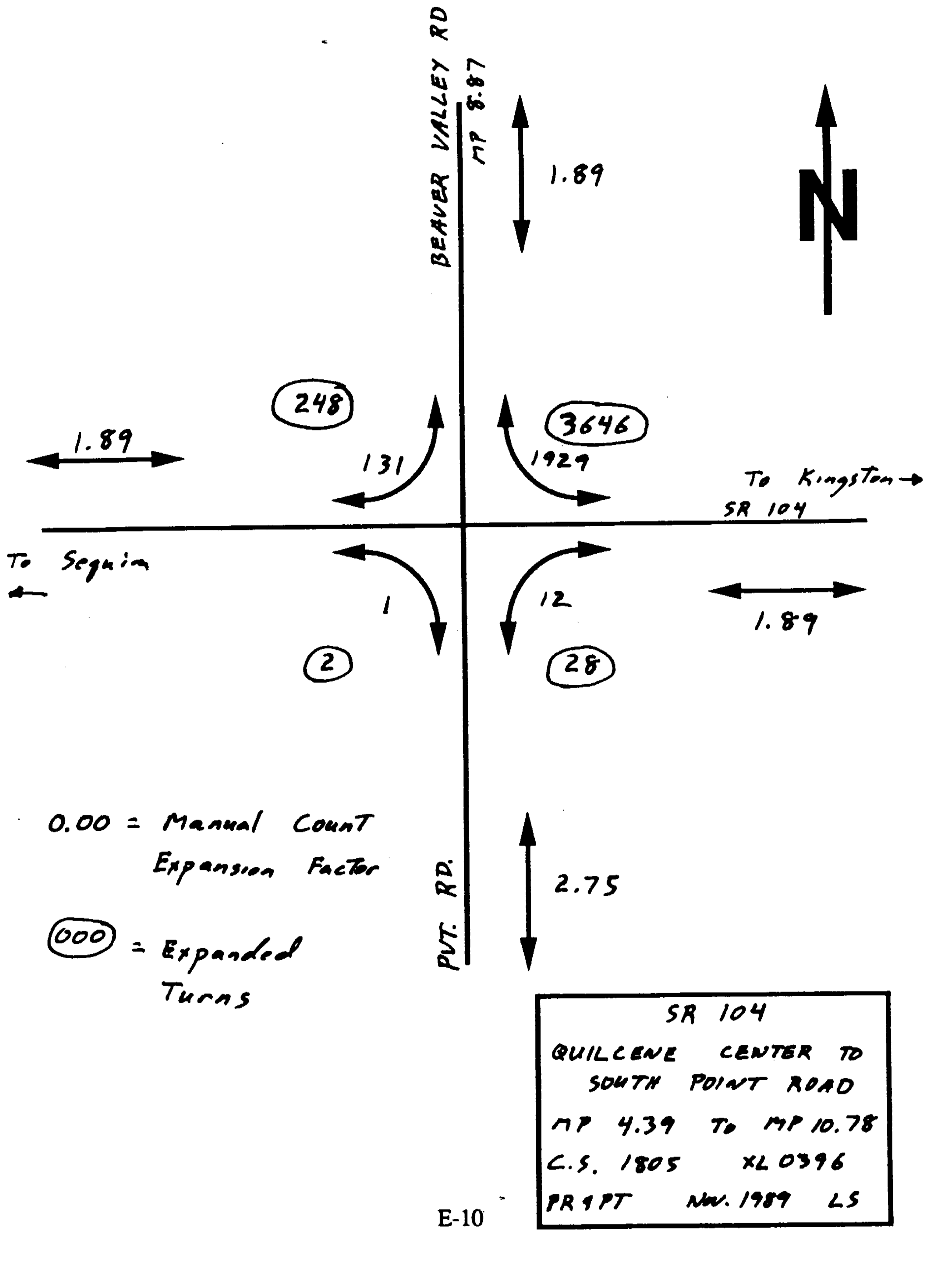
Ctr #	AWD	A/C FAC		Other FAC		Seas Fac		Mech M/C Time	*	Adj Fig	M/C Vol	MC Mech	ADT Day of M/C	*		M/C Exp Fac	Adj Exp Fac	Comments
713						.99		616 1480		574 1380	705 1017		3083 4373					BC - Est Vol
713						.99		796 530*		742 494	576 390*		3324 3238					BC - Est Vol *1400 - 1600
733	34?	0.81	28	0.8	22	.99	22	6 6		5 5	6 2	0.80	43 24		22	2.75		
652	2016	0.932	1879	1.077	2024	.99	2003	491 610		1026	499 606	1.077	2004 2053		2036	1.87	1.89	
652	1991	0.932	1856		1856	.99	1837	429 605		963	386 573	0.999	1965 2028		1861	1.94		
705	5103	0.931	4776	0.977	4667	.99	4620	1246 1710		2766	1146 1556	0.977	5041 5319		4737	1.75	1.89	
705	4886	0.931	4573		4573	.99	4528	999 1397		2242	906 1337	1.000	4788 4907		4537	2.02		
710	3152	0.917	2889	1.015	2932	.99	2903			686 1011	705 1017	1.015			2878 3025	1.74	1.89	
729	3105	0.922	2863	1.018	2915	.99	2886			550 839	576 838	1.018			2811 2852	2.04		

