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FRELANE: An Analysis Model for Major Freeway Weaving Sections and Selected Freeway Segments: User's Guide

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FINAL REPORT
UCB-ITS-RR-93-14

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16. ABSTRACT

The purpose of this report is to discuss aspects of salt marsh mitigation to determine information and data needs that are necessary to develop more effective methods for the enhancement, restoration or creation of salt marshes. The information developed is primarily applicable to the California coast with general application to other coastal salt marsh areas. The information essential to determine more effective methods occur in the areas of 1.) hydrodynamic process, 2.) soil development, 3.) vegetation establishment, 4.) monitoring, 5.) spatial requirements, 6.) construction and equipment, and 7.) stormwater treatment.

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16. Abstract
Analysis of weaving and non-weaving segments along a freeway is a necessary step in the design and/or reconstruction of highway facilities to evaluate Level-of-Service.

Using data collected on eight types of isolated segments (straight pipe, on-ramp, off-ramp, on-ramp followed by an off-ramp w/o an auxiliary lane, consecutive on-ramps, ramp weaves, four types of major weaves, and a ramp weave followed by an off-ramp) analysis models have been constructed for evaluating primarily four-lane freeway sections. The analysis model implemented includes both the use of empirical information and the extension of the analysis limits using results from a microscopic simulation model.

Analysis methods include point flow by movement and total point flow. Point flow by movement estimates the flow of each movement and sums them to determine the total volume at a point. Total point flow estimates the volume directly. Both methods are available for ramp weave analysis. The point flow by movement method is the implementation of Caltrans Traffic Bulletin No. 4 "Level D" with a modification to the estimate of the freeway to freeway percentage in the rightmost through lane. Caltrans Traffic Bulletin #4 estimates of the same value remain available to the user.

The FREWEV model has been included in its entirety in FRELANE.

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1. INTRODUCTION.

FRELANE is an interactive menu driven computer program for designing and analyzing eight different types of freeway segments. FRELANE enables the user to select one of the eight freeway segments, to enter input data on graphic screens of that segment, and then to analyze the freeway section using either the point flow by movement prediction method or the total point flow prediction method. These two point flow prediction techniques have been developed for specific segment types in previous ITS-UCB research. (1),(2),(3)

This USER'S GUIDE has been written for Release 2.0 of the FRELANE model which is capable of analyzing the following types of freeway segments:

1. MAJOR WEAVE (four types)
2. SIMPLE WEAVE with an auxiliary lane
3. ON-OFF without an auxiliary lane
4. STRAIGHT PIPE
5. ISOLATED ON
6. ISOLATED OFF
7. ON-ON
8. MULTIPLE WEAVE (one type)

FRELANE can be run in two different modes. The Empirical mode allows the program to analyze only sections that adhere to the design and demand values for which empirical data was observed. The Empirical and Simulation mode not only allows the program to analyze sections for which there is empirical data but also to analyze sections that have design and demand values outside the range for which the empirical data was collected. The data for such sections has been generated through simulation runs. Additional information on the data and assumptions about that data can be found in two separate technical documents. (4),(5)

FRELANE is written for the IBM PC and requires a math coprocessor. Printouts of the freeway geometry require a printer with the IBM character set.

2. THE FRELANE MODEL.

2.1. Background.

Research supported by CALTRANS and FHWA was conducted at UC Berkeley's Institute of Transportation Studies in an "effort to develop and calibrate a more reliable technique for evaluating weaving performance." (1) One of the recommendations of this research was to computerize the resulting weaving model. Such a computer model, FREWEV, was developed.

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The model calculates the amount of traffic by movement at up to 7 points along a weaving section for each of the lanes which are involved in the weave (the conflict area). These volumes are referred to as point flows throughout this document and in the model. From the resulting sums of the point flows, densities are calculated and Level of Service identified. The four movements involved are those traditionally associated with weaving: through freeway, freeway to off-ramp, on-ramp to freeway, and on-ramp to off-ramp. These are commonly referred to throughout this documentation and in the model outputs as Freeway to Freeway (FF), Freeway to Ramp (FR), Ramp to Freeway (RF), and Ramp to Ramp (RR).

The model also calculates the amount of traffic crossing the lane boundaries in the conflict area. These values are computed for each segment between the seven possible points that are used for point flows.

FREWEV produces a variety of screen displays and hard copy outputs.

2.2 Development of the FRELANE model.

The present project has been concerned with developing a new model called FRELANE. The FRELANE model contains the previously developed FREWEV model plus the implementation of the Empirical and Simulation analysis of additional segments of the freeway using point flow prediction methods that have been recently developed at ITS-UCB. This method for estimating total point flow is described in "Improved Freeway Analysis Techniques: Ramp and Weaving Operations for Freeway Lane Model" (2), and "Improved Freeway Analysis Techniques: Flow Fundamentals for Freeway Lane Model". (3)

The total point flow method has been implemented for all of the seven remaining segments. This method uses a regression based set of equations to estimate the total point flow at an analysis point within the section. It was developed when the point flow by movement approach used to analyze Major Weaves was found inadequate to consistently and reliably estimate the point flows in ramp and multiple weaving section analyses. (2) The individual movement flows and lane changing are estimated using some very strong assumptions about the behavior of individual movements and "net" lane changing. (5)

The "Level D" Method as described in Caltrans Traffic Bulletin No. 4 (6) (with FF percentages modified based on ITS-UCB research- see Appendix Section 8.7) has been added to FRELANE for the analysis of Simple Weaving sections. This addition allows for a comparison between the total point flow method and the "Level D" Method for this type of freeway segment.

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FRELANE produces the same information for the remaining seven segment types as it does for Major Weaves. This includes the total point flow at each of the analysis points, the point flow by movement at each analysis point, and the amount of traffic crossing the lane boundaries in the conflict area computed between each of the analysis points.

FRELANE produces the same variety of screen displays and hard copy outputs provided by the FREWEV model.

2.3 Types of segments that can be analyzed.

2.3.1 Major Weaving sections.

The major weaves analyzed by this program can be classified as type B or C according to the 1985 Highway Capacity Manual. (7) A type B weaving section has one weaving movement which requires no lane changing and the other weaving movement needing one lane change. Two type B weaves have been incorporated into the FRELANE model: a weave with a one lane on-ramp followed by a two lane off-ramp, and a weave with a two lane on-ramp followed by a two lane off-ramp. Both type B weaving sections in the model are restricted to five lanes in the weaving section. With a type C weave, one weaving movement may be accomplished without lane changing and the other requires two or more lane changes. The two type C weaves in the program are a one lane on-ramp/two lane off-ramp combination and a two lane on-ramp followed by a one lane off-ramp. Both type C weaving sections in the model can have either five or six lanes in the weaving section.

The major weaving sections analyzed by this model are shown in Figure 2.1. Note that the model evaluates only those lanes that are actually involved in the weaving movements.

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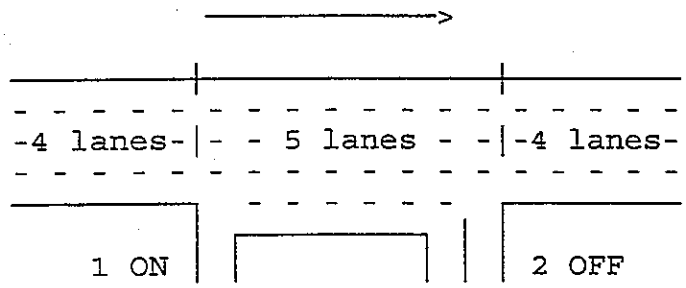
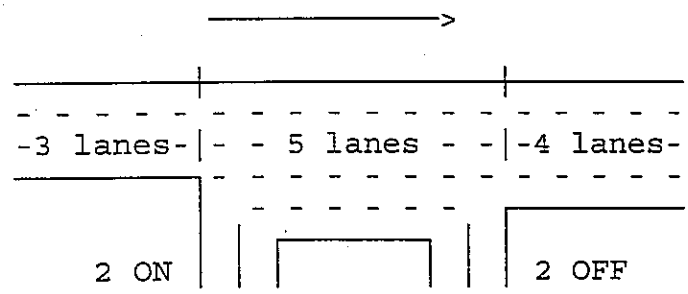
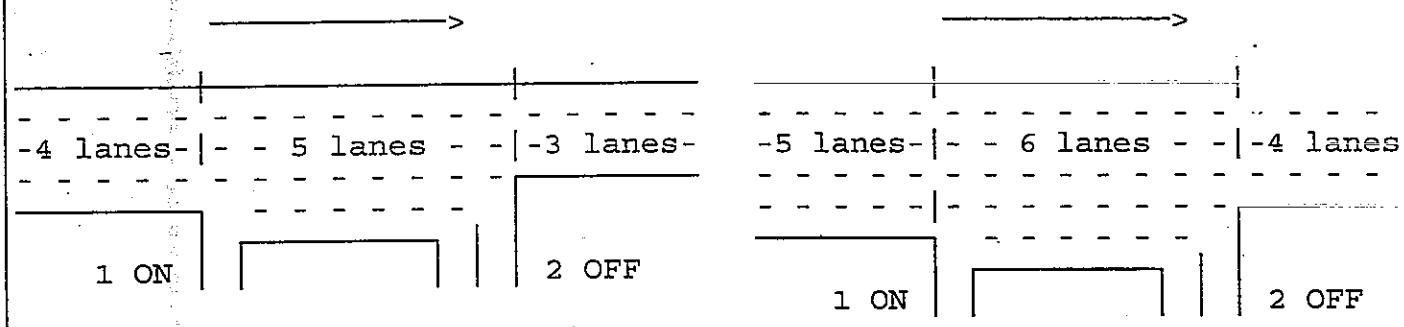


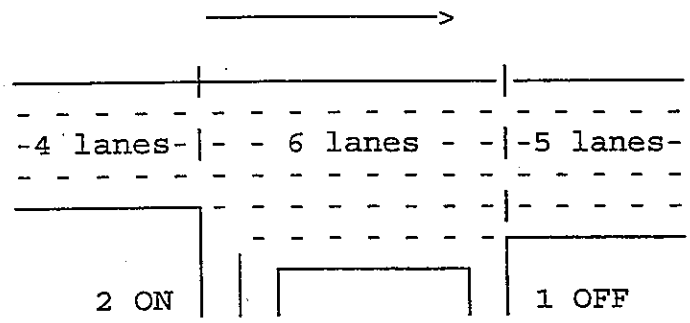
Type B Weaving Section with one lane on-ramp / two lane off-ramp



Type B Weaving Section with two lane on-ramp / two lane off-ramp



Type C Weaving Sections with one lane on-ramp / two lane off-ramp



Type C Weaving Section with two lane on-ramp / one lane off-ramp

Figure 2.1 Major Weaving sections analyzed by the FRELANE model.

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2.3.2 Simple Weaving section.

The simple weaving section analyzed by this model is shown in Figure 2.2. It consists of a one lane on-ramp connected by an auxiliary lane to a one lane off-ramp. There are five lanes in the analysis section. Note that the model evaluates only those lanes that are actually involved in the weaving movements.