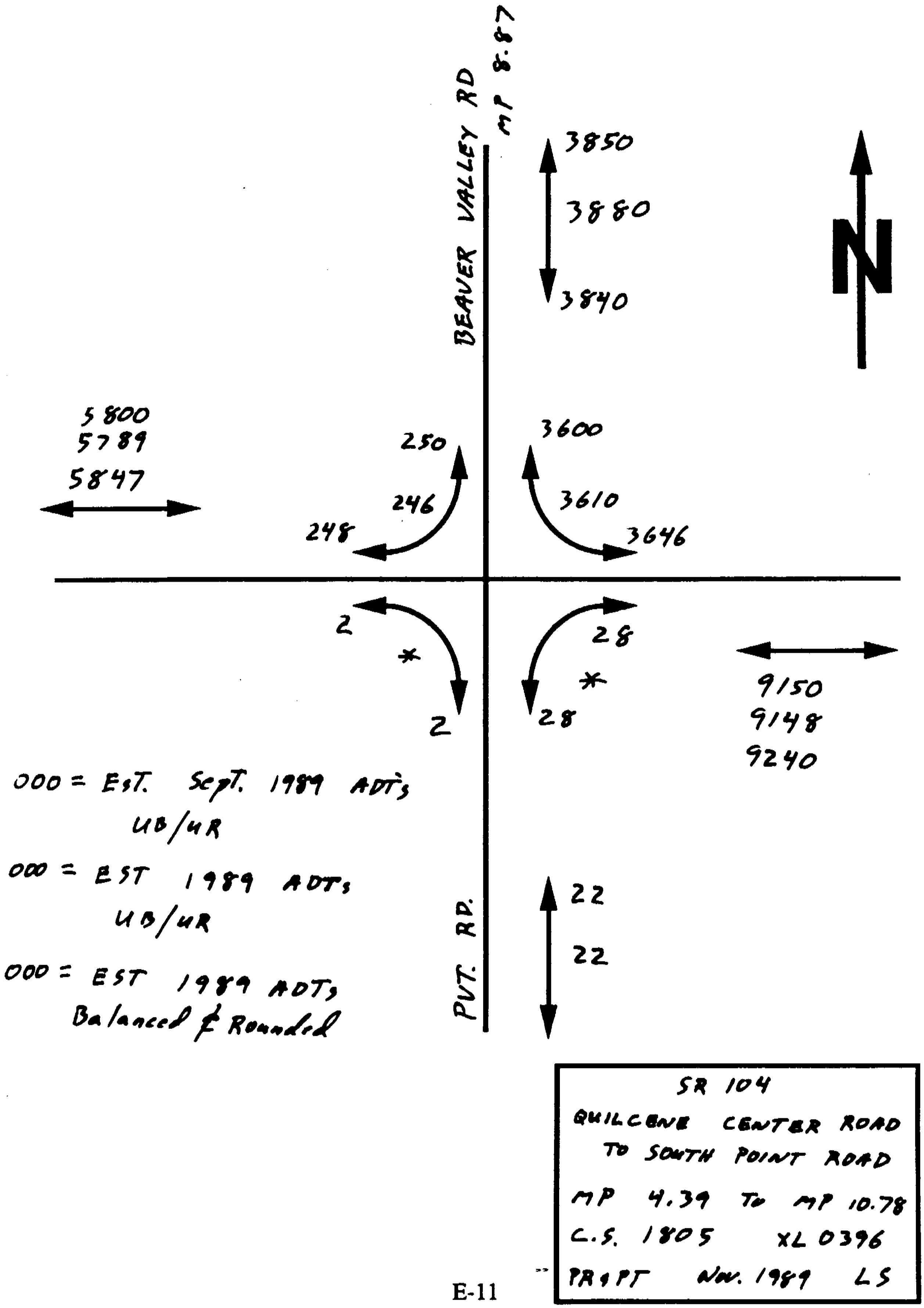
10/87 Jct. SR 104/Beaver Valley Road (By Dist #3)

															Manual count
54	4600							1990			2111				done one week
															before vounters
82	7170							3140			3237				were set.
62	2890							1310			1304				



SR 104
QUILCENE CENTER TO
SOUTH POINT ROAD
MP 4.39 To MP 10.78
C.S. 1805 XL 0396
PR & PT Nov. 1989 LS


BEAVER VALLEY RD
MP 8.87
1.89
N
248
3646
1.89
131
1929
To Kingston →
SR 104
To Sequim ←
1
12
1.89
2
28
0.00 = Manual Count Expansion Factor
PVT. RD.
2.75
000 = Expanded Turns
SR 104
QUILCENE CENTER TO SOUTH POINT ROAD
MP 4.39 TO MP 10.78
C.S. 1805 XL 0396
PR 4 PT NOV. 1989 LS



BEAVER VALLEY RD
MP 8.87
3850
3880
3840
5800
5789
5847
250
246
248
3600
3610
3646
2
*
2
28
*
28
9150
9148
9240
000 = EST. Sept. 1989 ADT's UB/UR
000 = EST 1989 ADTs UB/UR
000 = EST 1989 ADTs Balanced & Rounded
PVT. RD.
22
22
SR 104
QUILCENE CENTER ROAD
TO SOUTH POINT ROAD
MP 4.39 To MP 10.78
C.S. 1805 XL 0396
PR&PT Nov. 1989 LS

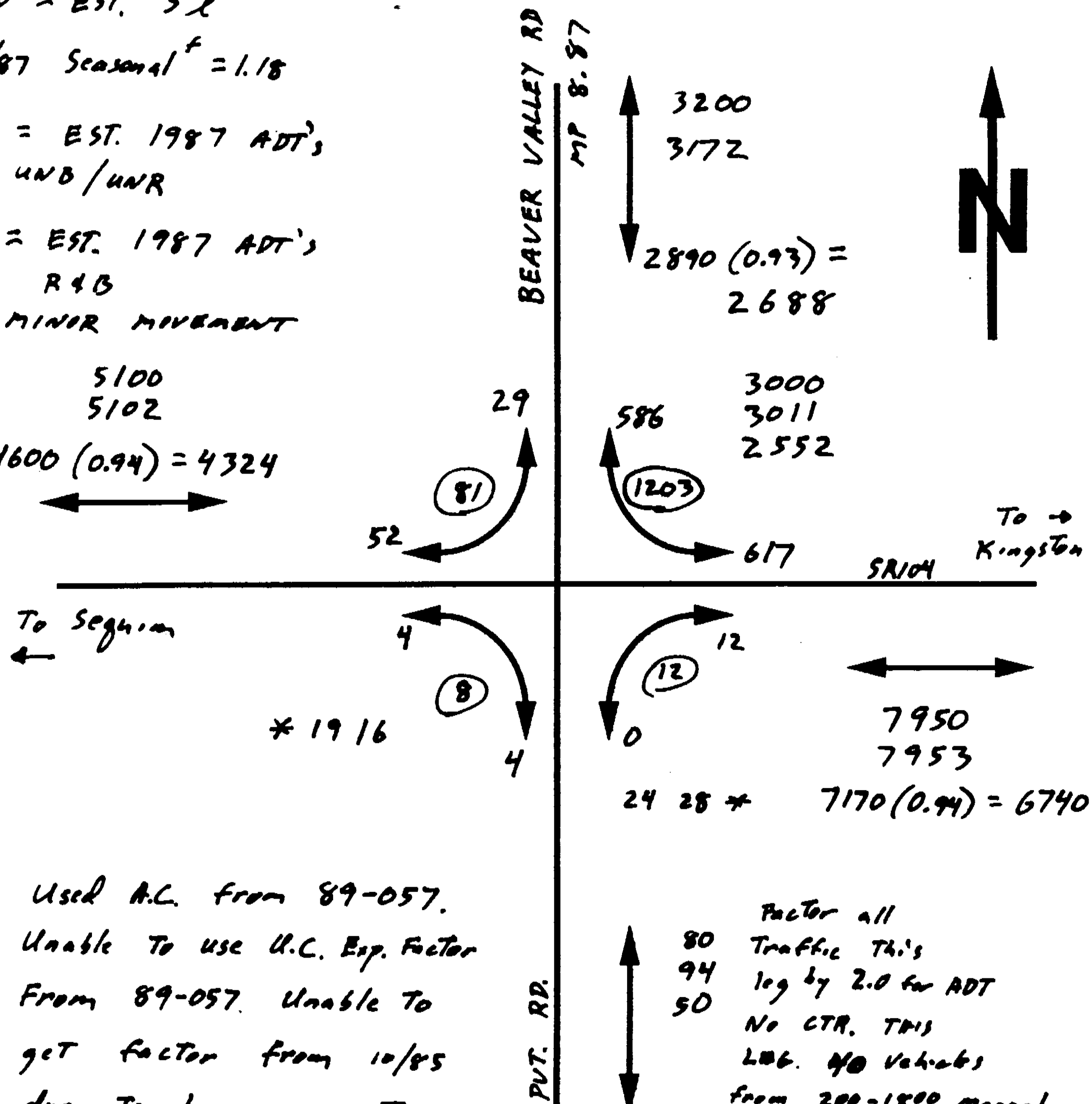
000 = EST. 3 ℓ f

10/87 Seasonal f = 1.18

000 = EST. 1987 ADT's UNB/UNR

000 = EST. 1987 ADT's R & B

* = MINOR MOVEMENT



Used A.C. from 89-057. Unable To use U.C. Exp. Factor From 89-057. Unable To get factor from 10/85 due To human count and recording counters set different days.