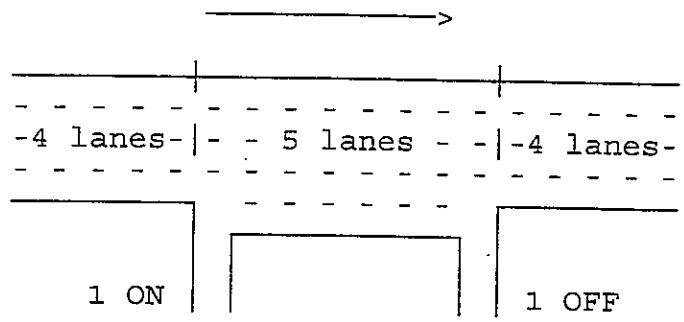
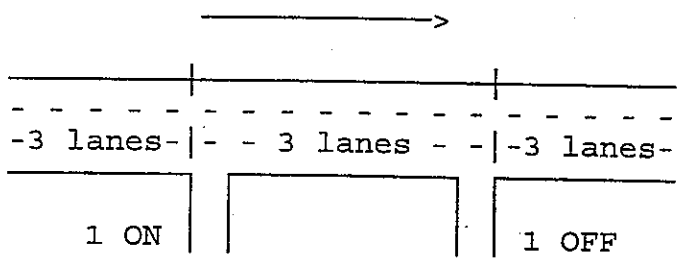


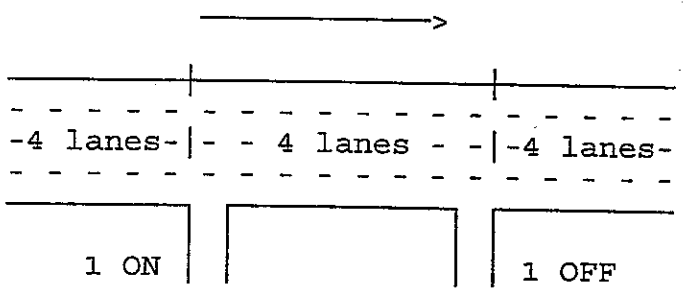
Figure 2.2 Simple Weaving section analyzed by the FRELANE model.

2.3.3 On-Off sections.

The On-Off sections analyzed by this model are shown in Figure 2.3. There is no auxiliary lane connecting the one lane on-ramp to the one lane off-ramp. The number of lanes may be either three or four. Note that the model evaluates only the two right-most lanes.



On-Off Section with three lanes



On-Off Section with four lanes

Figure 2.3 On-Off sections analyzed by the FRELANE model.

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2.3.4 Straight Pipe sections.

The Straight Pipe sections analyzed by this model are shown in Figure 2.4. The number of lanes may be either three or four. Note that the model evaluates only the two right-most lanes.

```
                    ------------->

 ----------|-----------------|----------
 -3 lanes- - - 3 lanes - - -3 lanes-
 - - - - -|- - - - - - - -|- - - - -
 ------------------------------------------

        Straight pipe section with three lanes

                    ------------->

 ----------|-----------------|----------
 - - - - - - - - - - - - - - - - - - -
 -4 lanes-|- - 4 lanes - -|-4 lanes-
 - - - - - - - - - - - - - - - - - - -
 ----------|-----------------|----------

        Straight pipe section with four lanes
```

Figure 2.4 Straight Pipe sections analyzed by the FRELANE model.

2.3.5 Isolated On section.

The Isolated On section analyzed by this model is shown in Figure 2.5. There is a one lane on-ramp and four lanes in the section. Note that the model evaluates only the two right-most lanes.

```
                    ------------->

 ----------|-----------------|----------
 - - - - - - - - - - - - - - - - - - -
 -4 lanes-|- - 4 lanes - -|-4 lanes-
 - - - - - - - - - - - - - - - - - - -
 ----------| |-----------------|----------
           | |
     1 ON  | |
```

Figure 2.5 Isolated On section analyzed by the FRELANE model.

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2.3.6 Isolated Off section.

The Isolated Off section analyzed by this model is shown in Figure 2.6. There is a one lane off-ramp and four lanes in the section. Note that the model evaluates only the two right-most lanes.

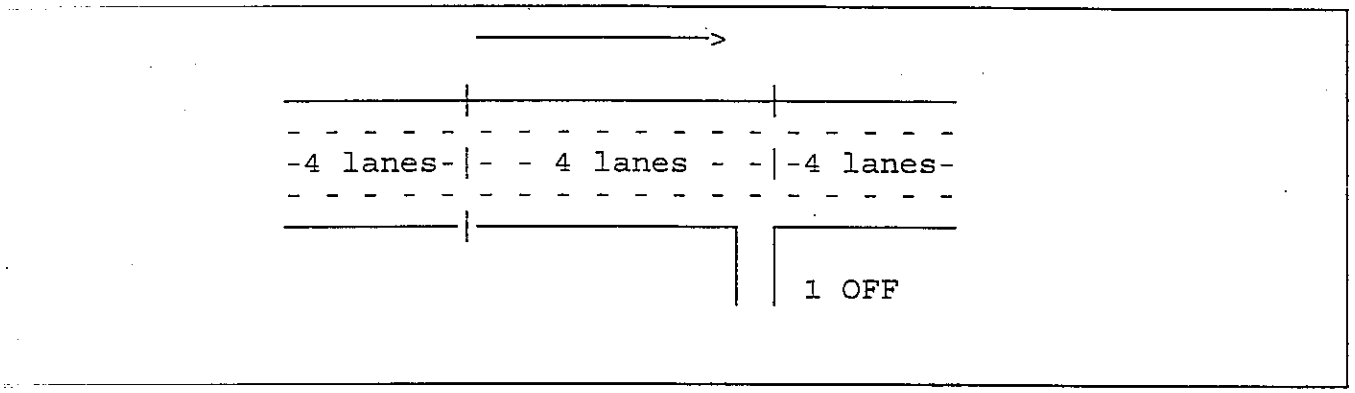

Figure 2.6 Isolated Off section analyzed by the FRELANE model.

2.3.7 On-On section.

The On-On section analyzed by this model is shown in Figure 2.7. There is a one lane on-ramp followed by a one lane on-ramp. There are four lanes in the section. Note that the model evaluates only the two right-most lanes.

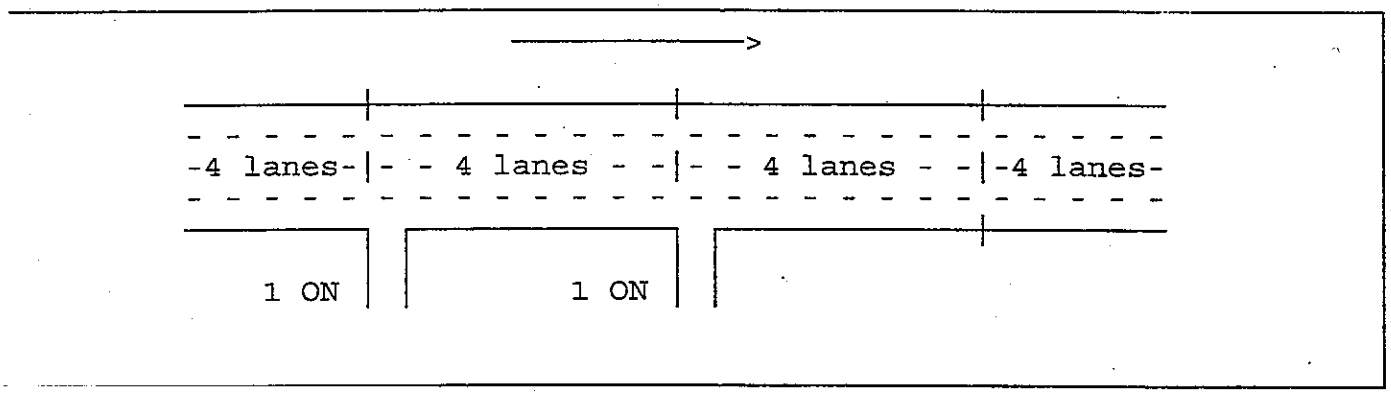

Figure 2.7 On-On section analyzed by the FRELANE model.

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2.3.8 Multiple Weave section.

The Multiple Weave section analyzed by this model is shown in Figure 2.8. There is a one lane on-ramp connected by an auxiliary lane to a one lane off-ramp followed by a one lane off-ramp. There are five lanes in the weaving section and four lanes in the following section. Note that the model evaluates the three right-most lanes in the weaving section and the two right-most lanes in the following section.

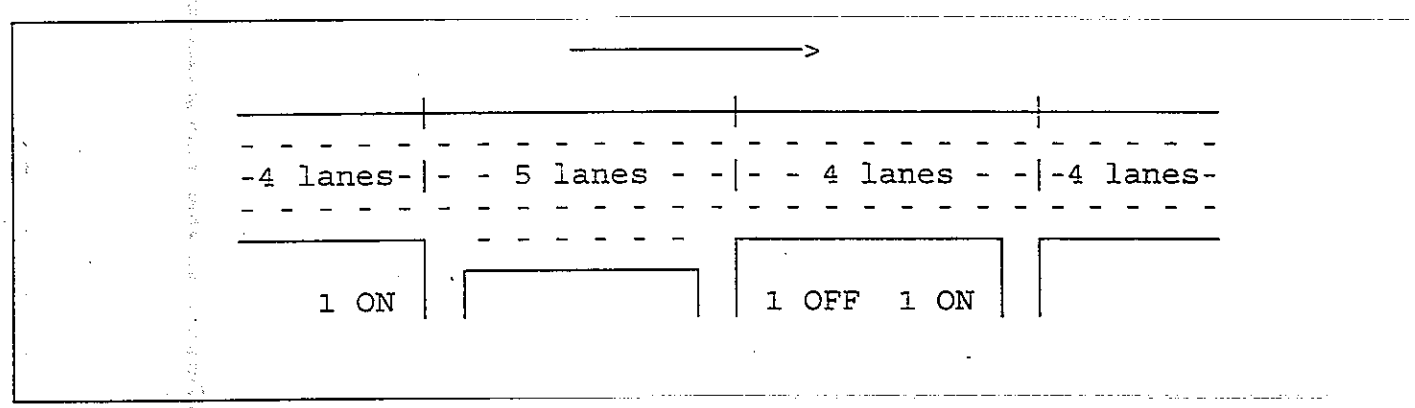

Figure 2.8 Multiple Weave section analyzed by the FRELANE model.

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2.4 Model assumptions and constraints.

The FRELANE model is based on the following assumptions:

(a) The analysis section is operating with under capacity conditions;

(b) The freeway design is "ideal" as to width of lane, shoulders, and other features;

(c) The freeway can be divided into subsections which can be considered as discrete homogeneous segments in terms of demands and capacities;

(d) All ramps must be on the right side of the freeway; and

(e) The analysis section is not influenced by ramps or lane adds/drops located upstream or downstream of the analysis section.

The user should be aware of the more significant constraints of the FRELANE program which are as follows:

(a) The maximum number of subsections is limited by the freeway segment type to either three or four;

(b) The model analyzes the freeway section for a one hour time period;

(c) The model can analyze eight specific freeway section types; and

(d) The current version of the model restricts the user to the design and demand values that were observed during the research upon which this model is based (1),(2),(3) or to the simulated extension of those empirical limits. (4)

Note that the previously developed FREWEV model has been completely incorporated within the FRELANE model. The assumptions and constraints have been slightly modified for FRELANE, in order to accommodate the additional seven segment types that have been add to the model.

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2.5 FRELANE input and output.

The input and output for the FRELANE model are shown in Figure 2.9. In the following general discussion, step numbers refer to numbers in Figure 2.9.

Steps 1-2. The model requires two major types of input data

1. The freeway design features include subsection lengths, subsection capacities, position and capacities of on- and off-ramps, number of lanes, and subsection grade.

2. The freeway demand pattern refers to the demand at the mainline origin, at each ramp, and at the mainline destination, as well as the ramp to ramp demand. Demand data also includes percent trucks and peak hour factors. Optional data in the form of user supplied truck factors and/or user-supplied freeway to freeway percentages can also be entered under special circumstances.

Steps 3-10. The model produces eight major types of output.

3. A screen display of the level of service for the analysis section which shows the LOS superimposed on the geometry of the section at up to 7 points for each lane in the conflict area.

4. A screen display of the table of point flows for the analysis section for each of the analyzed lanes.

5. A printed output of the table of point flows for the analysis section for each of the analyzed lanes.

6. A printed map of the point flows superimposed on the geometry of the analysis section. Point flows are printed at up to 7 points for each analyzed lane in the conflict area. The map is rotated 90 degrees to correspond to current diagrams used by Caltrans.

7. A screen display of the table of lane changing values for the analysis section for each of the analyzed lanes.

8. A printed output of the table of lane changing values for the analysis section for each of the analyzed lanes.

9. A printed map of design and demand input superimposed on the geometry of the freeway.

10. A printed map of level of service of the analysis section superimposed on the geometry of the freeway. The LOS is displayed for each analyzed lane at up to 7 points.