SR 104
QUILCENE CENTER TO SOUTH POINT ROAD
MP 4.39 To MP 10.78
C.S. 1805 XL0396
PR & PT Nov. 1989 LS

89-035 AXLE CORRECTION FACTORS

N/Leg

	07/11	14-18	Tot	
2	821	1124	1945*2	3890
3	21	18	39 * 3	117
4	2	4	6 * 4	24
5	33	18	51 * 5	255
6	6	13	19 * 6	114
7	2	2	4 * 7	28
	885	1179	2064	4428 / 2

2064/2214 = 0.9322

S/Leg

	07-11	14-18	Tot	
2	2	9	11	22
3	3	2	5	15
5	1	0	1	5
	6	11	17	42/2

17/21 = 0.8095

E/Leg

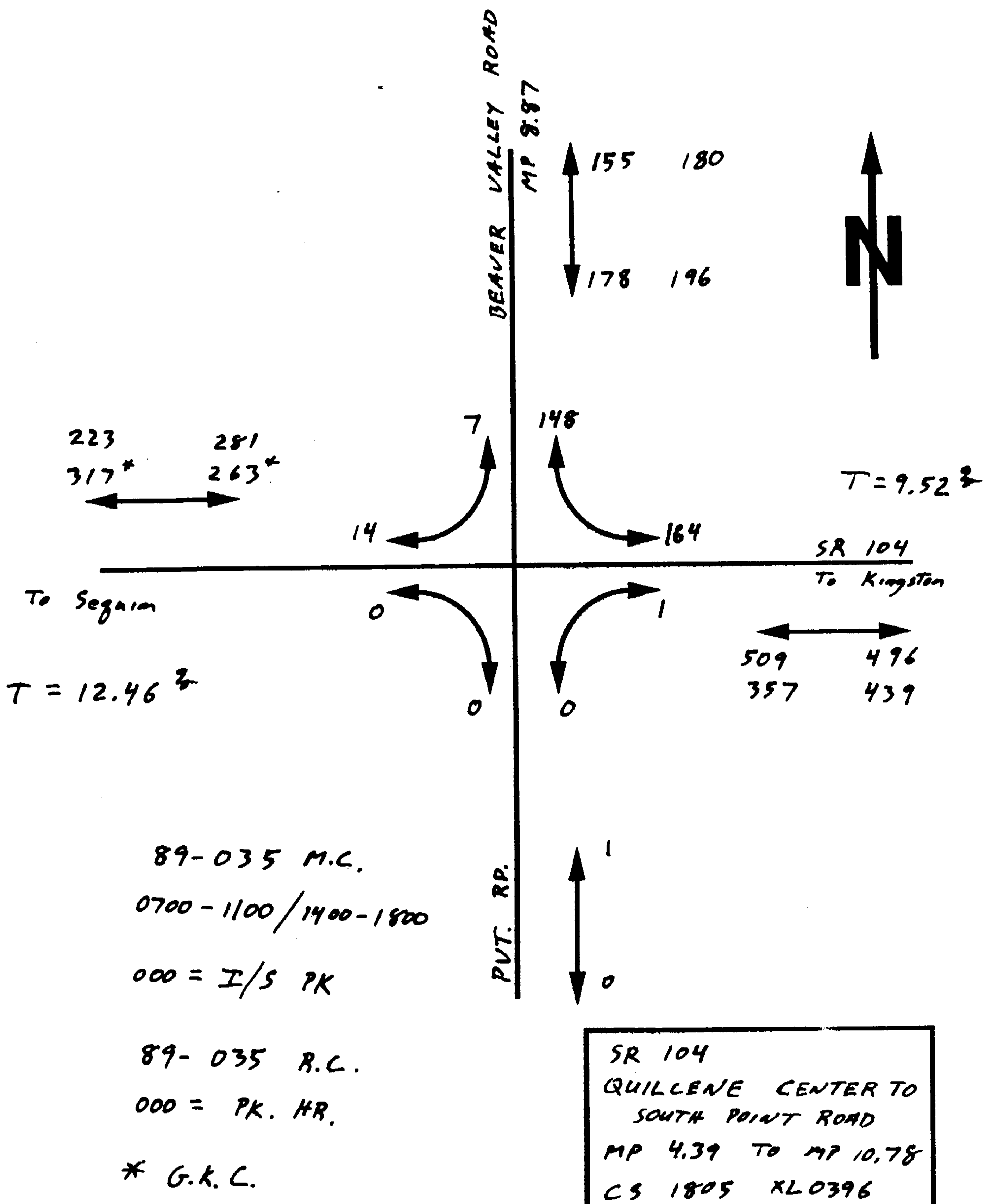
	07/11	14-18	Tot	
2	1917	2784	4701	9402
3	34	30	64	192
4	7	6	13	52
5	64	41	105	525
6	16	20	36	216
7	14	12	26	182
	2052	2893	4945	10569/2