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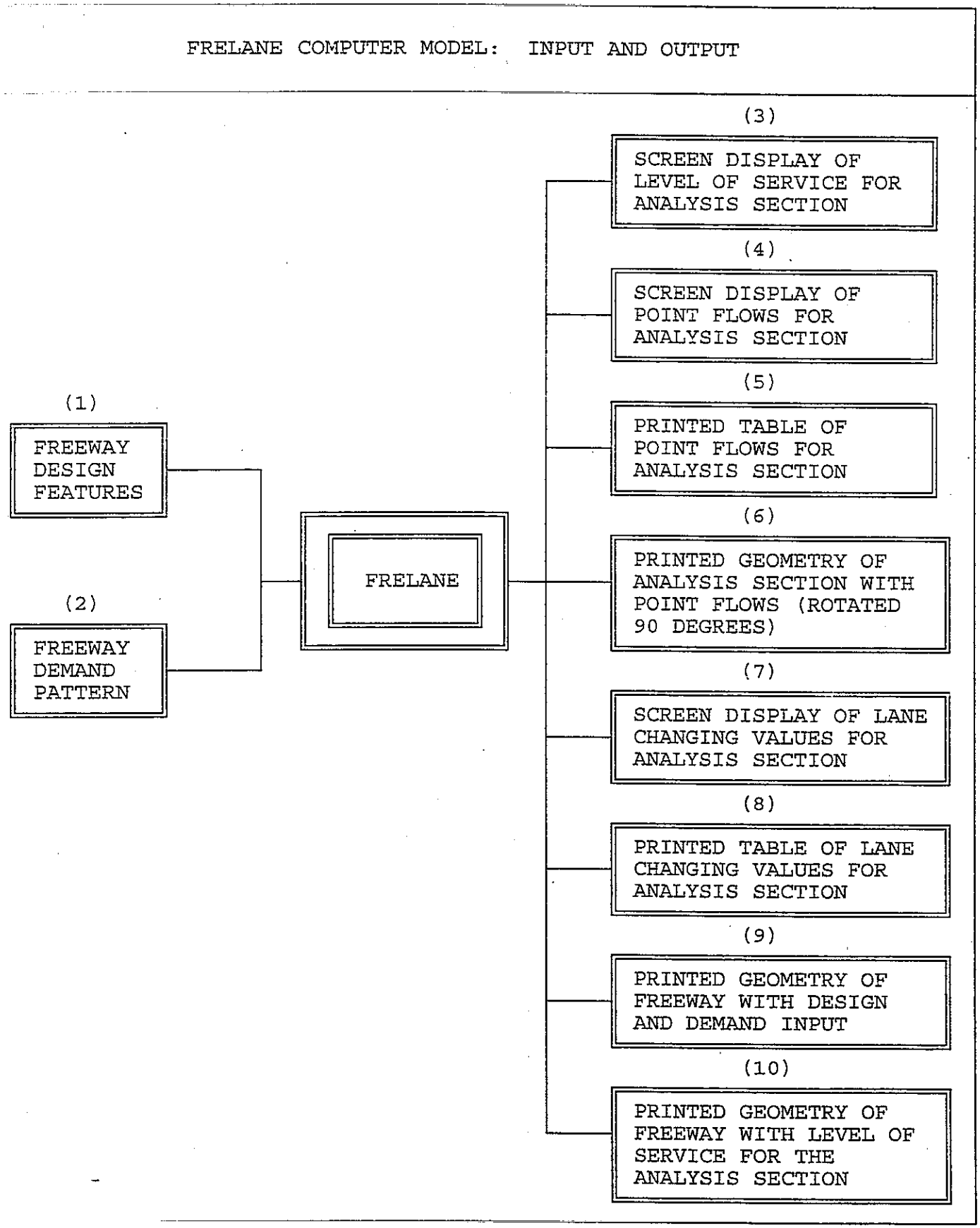

Figure 2.9 Input and output for the FRELANE model.

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2.6 Description of the FRELANE model.

The FRELANE model enables the user to control the operations of the program from a series of menus. The user is first presented with a SEGMENT SELECTION MENU from which one of a possible eight different freeway segments can be selected. After the segment type is selected, the MAIN MENU which is the same for each of the segment types appears on the screen. A schematic of the MAIN MENU is shown in Figure 2.10. The user can quit the MAIN MENU returning to the SEGMENT SELECTION MENU, start a new problem, save and retrieve data sets, add to or modify an existing data set, analyze the freeway section, and print maps of the freeway geometry with either the input data or the level of service included.

When starting a new problem the user will first be asked to identify the freeway by district, county, route, and post-mile. The user can then enter additional information that will describe the data set. This information will be stored as part of the data set so that the user will always be able to determine which freeway is defined in any particular data set. The user is then asked to pick the desired freeway configuration from those contained in the model for the selected freeway segment type. The user-selected geometry becomes the basis for graphic screens onto which the user enters the remaining design data.

The user enters demand data on graphic screens based on the selected geometry. The demands need to be provided for the mainline origin and each on-ramp and off-ramp. In addition, the ramp to ramp demand must be entered when appropriate. From these values the program computes the mainline destination demand. All of this input is added to the data set.

Optional data in the form of user supplied truck conversion factors or use-supplied freeway to freeway percentages may be added to the data set for special circumstances.

It is highly recommended that the user return to the MAIN MENU and save the data set to disk after all input has been entered. **If the data set is not saved before quitting the MAIN MENU, it will be lost and the user will not be able to retrieve it during another session.**

The user can then analyze the freeway section and view a screen display of the level of service, a table of the point flows, or a table of the lane changing values. In addition the user can get a printout of the point flow table, a printout of the analysis section with point flows, or a printout of the lane changing table.

Two different maps of the geometry of the freeway can be requested: one with the design and demand inputs, and the other with the level of service printed at up to 7 points for the lanes in the conflict area. A three subsection geometry map contains 60 lines of output and can be printed on one page, if the printer is set to 60 lines per page before running FRELANE.

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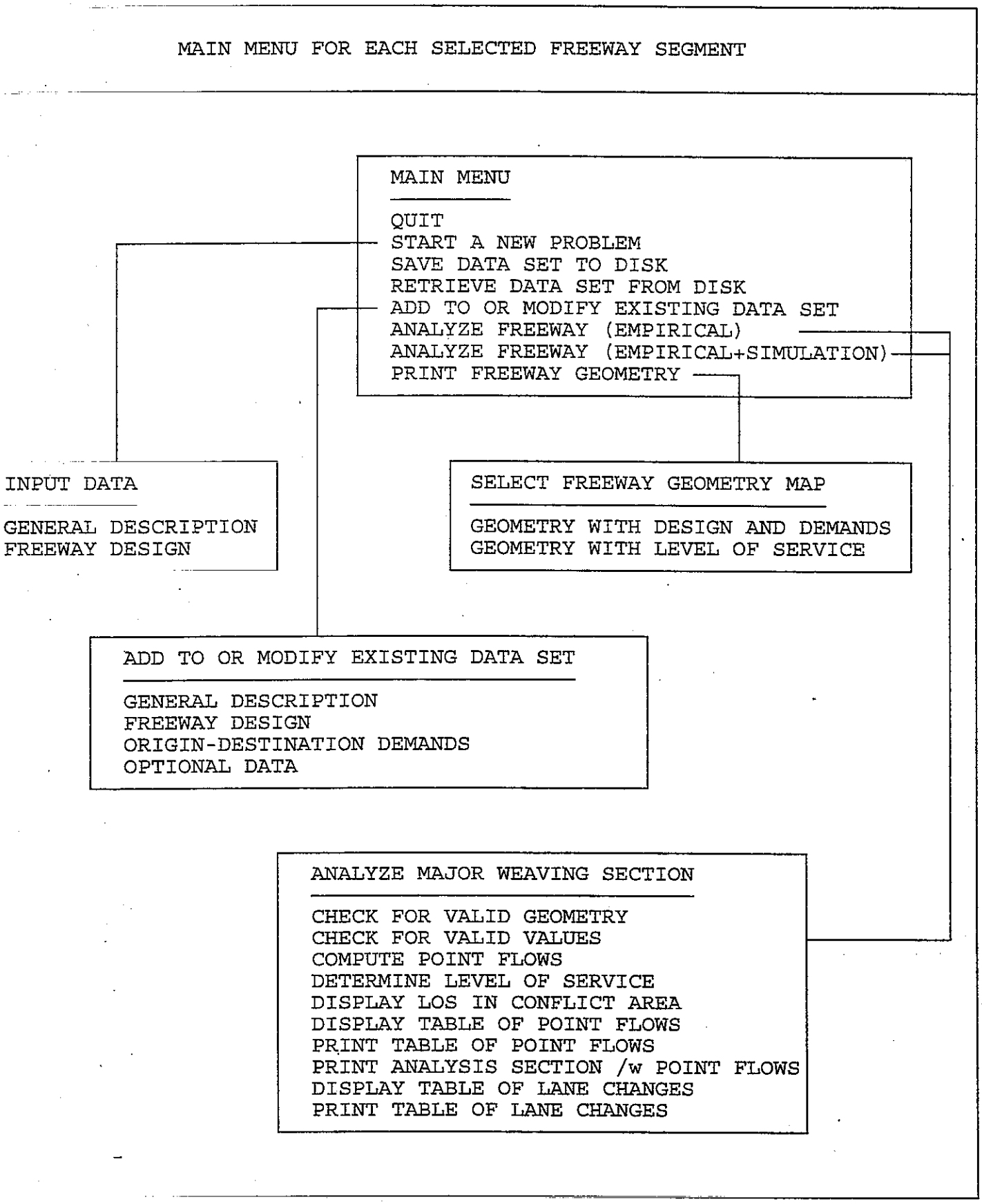

Fig. 2.10 Schematic of the MAIN MENU for each selected freeway segment.

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3. FREEWAY SECTION USED IN FRELANE SAMPLE SESSION

The segment of freeway used for the sample run described in Sections 4 and 5 is a three subsection Type B major weaving section. The freeway geometry is shown in Figure 3.1. Note that subsection 2 contains a one lane on-ramp followed by a two lane off-ramp, both on the right side of the freeway with capacities of 1500 and 3000 passenger-cars per hour respectively.

Subsections 1 and 3 each have four lanes and a length of 4000 feet; subsection 2 has five lanes and a length of 1460 feet. Each subsection of the freeway segment has a capacity of 2000 passenger-cars per hour per lane.

The demands for the mainline origin, mainline destination, the on-ramp, and off-ramp, as well as the ramp to ramp demand, are also shown in Figure 3.1. This sample segment is on level terrain with no trucks and no peak hour factor.

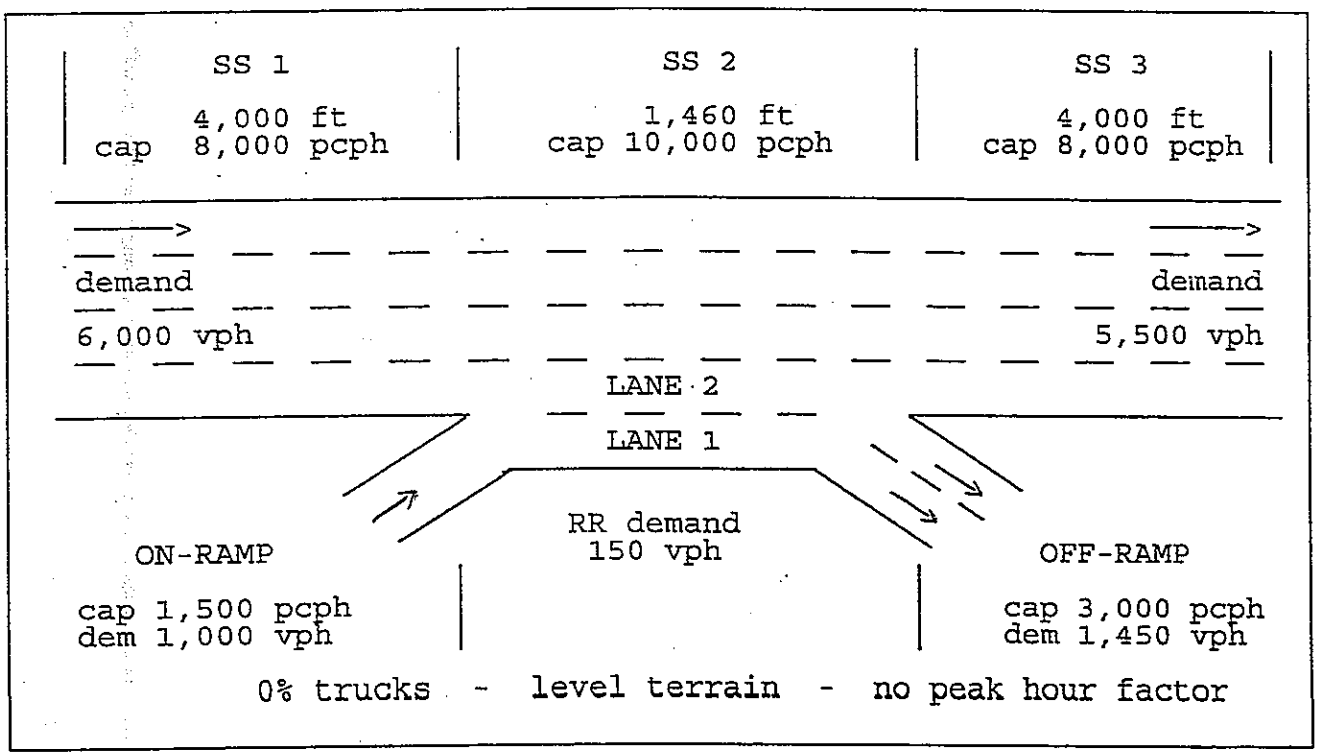

Figure 3.1 Freeway section used in sample session.

4. SAMPLE FRELANE SESSION.

Before starting this sample session, set your printer to Portrait mode (standard setting) and to 60 lines per page. If the printer is set to less than 60 lines per page, each freeway map will be split instead of being printed on one page. Consult the manual for the printer that is being used to determine how to change these settings. Additional information on printing can be found in Appendix Section 8.9.

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To begin the sample session type **FRELANE** at the DOS prompt. Three introductory screens of welcoming and introductory materials will appear as shown in the following three figures:

```
                    W E L C O M E

                          T O

FFFFFF   RRRRRRR   EEEEEE   LL        AAAA     NN     NN   EEEEEE
FF       RR    RR  EE       LL       AA  AA    NNNN   NN   EE
FF       RR    RR  EE       LL      AA    AA   NN NN  NN   EE
FFFFF    RRRRRRR   EEEE     LL      AAAAAAAA   NN  NN NN   EEEE
FF       RR  RR    EE       LL      AA    AA   NN   NNNN   EE
FF       RR   RR   EE       LL      AA    AA   NN    NNN   EE
FF       RR    RR  EEEEEE   LLLLLL  AA    AA   NN     NN   EEEEEE

            IIIIIIIIII    TTTTTTTTTTTT     SSSSSS
                II            TT         SS    SS
                II            TT         SS
I N S T I T U T E   O F   T R A N S P O R T A T I O N   S T U D I E S
                II            TT              SS
                II            TT         SS    SS
            IIIIIIIIII        TT          SSSSSS

U N I V E R S I T Y   O F   C A L I F O R N I A   A T   B E R K E L E Y

                    Press any key to continue
```

Figure 4.1 Introductory screen.

```
                I N   C O O P E R A T I O N   W I T H

 CCCCC    AAAA    LL   TTTTTTTTTT  RRRRRRR    AAAA    NN     NN   SSSSSS
CC       AA  AA   LL       TT     RR     RR   AA  AA   NNNN   NN  SS    SS
CC      AA    AA  LL       TT     RR     RR  AA    AA  NN NN  NN  SS
C A L I F O R N I A   D E P A R T M E N T   O F   T R A N S P O R T A T I O N
CC      AA    AA  LL       TT     RR    RR   AA    AA  NN   NNNN        SS
CC      AA    AA  LL       TT     RR     RR  AA    AA  NN    NNN  SS    SS
 CCCCC  AA    AA  LLLLLL   TT     RR     RR  AA    AA  NN     NN   SSSSSS

                              A N D

            FFFFFFFF  HH    HH   WW          WW    AAAA
            FF        HH    HH   WW          WW   AA  AA
            FF        HH    HH   WW    WW    WW  AA    AA
    F E D E R A L   H I G H W A Y   A D M I N I S T R A T I O N
            FF        HH    HH   WW  WW  WW  WW  AA    AA
            FF        HH    HH   WW WW    WW WW  AA    AA
            FF        HH    HH   WWW        WWW  AA    AA

                    Press any key to continue
```

Figure 4.2 Introductory screen.

```
                    F R E L A N E          Release 2.1    6/30/94

FRELANE is an analytical model for predicting traffic performance as a
function of demand and design for specific ** ISOLATED ** freeway segments.
FRELANE requires a math coprocessor.  Printouts of the freeway geometry
require a printer that has the IBM character set.

FRELANE operates in two modes:
  1) using only EMPIRICAL data to analyze the freeway segment or
  2) using EMPIRICAL and SIMULATION data for the analysis.

*****************************************************************************
WARNING :  A password is needed to activate SIMULATION data during analysis
or to enter USER-SUPPLIED FF PERCENTAGES. When using these options make sure
your volumes do not exceed the design criteria of your agency and that the
analysis produces results that are reasonable for under-capacity conditions.
*****************************************************************************
Copyright (c) 1993,1994 The Regents of the University of California

CALTRANS and the FHWA reserve a royalty-free, non-exclusive, and irrevocable
license to reproduce, publish or otherwise use, and to authorize others to
use, this work for Government purposes.

                    Press any key to continue
```

Figure 4.3 Introductory screen.

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4.1 Segment selection menu

Press any key to move through the introductory screens. The SEGMENT SELECTION MENU will then appear as shown in Figure 4.4.

```
                    FRELANE SEGMENT SELECTION MENU

The FRELANE model is designed to analyze traffic performance, including
estimation of lane flows at 500 foot intervals, number of lane changes over
500 foot intervals, and the resulting Level of Service, for the eight types of
ISOLATED freeway segments listed below.  A schematic help screen that displays
the geometries that FRELANE can analyze is available for each type of segment
by pressing the associated F key. (e.g. For a Major Weave schematic press F1.)
-------------------------------------------------------------------------------

                  0  -->  Quit FRELANE
                  1  -->  Major Weave
                  2  -->  Simple Weave with aux lane (TPF or Level D Method)
                  3  -->  On-off with no aux lane
                  4  -->  Straight Pipe
                  5  -->  Isolated On
                  6  -->  Isolated Off
                  7  -->  On-on
                  8  -->  Multiple weave

-------------------------------------------------------------------------------
 SEGMENTS ASSUMED FREE FROM INFLUENCE OF NEIGHBORING RAMPS OR LANE ADDS/DROPS
-------------------------------------------------------------------------------
                           Choose your option:
```

Figure 4.4 SEGMENT SELECTION MENU

It should be noted again that the freeway segments are assumed to be free of all influence from neighboring ramps or neighboring lane adds/drops.

To view the geometry of all Major Weaves that can be analyzed by FRELANE press F1. Select the Major Weave segment type by pressing 1.

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4.2 Main menu.

After Major Weaves have been selected, the MAIN MENU will appear as shown in Figure 4.5.

```
                    MAIN MENU                    Major Weave
-----------------------------------------------------
 0  --> Quit MAIN MENU
 1  --> Start a new problem
 2  --> Save data set to disk file
 3  --> Retrieve data set from  disk file
 4  --> Modify data set
 5  --> Analyze freeway: restricted to EMPIRICAL data
 6  --> Analyze freeway: extended by SIMULATION data
 7  --> Print freeway geometry with input or LOS analysis
-----------------------------------------------------
            Choose your option:
```

Figure 4.5 MAIN MENU

4.3 Starting a new problem.

Select option 1 to start a new problem.

4.4 General description of data set.

The general description screen will appear whenever a new problem is started. Type **F1** to edit the screen and thus enter the description of the new data set. The **Backspace** key can be used to correct typing mistakes. Accept each line of text and go on to the next, by pressing the **Enter** key. **F1** can be typed again from the option line if any information needs to be corrected. Remember that holding down the **Ctrl** key while pressing the **Backspace** key will return the cursor to the option line. Figure 4.6 shows the general description for the sample data set. When the general description is completed, type **F10** from the option line to go on to the next screen.

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```
                    GENERAL DESCRIPTION                Major Weave

  Project ID  district-
  county-route-postmile : 4-ALA-80-5.1/6.9

  Direction             : WB

  Time of data          : AM PEAK

  Date of data          : 12/5/90

  Date of investigation : 6/25/93

  Investigator          : ITS

  Comments              : SAMPLE DATA SET FOR
                        : FRELANE USER'S GUIDE

  File name    :

  FRELANE VERSION 2

F1: EDIT SCREEN    F10: EXIT SCREEN      Choose your option:
```

Figure 4.6 General description for the sample data set.

4.5 Design of subsection geometry.

The selection screen for the specific type of Major Weave will then appear as shown in Figure 4.7. The segment of freeway used for this run is a Type B with a one lane on-ramp and a two lane off-ramp. This type is selected by pressing 1.