4945/5285 = 0.9357

W/Leg

	07-11	14-18	Tot	
2	1186	1795	2981	5962
3	16	16	32	96
4	5	2		28
5	52	25	77	385
6	10	7	17	102
7	12	10	22	154
	1281	1855	3136	6727/2

3136/3364 = 0.9322



SR 104
QUILCENE CENTER TO SOUTH POINT ROAD
MP 4.39 TO MP 10.78
CS 1805 XL0396
PR & PT NOV. 1989 LS

PTR - 85 (SR 104 - MP 13.92)

Peak Hour

1986 - 8253 ADT

	K	D
1st	27.49	73.9/26.1
30th	14.99	24.3/75.7
50th	14.1	54.3/45.7
100th	12.76	46.5/53.6

"D", E/W

Avg - 50th hr - 44.24/55.26
Avg - 50th hr (pk/dir) = 67.1%

1987 - 9375 ADT

	K	D
1st	19.37	60.6/39.4
30th	13.97	34.7/65.3
50th	13.21	66.0/34.0
100th	12.49	45.4/54.6

D, E/W

Avg - 50th hr - 64.12/35.88
Avg - 50th hr (pk/dir) = 65.4%

Gf	88-89 (est)	6.1%
	87-88	6.5%
	86-87	13.6%
	86-88	10.5%

Used Gf of 5%/year

1988 - 9983

	K	D
1st	16.21	68.5/31.5
30th	13.03	73.3/26.7
50th	12.27	66.1/33.9
100th	11.21	60.5/39.5

D, E/W

Avg - 50th hr - 59.86/40.14
Avg - 50th hr (pk/dir) = 64.4%

1985 HCM:TWO-LANE HIGHWAYS
****

FACILITY LOCATION	SR 104 AT HOOD CANAL BRIDGE
ANALYST	LS
TIME OF ANALYSIS	
DATE OF ANALYSIS	11/89
OTHER INFORMATION	ESTIMATED 2009 DDHV

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS	3
PERCENTAGE OF BUSES	3
PERCENTAGE OF RECREATIONAL VEHICLES	5
DESIGN SPEED (MPH)	50
PEAK HOUR FACTOR	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)	65/35
LANE WIDTH (FT)	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT)	0
PERCENT NO PASSING ZONES	100

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	.92	.9
B	2.2	2	2.5	.7	.92	.88
C	2.2	2	2.5	.7	.92	.88
D	2	1.6	1.6	.7	.92	.93
E	2	1.6	1.6	.88	.92	.93

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME (vph): 2496
ACTUAL FLOW RATE: 2496

LOS	SERVICE FLOW RATE	V/C
A	64	.04
B	251	.16
C	503	.32
D	948	.57
E	2091	1

LOS FOR GIVEN CONDITIONS: E

1985 HCM:UNSIGNALIZED INTERSECTIONS
****

IDENTIFYING INFORMATION

AVERAGE RUNNING SPEED. MAJOR STREET	55
PEAK HOUR FACTOR	1
AREA POPULATION	150000
NAME OF THE EAST/WEST STREET	SR 104
NAME OF THE NORTH/SOUTH STREET	BEAVER VALLEY ROAD
NAME OF THE ANALYST	LS
DATE OF THE ANALYSIS (mm/dd/yy)	11/89
TIME PERIOD ANALYZED	PEAK
OTHER INFORMATION	EST 2009 DDHVs

INTERSECTION TYPE AND CONTROL

INTERSECTION TYPE: T-INTERSECTION
MAJOR STREET DIRECTION: EAST/WEST
CONTROL TYPE SOUTHBOUND: STOP SIGN

TRAFFIC VOLUMES

	EB	WB	NB	SB
LEFT	30	0	--	297
THRU	472	856	--	0
RIGHT	0	571	--	26

NUMBER OF LANES

	EB	WB	NB	SB
LANES	1	1	--	1

ADJUSTMENT FACTORS

	PERCENT GRADE	RIGHT TURN ANGLE	CURB RADIUS (ft) FOR RIGHT TURNS	ACCELERATION LANE FOR RIGHT TURNS
EASTBOUND	0.00	90	20	N
WESTBOUND	2.00	90	20	N
NORTHBOUND	-----	---	---	-
SOUTHBOUND	2.0	90	20	N

VEHICLE COMPOSITION

	% SU TRUCKS AND RV's	% COMBINATION VEHICLES	% MOTORCYCLES
EASTBOUND	11	3	0
WESTBOUND	8	3	0
NORTHBOUND	---	---	---
SOUTHBOUND	11	1	0

CRITICAL GAPS

	TABULAR VALUES (Table 10-2)	ADJUSTED VALUE	SIGHT DIST. ADJUSTMENT	FINAL CRITICAL GAP
MINOR RIGHTS SB	6.50	6.50	0.00	6.50
MAJOR LEFTS EB	5.50	5.50	0.00	5.50
MINOR LEFTS SB	8.00	8.00	0.00	8.00

IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET	SR 1-4
NAME OF THE NORTH/SOUTH STREET	BEAVER VALLEY ROAD
DATE AND TIME OF THE ANALYSIS	11/89; PEAK
OTHER INFORMATION	EST 2009 DDHV's

CAPACITY AND LEVEL-OF-SERVICE

MOVEMENT	FLOW-RATE v (pcph)	POTENTIAL CAPACITY c_p (pcph)	ACTUAL MOVEMENT CAPACITY c_M (pcph)	SHARED CAPACITY c_{SH} (pcph)	RESERVE CAPACITY $c_R = c_{SH} - v$	LOS
MINOR STREET						
SB LEFT	388	45	40	> 40	> -348	> F
				> 42	> -380	> F
RIGHT	34	188	188	> 188	> 154	> D
MAJOR STREET						
EB	33	184	184	184	151	D

IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET	SR 1-4
NAME OF THE NORTH/SOUTH STREET	BEAVER VALLEY ROAD
DATE AND TIME OF THE ANALYSIS	11/89; PEAK
OTHER INFORMATION	EST 2009 DDHV's

DATE: November 27, 1989
FROM: C.A. Smith / J.S. Burgin
PHONE: 3-5386 3-3210

Subject: SR 1-4 CS 1630
Quilcene Center Road to
South Point Road
MP 4.39 to MP 10.78

TO: A.T. Smelser/R.C. Wade
MS: KT-11

In response to your July 12, 1989 request, attached are two sketches showing the estimated 1989 ADTs and DDHVs (sketch #1) and the estimated 2009 ADTs and DDHVs (sketch #2) for the above referenced section of highway.

The estimated truck percentages during the design hour are as follows:

"T" = 11.0 % * on SR 104 East of Beaver Valley Road

"T" = 14.0 % * on SR 104 West of Beaver Valley Road

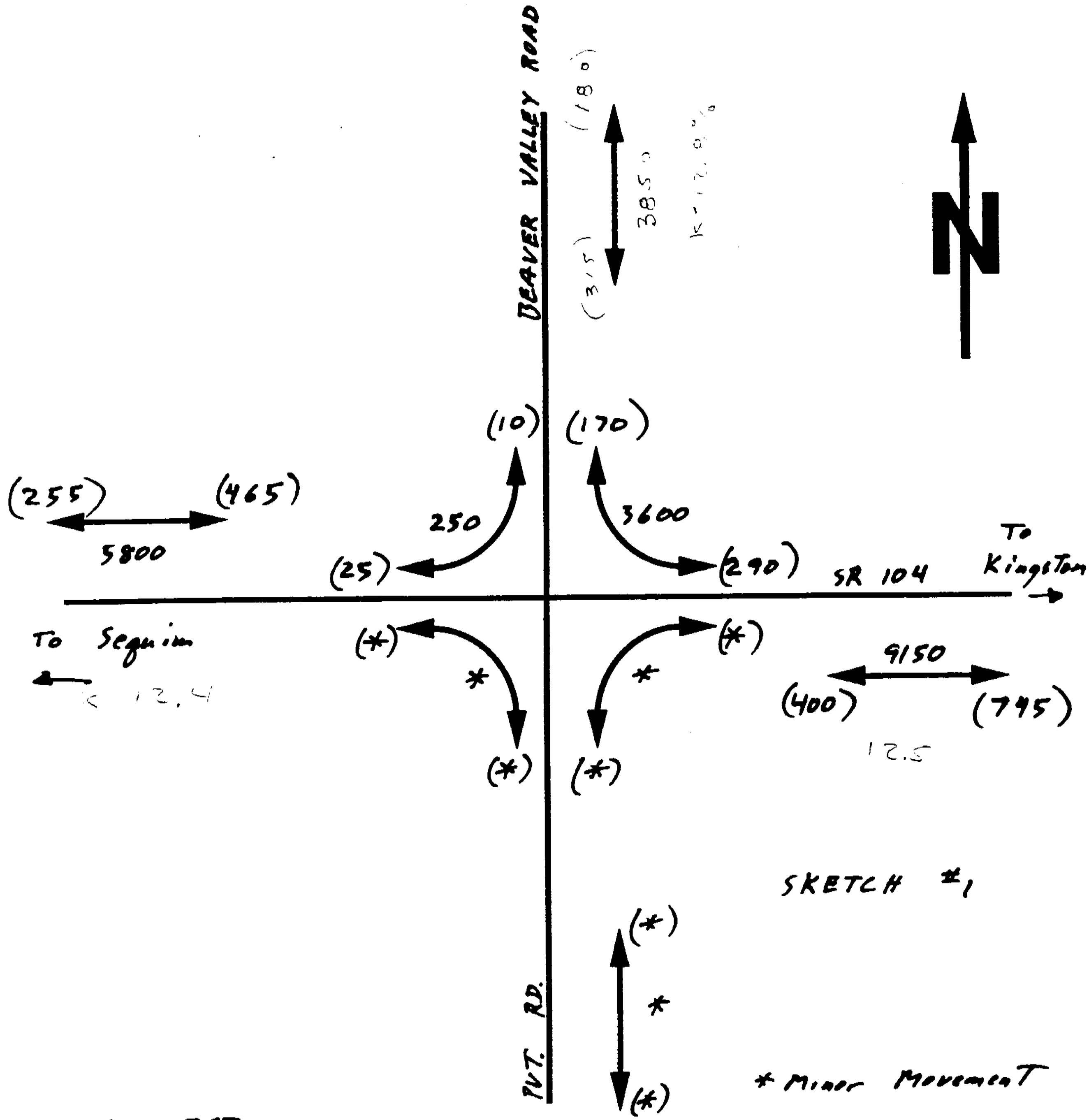
"T" = 12.0 % * on Beaver Valley Road

* Includes passenger cars and pickups pulling trailers.

If you have any questions, please contact Jay Burgin at the above number.

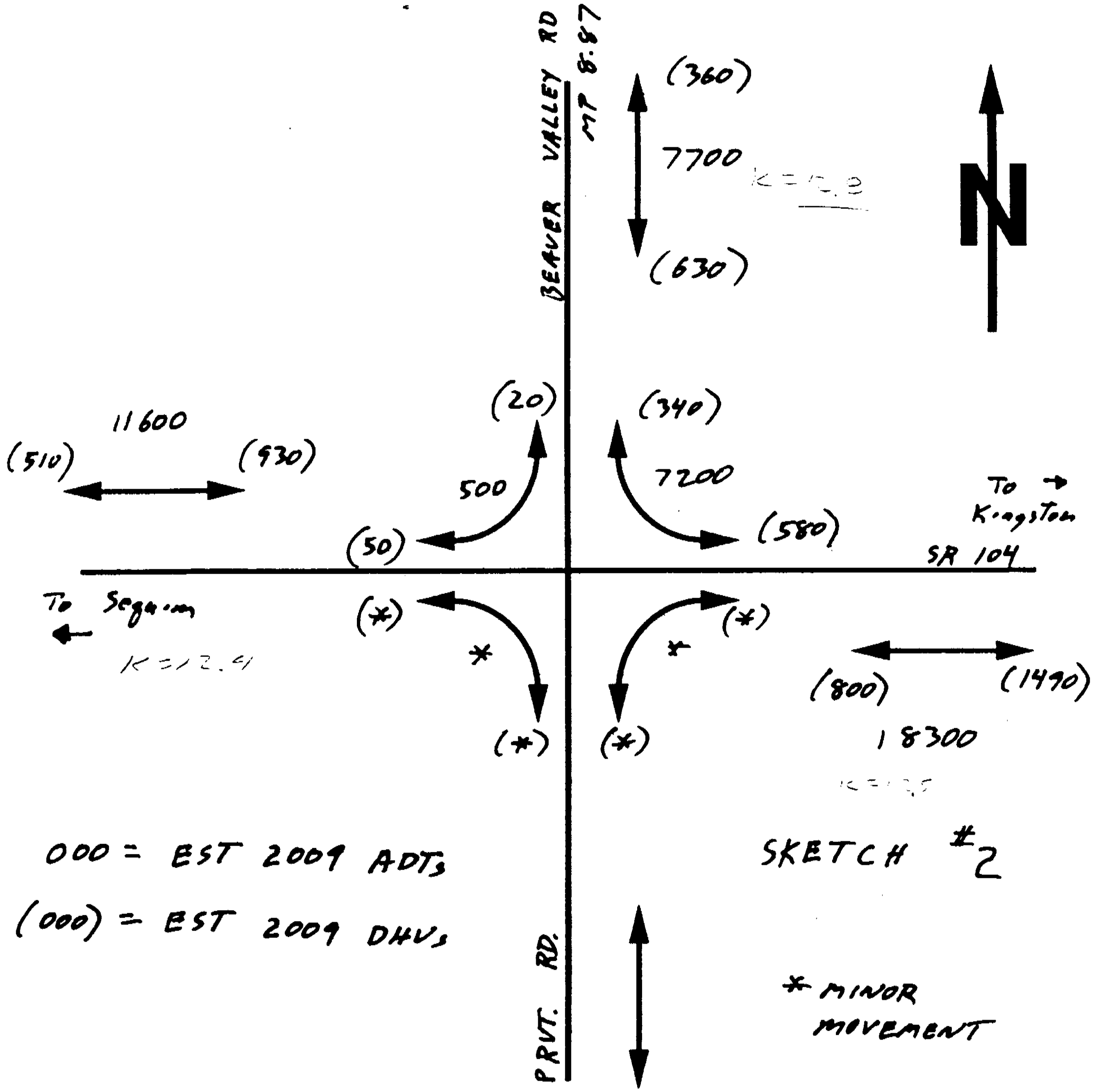
CAS:der
JSB
Attachments

cc: E.R. Burch - Design KF-01
C.D. Hornbuckle - District 3 KT-11
D.W. Freeman - District 3 KT-11
M. McFarland - District 3 KT-11