```
                    TYPE B MAJOR WEAVES
1 --> 5 lane weaving section          2 --> 5 lane weaving section
-4 lanes-|- - 5 lanes - -|-4 lanes-   -3 lanes-|- - 5 lanes - -|-4 lanes-
1 ON                 2 OFF            2 ON                 2 OFF
                    TYPE C MAJOR WEAVES
3 --> 6 lane weaving section
4 --> 5 lane weaving section          5 --> 6 lane weaving section
-5 lanes- - - 6 lanes - - -4 lanes-   -4 lanes- - - 6 lanes - - -5 lanes-
-4 lanes-|- - 5 lanes - -|-3 lanes-   - - - - -|- - - - - - - -|- - - - -
1 ON                 2 OFF            2 ON                 1 OFF
        0: (exit)  1 - 5:   Choose your option:
```

Figure 4.7 Major Weaves selection screen.

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When the Major Weaving section type is selected the program automatically creates the geometry for that type. The first subsection of a three subsection freeway segment will then appear. It will contain default values for each entry, which may be accepted as is or changed. In order to change any of the values type **F1**. Type a new value or press **ENTER** to accept the default.

A description of the length of subsection measurement is discussed in Appendix Section 8.1. A help screen which list the valid ranges for subsection lengths that can be analyzed by the program can be viewed by typing **F2**. The screen should now appear as shown in Figure 4.8.

VALID INPUT RANGES: TYPE B WEAVING SECTION
ONE LANE ON-RAMP / TWO LANE OFF-RAMP 5 LANES IN WEAVING SECTION

	FR+RF <= 2000		2000 < FR+RF FR+RF <= 2300		FR+RF > 2300	
EMPIRICAL ANALYSIS	MIN	MAX	MIN	MAX	MIN	MAX
LENGTH OF SS1	10	32767	10	32767	10	32767
LENGTH OF SS2	1000	1500	1000	1500	1250	1500
LENGTH OF SS3	10	32767	10	32767	10	32767
SIMULATION ANALYSIS	MIN	MAX	MIN	MAX	MIN	MAX
LENGTH OF SS1	10	32767	10	32767	10	32767
LENGTH OF SS2	750	2500	750	2500	750	2500
LENGTH OF SS3	10	32767	10	32767	10	32767

Press any key to continue

Figure 4.8 Help screen of valid input ranges.

Press any key to return to the previous screen which displays the first subsection for the sample run. Type **F1** to edit the screen and thus enter the actual values for the remaining design parameters. Notice that the general per lane ramp capacity default, which the user can specify, will apply to all ramps; the user, however, may change any of the ramp capacity values if desired. The description of the subsection must necessarily be short, but should be as complete as possible. The length of the subsection should be entered in feet, the capacity in passenger cars per hour of through traffic. The subsection grade needs be entered so that the demands which are entered as vehicles per hour can be accurately converted by the model to passenger cars per hour. The grade should be specified as a value between -6.0% and +6.0% where 0.0% indicates a flat terrain. The geometry and design for subsection 1 of the sample data is shown in Figure 4.9.

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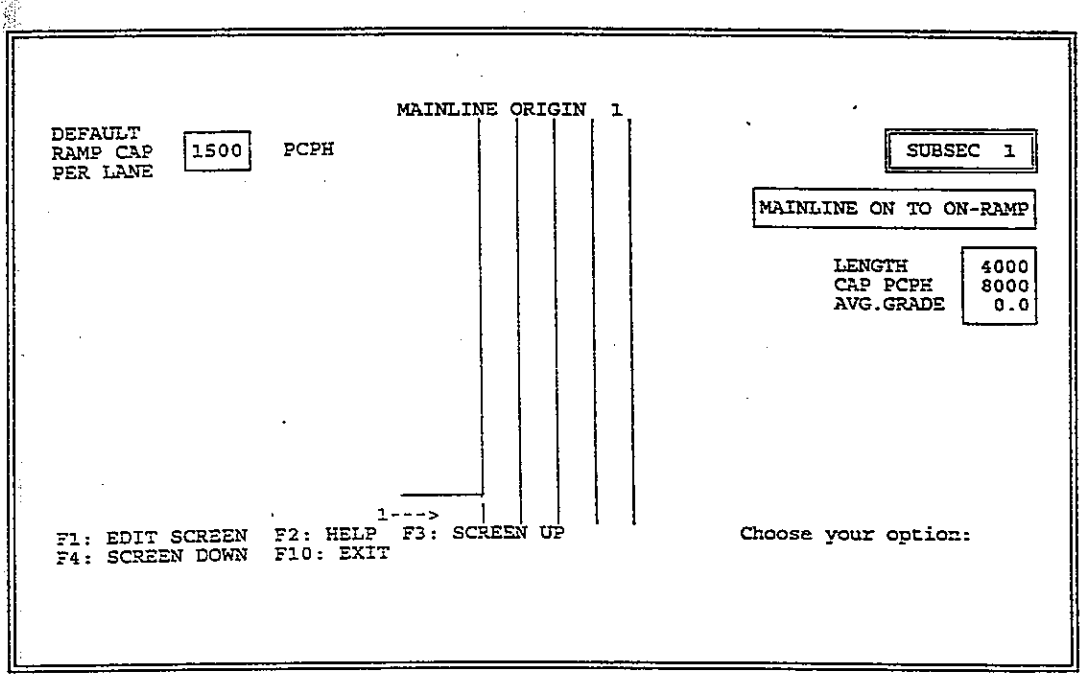

Figure 4.9 Geometry and design for subsection 1.

Design data for the subsequent subsections are added to the data set by pressing **F4** from the option line in order to display the next subsection. The same procedure is followed as for the first subsection. Note that if a subsection has an origin or destination, the appropriate multiple of the default per lane ramp capacity that was entered on the first subsection screen is displayed as the ramp capacity. The user may change any ramp capacity.

The user may scroll through the subsections by pressing **F3** to see the previous subsection or **F4** to see the next subsection.

The design geometry for the entire sample run can be seen in the printout of the freeway geometry which is shown in Figure 4.10. Details on how to request such a printout will be given in Section 4.11.

When all the subsections have been entered, press **F10** to leave the design section of FRELANE.

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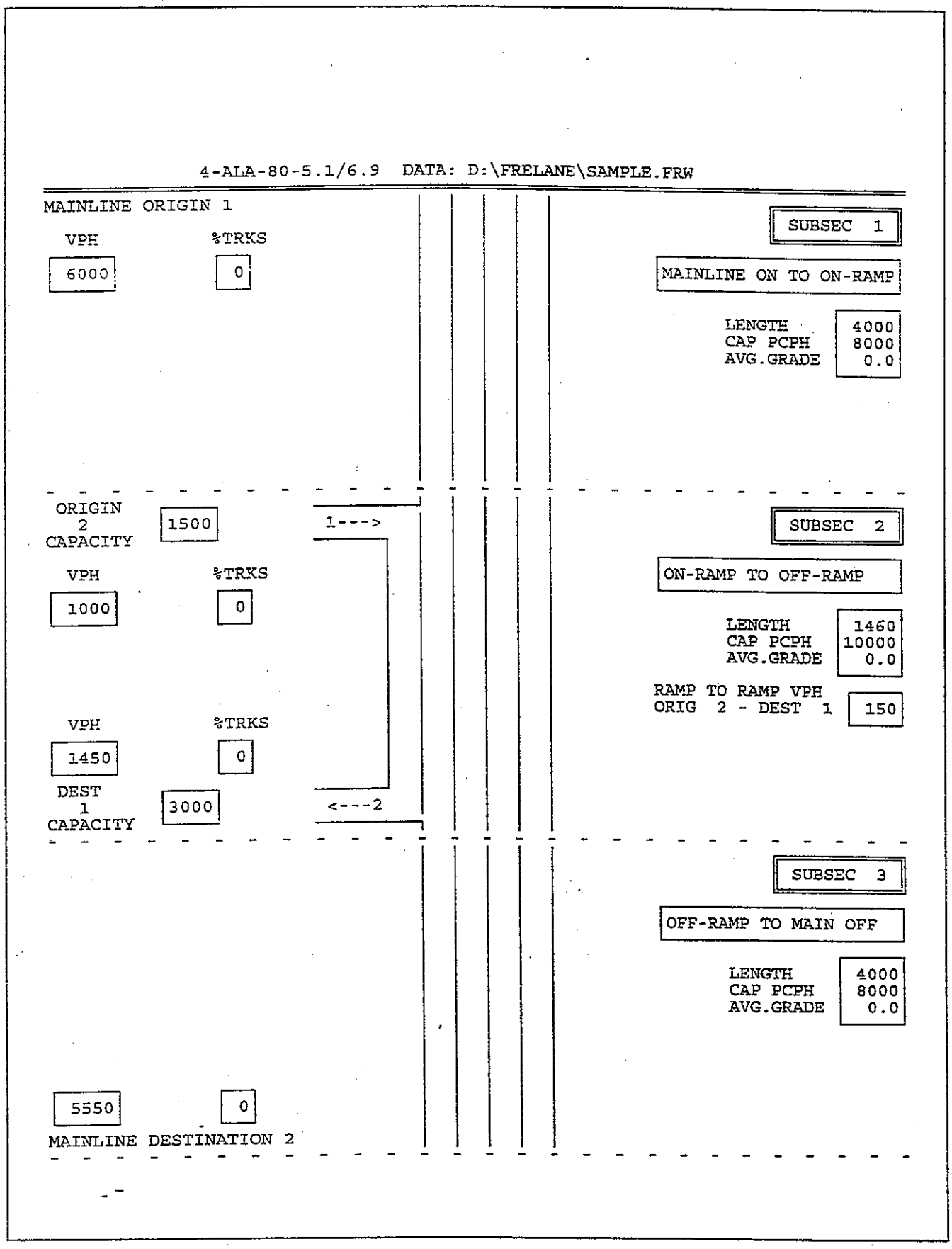

Figure 4.10 Freeway geometry with design and demand inputs.

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4.6 Modification menu.

The MODIFICATION MENU will appear on the screen as shown in Figure 4.11.

```
                                                    Major Weave

          MODIFICATION MENU

     0  --> Return to MAIN MENU

     1  --> Modify general description

     2  --> Modify subsection variables
            for given segment type

     3  --> Input/modify freeway demands

     4  --> Input/modify optional data



              Choose your option:
```

Figure 4.11 MODIFICATION MENU

4.7 Demand data.

To enter the demand data, select option 3 from the MODIFICATION MENU, shown previously in Figure 4.11. The FREEWAY DEMAND DATA screen will appear with default values. Press **F1** to edit the screen.

The user must enter demands as vehicles per hour. The user will also be asked to enter a default value for the percent trucks at each origin and at each destination. The model will convert vehicles per hour to passenger car equivalents based on percent trucks, subsection grade, and length of grade (see Appendix Section 8.2).

If the peak hour factors option is selected, the user will be asked to supply a default value for the peak hour factor with a value between .6 and 1.0. See Appendix Section 8.3 for a detailed description of peak hour factors.

The user may also specify the hour for which the demands were collected. This value is only informational and does not appear in any other context.

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The demand data screen for the sample run is shown in Figure 4.12. The demands will be entered as vehicles per hour with a default truck percent of zero. Peak hour factors are not selected. The demand represents traffic at 8:00 AM. Press **F10** to go on to the next screen.

```
                    FREEWAY DEMAND DATA

Demand data is entered as vehicles per hour (vph)

     Default percent trucks     :  0

Peak hour factors               : 0

     0:  do not use peak hour factors
     1:  use peak hour factors


          Press  "Ctrl <--BkSp"  to go to "Choose your option: " prompt.

F1: EDIT SCREEN  F2: HELP  F10:  EXIT                Choose your option:
```

Figure 4.12 FREEWAY DEMAND DATA screen

The geometry for the first subsection will be displayed on the screen. The defaults for the demands will always need to be changed to represent the data for a particular freeway. Press **F1** to edit the screen. Note that the user-supplied default percent trucks at each origin and destination may be changed. Similarly, if peak hour factors have been selected, the user supplied default peak hour factor may be changed at each origin and at each destination.

A help screen which list the valid volume ranges for this specific geometry can be viewed by typing **F2**. The screen should now appear as shown in Figure 4.13. Press any key to display a similar table of valid input ranges for simulation analysis (not shown). Then press any key to return to the previous geometry screen.

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VALID INPUT RANGES : TYPE B WEAVING SECTION
ONE LANE ON-RAMP / TWO LANE OFF-RAMP 5 LANES IN WEAVING SECTION

	FR+RF <= 2000		2000 < FR+RF FR+RF <= 2300		FR+RF > 2300	
EMPIRICAL ANALYSIS	MIN	MAX	MIN	MAX	MIN	MAX
VOLUME OF SS1	3148	8249*	4890	6973*	6298	8799*
ON-RAMP VOL	177	1272*	205	1373*	249	450*
OFF-RAMP VOL	505	2001*	787	2237*	2226	2791*
VOLUME OF SS2	3521	9372*	5269	7792*	6548	9123*
VOLUME OF SS3	2689	8793*	3280	7005*	4322	6424*
FF VOLUME	2405	7670	3090	5691	4155	6299
FR VOLUME	445	1855	728	2084	2143	2603
RF VOLUME	59	1123	77	1314	125	320
RR VOLUME	0	218	59	202	71	216
WEAVING VOL FR+RF	758	1997	2017	2222	2310	2766

* MAXIMUM VALUE WILL BE REPLACED BY USER-SUPPLIED CAPACITY WHEN THAT CAPACITY IS LESS THAN THIS MAXIMUM

Press any key to continue

Figure 4.13 Help screen of valid input ranges.

Scroll through the rest of the subsections that have an origin and/or a destination in order to enter the demands for each. Note that the peak hour factor for the ramp to ramp demand is computed by the model as are all values for the mainline destination. The screen for subsection 2 of the sample run should appear as shown in Figure 4.14. The demands for the entire sample run can be seen in the printout of the freeway geometry which was shown in Figure 4.10.

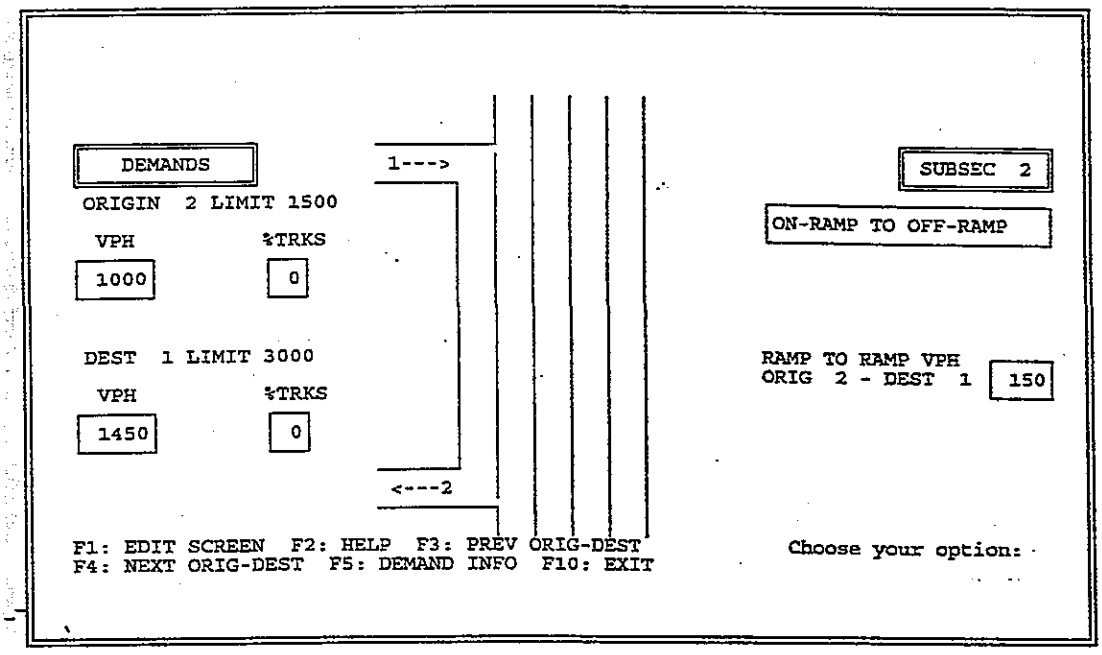

Figure 4.14 Demands for subsection 2 of sample data.

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Press F10 to return to the MODIFICATION MENU as shown in Figure 4.11.

4.8 Optional data.

The user can enter optional data in the form of user-supplied truck conversion factors. However, this option should be used only when it is known that special circumstances of the weaving section would cause the embedded truck conversion factors to be inappropriate. See Appendix Section 8.2 for the tables of truck conversion factors that are embedded in the program and a discussion of how they are used.

Additional optional data consists of user-supplied freeway to freeway percentages (appropriate only for Major Weaves and the Level D analysis of Simple Weaves). A discussion of user-supplied freeway to freeway percentages can be found in Appendix Section 8.8.

4.9 Saving the data set.

All the basic data for the freeway section for the sample session has been entered. Select option 0 to return to the MAIN MENU.

The newly created data set will be lost if you quit the MAIN MENU before saving it. To save the data set, select 2 from the MAIN MENU. The program will prompt you for the name of the data set. Type up to eight alphanumeric characters that will uniquely identify this data set. All data sets created by the FRELANE program will have an extension specific to the type of segment automatically appended to the file name that is typed. The extensions for the eight freeway segment types are listed in Appendix Section 8.10. The sample data set was saved as shown in Figure 4.15.

```
Enter new disk file name for this data set
(Return key will cancel save command)
: SAMPLE
```

Figure 4.15 Saving the sample data set.

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4.10 Analyzing the freeway section.

In order to analyze the freeway section, select option 5 or 6 from the MAIN MENU as previously shown in Figure 4.5. Option 5 analyzes the weaving section only if it has the same design and demand features as observed for the empirical data. Option 6 extends analysis to sections with a wider range of design and demand features by using data that was generated through simulation runs. (See Appendix Section 8.4 for a listing of valid input variable ranges for the various freeway segments.)

If option 6 is selected, the user will be asked for a password. Although extreme care was taken during generation of the simulation data (4) to assure that the data limits were not extended beyond reasonable results, the password helps to assure that more expert judgement be applied to the analyses derived from simulated data. In addition, a warning message appears if the average per lane volume over all lanes exceeds 1900 pcph and/or the average per lane volume over all lanes in the conflict area for any analysis point exceeds 1900 pcph.

When either option 5 or option 6 is selected, the first subsection of the freeway will appear as shown in Figure 4.16.