000 = EST 1989 ADTs
(000) = EST 1989 DHVs

SR 104
QUILCENE CENTER TO
SOUTH POINT ROAD
M.P. 4.39 TO MP 10.78
C.S. 1805 XL 0396
PR & PT NOV. 1989 LS



SR 104
QUILCENE CENTER TO
SOUTH POINT ROAD
MP 4.39 TO MP 10.78
C.S. 1805 XL 0396
PR & PT Nov. 1989 LS

Worksheet 1. Summary Traffic Information

SR#	104	Beginning Milepost	4.39	Ending Milepost	10.78
Forecaster's Name:	EXAMPLE			(This sheet for E. of Beaver Valley Rd.)	
Base Year	1989	Forecast Year	2009	Duration	20 yrs.

BASE YEAR CONDITIONS

Automobile Volume =	8140	Other 2-Tire, 4-Axle Veh. =		Other Vehicles (Specify type and vehicle):	
Buses =		4-Axle Single Trailer			
2-Axle, 6-Tire SU		5-Axle Single Trailer		5-Axle Multi-Trailer	
3-Axle Single Units		6+ Axle Single Trailer		6-Axle Multi-Trailer	
4+ Axle Single Units				7+ Axle Multi-Trailer	
Total Single Units	460	**Total Single Trailers**	280	**Total Multi-Trailers**	280
AADT =	9150	Percent Trucks (Daily) =	11%	K =	12.5
		Percent Trucks (Pk. Hr.) = T =	11%	D =	65/35

FORECAST YEAR CONDITIONS

Automobile Volume =	16,290	Other 2-Tire, 4-Axle Veh. =		Other Vehicles (Specify type and vehicle):	
Buses =		4-Axle Single Trailer			
2-Axle, 6-Tire SU		5-Axle Single Trailer		5-Axle Multi-Trailer	
3-Axle Single Units		6+ Axle Single Trailer		6-Axle Multi-Trailer	
4+ Axle Single Units				7+ Axle Multi-Trailer	
Total Single Units	910	**Total Single Trailers**	550	**Total Multi-Trailers**	550
AADT =	18,300	Percent Trucks (Daily) =	11%	K =	12.5
		Percent Trucks (Pk. Hr.) = T =	11%	D =	65/35

WORKSHEET 2
VOLUMES AND ESALS BY PROJECT YEAR

Current Year: 1989 Design Year: 2009

Project Opens: 1989 Design Period 20 yrs

Actual Forecast Duration 20 yrs

Year	89	90	91	92	93	94	95	96	97	98
Forecast Volumes (AWDT)	9150	9610	10,070	10,530	10,980	11,440	11,900	12,360	12,810	13,270
Forecast Truck Volumes (AWDT)	1000	1060	1,110	1,160	1,210	1,260	1,311	1,360	1,410	1,460
Forecast ESALs (Annual, in 000)	312	328	344	359	375	391	406	422	437	453
Cumulative Project ESALs (Annual, in 000)	312	640	984	1,343	1,718	2,109	2,515	2,937	3,374	3,827

Year (continued)	99	2000	01	02	03	04	05	06	07	08	
Forecast Volumes (AWDT)	13,730	14,190	14,640	15,100	15,560	16,020	16,470	16,930	17,390	17,850	18,300
Forecast Truck Volumes (AWDT)	1,510	1,560	1,610	1,660	1,720	1,770	1,820	1,870	1,920	1,970	
Forecast ESALs (000) (Annual, in 000)	469	484	500	515	531	547	562	588	594	609	
Cumulative Project ESALs (Annual, in 000)	4,296	4,780	5,280	5,795	6,326	6,873	7,435	8,013	8,607	9,216	

DESIGN ESAL 9,215,800

WORKSHEET 3
ASSUMPTIONS USED IN THE FORECAST

Project SR 104 Forecasters Initials EX.

Date Forecast Completed 11/27/89

Major road system improvements included in the forecast

NO additional lanes assumed.

Special economic growth included in the forecast

From Jefferson County Planning Dept. Assumes no new developments. The land remains in Timber production.

Sources for land use, population and current year traffic estimates used in the forecast

(See above) Traffic counts Taken from 89-057, 85-073 and PTR-085. Also looked at prior studies done on SR-104. (8/28/86 by Banick, 3/12/86 by Haha) and available Hood Canal Bridge data.

Mitigating circumstances and growth rates assumed in the forecast

Assumes recent 6% growth will continue and then moderate to 4%. Assumes overall 5% straightline growth.

Had major differences in Truck Traffic measurements in the available count data. Assumed an average of measured data for estimating "T" and took the Traffic Report estimate for daily estimate.