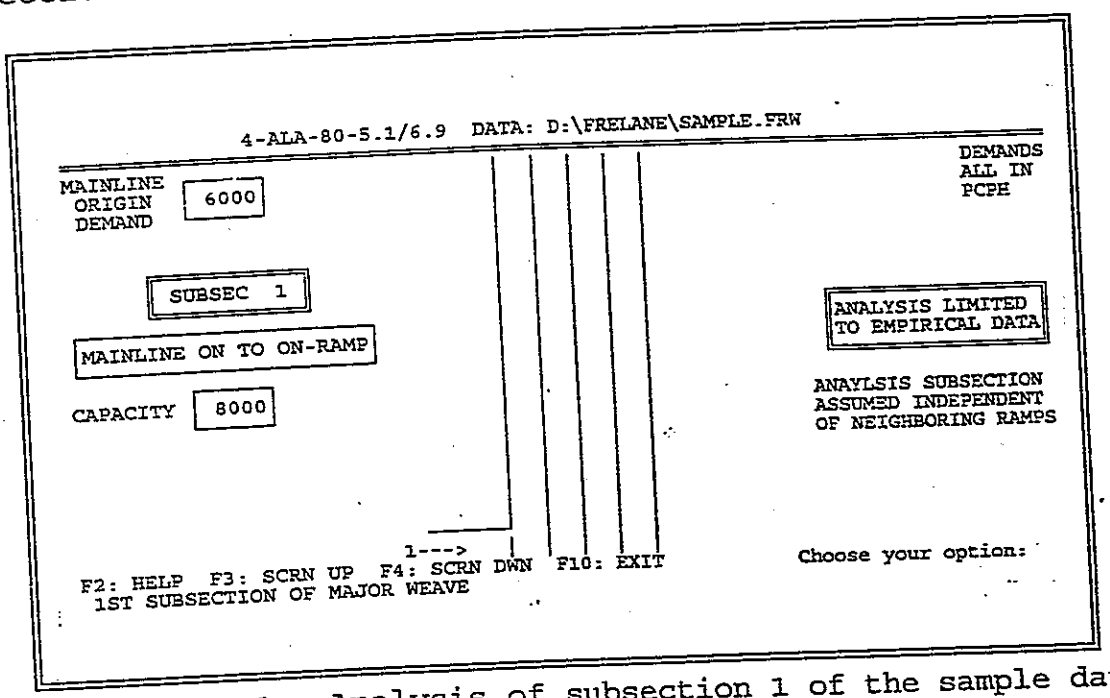

Figure 4.16 Analysis of subsection 1 of the sample data.

Note that a description of the type of subsection appears below the option line. In this case, subsection 1 is perceived as a "straight pipe" section as well as the first subsection of a recognizable major weave that can be analyzed by the program.

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Press **F4** to scroll to the next subsection. The screen should now appear as in Figure 4.17.

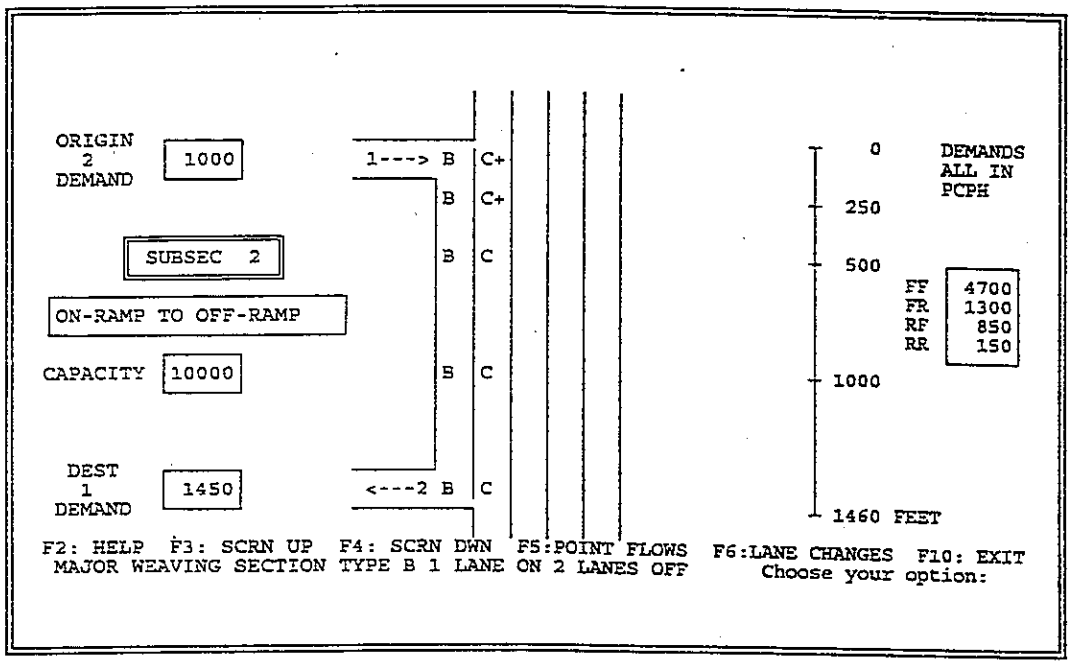

Figure 4.17 Analysis of subsection 2 of the sample data.

The program displays the type of Major Weave that is being analyzed below the option line and the Level of Service at points on each of the right-side two lanes. The level of service ranges are listed in Appendix Section 8.5 and can be viewed from a help screen by pressing **F2**. Press any key to return to the analysis screen of Figure 4.17.

The table of point flow values can be viewed by pressing **F5**. From the display of the table of point flows, the point flows can be printed as a table or can be printed superimposed on a schematic of the weaving section which is rotated 90 degrees. The rotated map requires that the printer be set to Landscape mode and 45 lines per page. If the printer cannot be set from the front panel, the schematics can be written to a file and printed from DOS after exiting FRELANE. Additional printing information is contained in Appendix Section 8.9. Both of these printouts for the sample freeway section can be found in Section 5. Press **F10** to return to the analysis screen of Figure 4.17.

The table of lane changing values can be view by pressing **F6** from the analysis screen. The table of lane changing values can be printed from the display of this table. A printout of the table of lane changing values for the sample freeway can be found in Section 5. Press **F10** to return to the analysis screen of Figure 4.17.

--The next subsection of the freeway can be viewed by pressing **F4**. To scroll to a previous subsection, press **F3**.

The program checks the input variables before calculating the LOS of service. If any of these variables are out of range

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for the particular weaving section the screen shown in Figure 4.18 will appear.

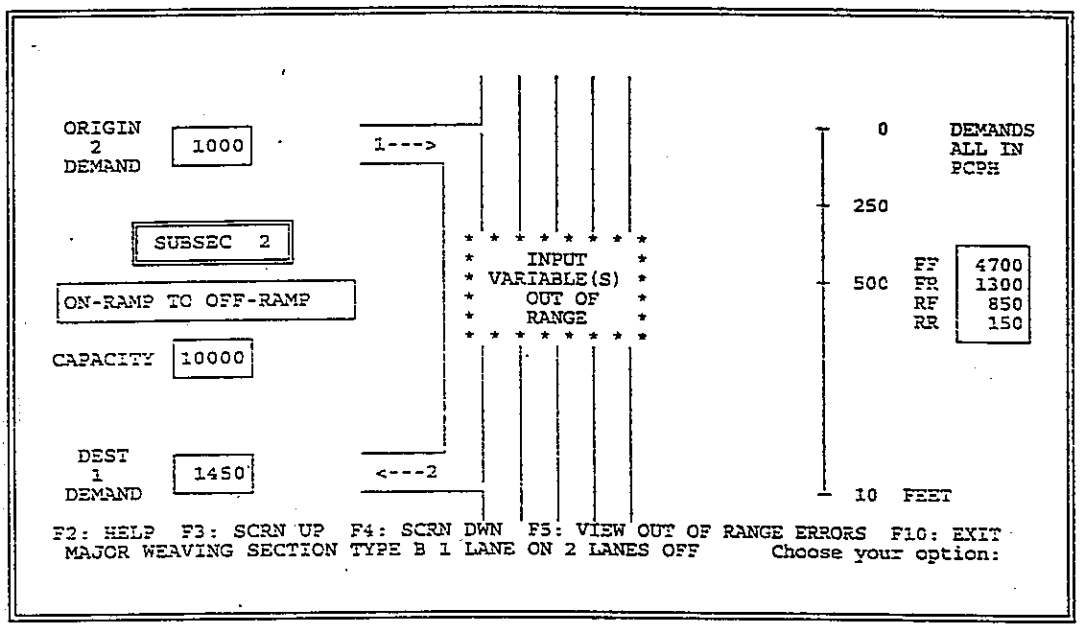

Figure 4.18 Analysis of major weave: out of range input.

To view a listing of input variables that are out of range press F5. Remember these ranges are somewhat restrictive for empirical data and are broader when using both empirical and simulation data. A complete listing of valid ranges for each segment type for empirical analysis is included in Appendix Section 8.4. The valid ranges for empirical and simulation analysis conditions are also included.

If the program does not recognize the freeway segment as one which it can analyze, the screen shown in Figure 4.19 will appear.

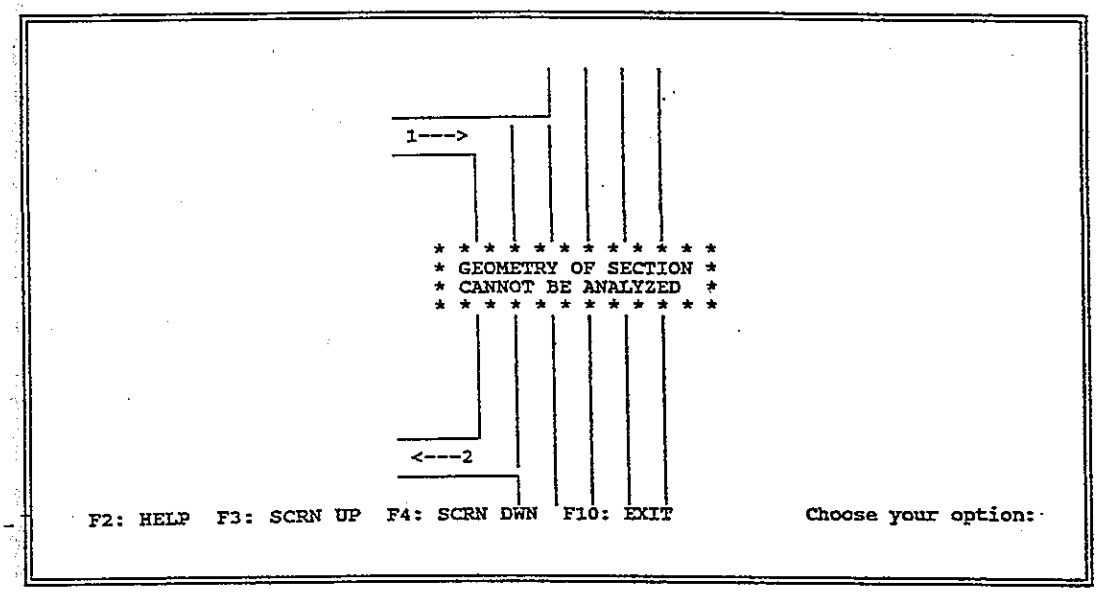

Figure 4.19 Analysis of non-valid freeway section.

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If there is no empirical data for the particular volume conditions of an otherwise acceptable geometric configuration a screen such as shown in Figure 4.20 will appear.

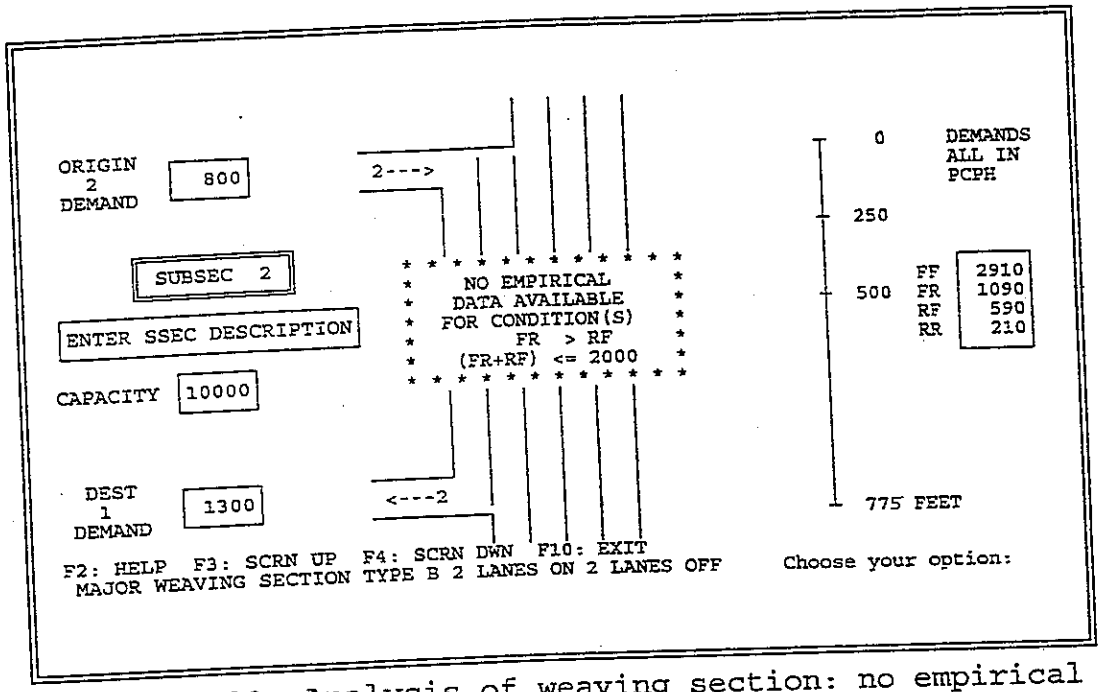

Figure 4.20 Analysis of weaving section: no empirical data.

In this example, the message indicates that for a Type B weaving section with a 2 lane on ramp and a 2 lane off ramp there is no empirical data for situations when FR (the freeway to ramp volume) is greater than RF (the ramp to freeway volume) and FR+RF, (the weaving volume) is less than or equal to 2000 passenger cars per hour. Appendix Section 8.4 indicates for which conditions there is no empirical data.

4.11 Printing the freeway geometry.

To get a printout of the freeway geometry, select option 7 from the MAIN MENU, shown previously in Figure 4.5. The FREEWAY MAP MENU will appear as shown in Figure 4.21. Select option 1 from the FREEWAY MAP MENU to get a printout of the freeway geometry with the input design and demand values as previously shown in Figure 4.10 and as will be shown in Section 5. Select option 2 from the FREEWAY MAP MENU to get a printout of the freeway geometry with the LOS output as will be shown in Section 5. Note that there is no need to request an analysis of the freeway from the MAIN MENU before selecting a freeway geometry map with LOS, because the model will analyze the section for LOS as it prints the map.

If the printer is set to 60 lines per page, these maps will each fit on one page. Your printer manual should be consulted to determine how to change any printer settings.

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```
                    FREEWAY MAP MENU

Printer should be in PORTRAIT mode set to print at 60 lines per page

        0  --> Return to MAIN MENU.
        1  --> Print geometry with INPUT.
        2  --> Print geometry with LOS ANALYSIS: limited to EMPIRICAL data
        3  --> Print geometry with LOS ANALYSIS: extended by SIMULATION

                    Choose your option:
```

Figure 4.21 FREEWAY MAP MENU

4.12 Retrieving an old data set.

Frequently, the user will want to either make another run using an old data set as is, or make some modifications to an old data set before running it again. In order to do this the user must first retrieve the old data set by selecting 3 from the MAIN MENU as shown previously in Figure 4.5. The user can type in the name of the data set to be retrieved as for the sample set shown in Figure 4.22.

```
Enter name of data set disk file to read
(Return key will list existing data sets)
: SAMPLE
```

Figure 4.22 Retrieving an old data set.

Instead of typing the name of the data set to be retrieved, the user can press return and FRELANE will display all data sets that have been created during past runs that have the Major Weave extension of .frw. See Appendix Section 8.10 for a listing of the extensions for the eight freeway segment types. To retrieve one of the listed data sets, move the highlight to the desired data file name by using the arrow keys and then press return. Note that the user can move to other directories on the same drive to search for appropriate data sets. If no data set is to be retrieved from the list, press esc.

If the retrieved data set is modified it should be saved again or the new data will be lost when the user quits the MAIN MENU. Select option 2 from the MAIN MENU and the message shown in Figure 4.23 will appear.

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```
Overwrite existing data set disk file  <D:\FRELANE\SAMPLE.FRW>? Y/N:
```

Figure 4.23 Saving a retrieved data set.

The user can either type **Y** to overwrite the old SAMPLE.FRW data set with the revised version that has just been created, or if both versions of the data set are to be kept, the user should type **N** and then enter a different name for the new data set when prompted.

5. SAMPLE OUTPUT

The program produces three output screen displays:

- a geometric representation of the freeway with the LOS for the analysis section,
- a table of point flows for the analysis section,
- and a table of lane changing values for the analysis section.

The user can get a printed copy of these screens, as well as any other screen, by doing a screen dump (Shift PrtSc).

The program also produces printed output which the user can request:

- the table of point flows for the analysis section, Figure 5.1,
- point flows superimposed on a schematic of the analysis section rotated 90 degrees, Figure 5.2,
- the table of lane changing values for the analysis section, Figure 5.3,
- a geometry map with design and demand inputs, Figure 5.4, and
- a geometry map with Level of Service output, Figure 5.5.

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4-ALA-80-5.1/6.9 DATA: D:\FRELANE\SAMPLE.FRW

MAJOR WEAVING SECTION TYPE B 1 LANE ON 2 LANES OFF: LIMITED TO EMPIRICAL DATA

SUBSEC 2 FF 4700 FR 1300 RF 850 RR 150

POINT FLOW TABLE

LOCATION (FEET)	MOVEMENT	LANE1 (PCPH)	LANE2 (PCPH)
0	FF	0	461
	FR	56	936
	RF	845	5
	RR	150	0
	TOTAL	1051	1402
250	FF	0	442
	FR	437	650
	RF	584	266
	RR	143	7
	TOTAL	1164	1365
500	FF	0	442
	FR	669	506
	RF	217	606
	RR	138	12
	TOTAL	1024	1566
1000	FF	0	437
	FR	817	439
	RF	16	658
	RR	131	19
	TOTAL	964	1553
1460	FF	0	454
	FR	860	439
	RF	0	589
	RR	131	19
	TOTAL	991	1501

Figure 5.1 Point flows for the sample major weaving section.

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4-ALA-80-5.1/6.9	ON-RAMP TO OFF-RAMP	MAJOR WEAVING SECTION TYPE B (1 ON - 2 OFF)

	0	250	500	1000	1460	
FF	461	442	442	437	454	LANE 2
FR	936	650	506	439	439	
RF	5	266	606	658	589	
RR	0	7	12	19	19	
TOT	1402	1365	1566	1553	1501	

FF	0	0	0	0	0	LANE 1
FR	56	437	669	817	860	
RF	845	584	217	16	0	
RR	150	143	138	131	131	
TOT	1051	1164	1024	964	991	

1000 ON

1450 OFF

MOVEMENTS ACROSS ALL LANES

FF	4700
FR	1300
RF	850
RR	150
TOTAL	7000

ANALYSIS LIMITED TO EMPIRICAL DATA

All point flows and totals are passenger cars per hour
Analysis subsection assumed independent of neighboring ramps

Figure 5.2 Point flows superimposed on schematic of the sample major weaving section rotated 90 degrees.

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4-ALA-80-5.1/6.9 DATA: D:\FRELANE\SAMPLE.FRW

MAJOR WEAVING SECTION TYPE B 1 LANE ON 2 LANES OFF: LIMITED TO EMPIRICAL DATA

SUBSECTION 2

TOTAL AVERAGE LANE CHANGES PER 250 FOOT LANE STRIPE

LOCATION (FEET)	LANE1/LANE2 (PCPH)	LANE2/LANE3 (PCPH)
0 - 250	649	114
250 - 500	604	115
500 - 1000	178	118
1000 - 1460	32	79

Figure 5.3 Lane changing values for the sample major weaving section.

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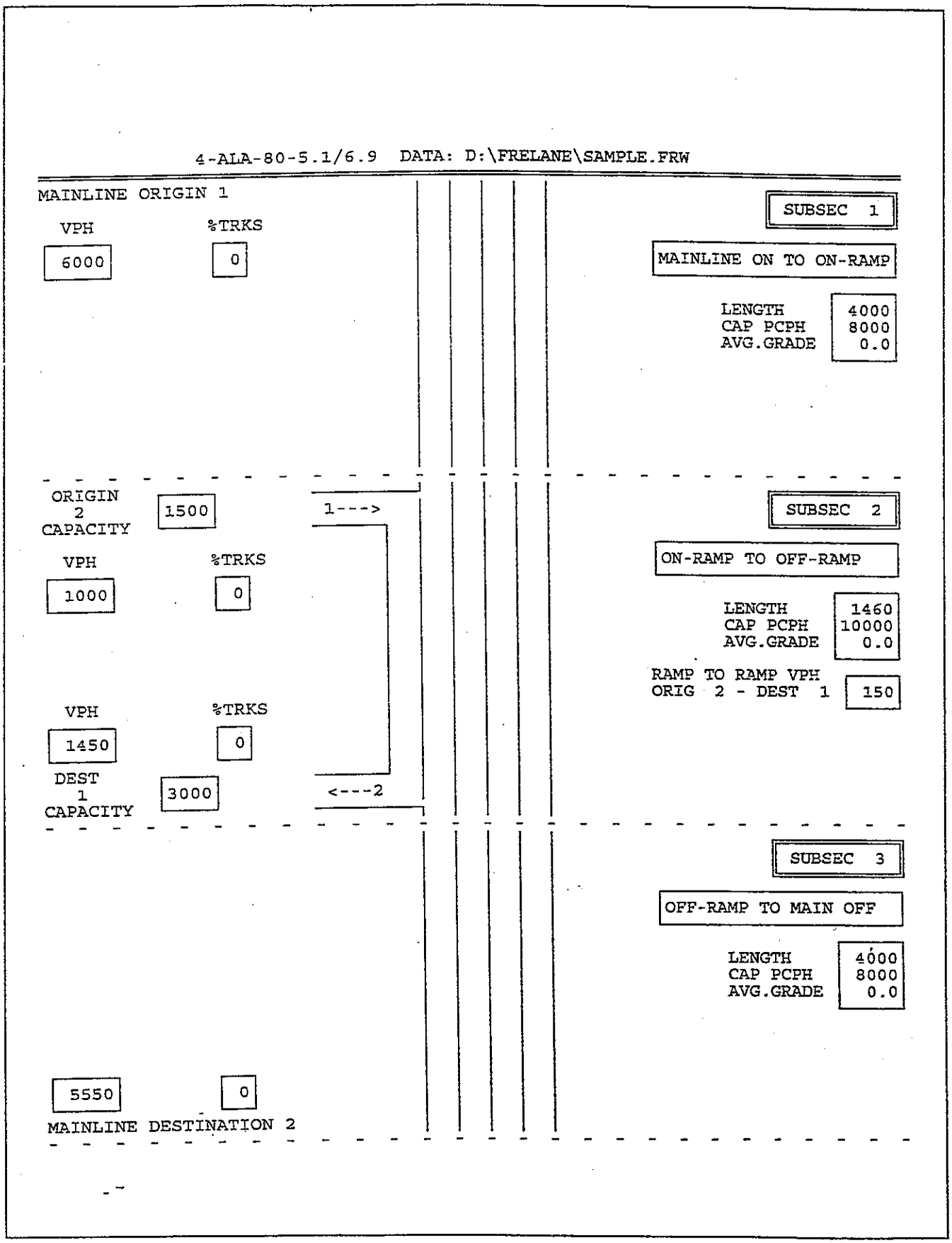

Figure 5.4 Sample freeway geometry with design and demand inputs.

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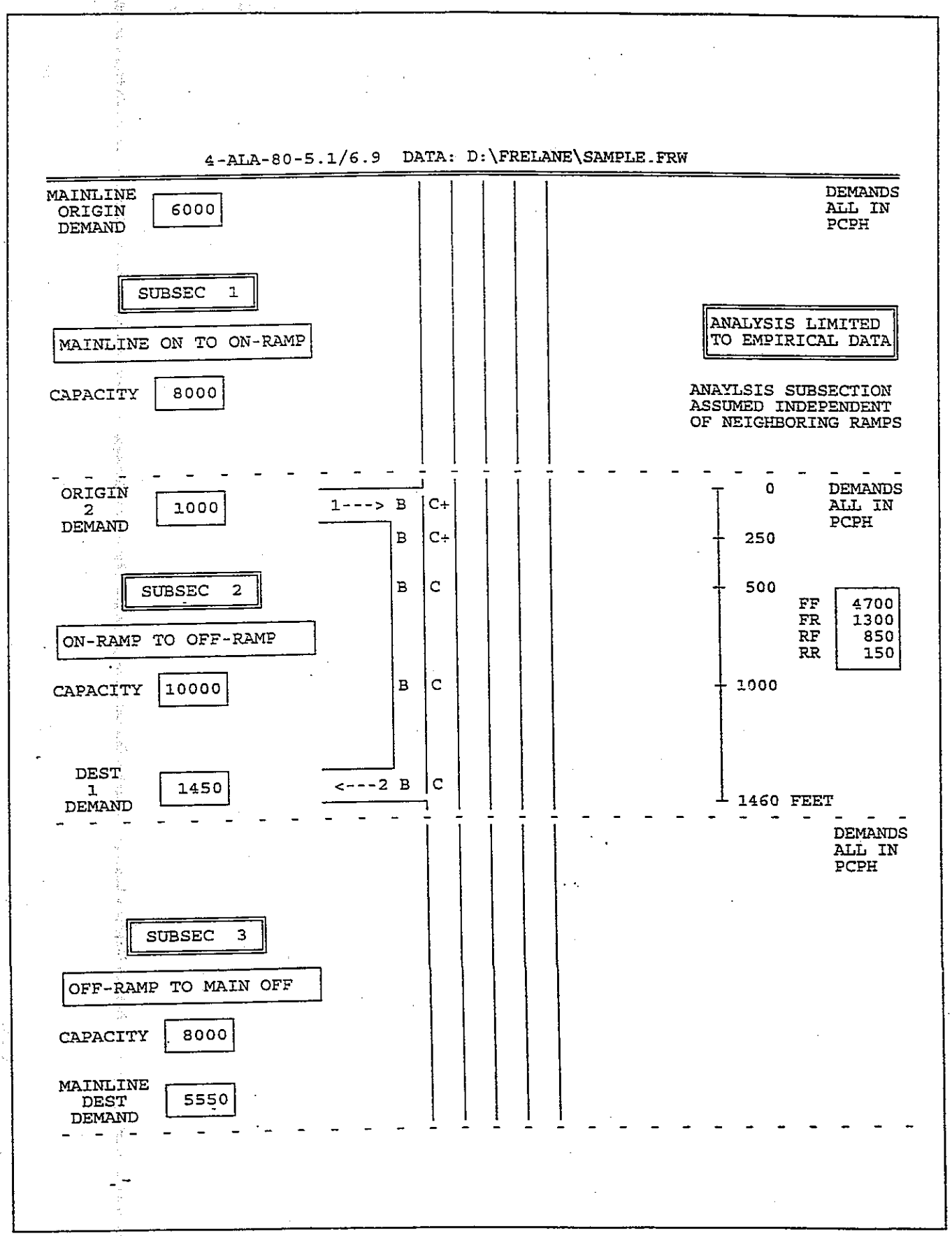

Figure 5.5 Sample freeway geometry with Level of Service output.

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6. ADDITIONAL COMMENTS ON THE EXISTING FRELANE MODEL

Additional enhancements could be made to the FRELANE model in order to increase its usefulness. These suggestions address a) issues surrounding the segments currently in the model and b) development of this model for other types of freeway analysis.

Segments presently in the model are evaluated using a level-of-service table which reflects how well the section operates based on simulation studies done for major weaves. If the table currently being used is unsatisfactory for particular segment types, alternative tables could be developed.

The program currently does not indicate how the left hand lanes of the freeway operate. There is some potential for acceptable ramp sections to occur simultaneously with unacceptable through freeway operations. It should be possible to get some estimate of the level-of-service in these lanes.

There are currently some variables, such as the FF percent in Lane 1 for isolated on-ramps, whose value must be estimated by the program in order to provide the "best" estimate. Modification of the program to allow the user to directly input these values is desirable. Such a modification would also require additional range checking and changes to the outputs to document the user supplied values used in the analysis.

Incorporating other freeway segment types not currently analyzed by the program, such as 3 and/or 5 lane freeway sections or additional multiple weaves, would be highly desirable. This could be accomplished in one of three ways: use of simulation models or current tables to create analysis capabilities for compound segments out of available segments, incorporation of data from other research projects in California and elsewhere, or implementation of current state of the practice methodologies (i.e. the HCM). The latter would be particularly useful for three-lane freeway segments for which data collection may be difficult.

The most challenging and potentially useful direction for future research is to begin to combine segments so that longer sections of freeways can be analyzed. Conditions for isolation need to be identified and analysis methods need to be developed for segments which are influenced by neighboring ramps. This work would follow naturally from the creation of compound segments using simulation models and existing data sets.

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7. REFERENCES

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8. APPENDICES

8.1 Geometric considerations

8.1.1 Determination of subsection length

The subsection length is used to compute length of grade for the conversion of vehicles per hour to passenger cars per hour. Subsections upstream and downstream of the analysis subsection may be as short as 10 feet in order to reflect the proper length of grade for the weaving subsection. **However, the analysis section is always considered to be independent of any influence from neighboring ramps (at least 4,000 ft distance) irrespective of the length of the adjacent subsections.**

In under capacity conditions, measurement of subsection length may be done by the method described in the Caltrans Highway Design Manual or by actual measurement of the striping without significantly effecting the results. Whichever method is chosen, apply it consistently throughout the freeway. If the freeway is close to capacity conditions, the shorter length is recommended.

8.1.2 Lane numbering convention

The model maintains the lane numbering convention established in the original report for analyzing major weaving sections. (1) Lane 1 is the right most lane in the subsection. This ensures that the analysis points can be compared by lane number for subsections with varying widths. The only exception to this convention is for the second analyzed subsection of the multiple weave segment. In this case the numbering established in the first analyzed subsection is carried through to the second analyzed subsection after the termination of the auxiliary lane - lane 1. Thus, in the second analyzed subsection there will be no lane 1, resulting in lane 2 becoming the right-most lane.

8.2 Passenger-car equivalency conversion factors

8.2.1 Application in the model

All demands are entered as vehicles per hour. The FRELANE model will automatically convert the demands to equivalent passenger cars per hour using passenger-car equivalency tables that are embedded in the program. For each subsection, the model calculates the percent trucks and buses in the subsection and determines the length of the grade. The length of the grade may equal the length of the one subsection being processed or may extend over several subsections. The model then selects the appropriate passenger-car equivalency conversion factor from the embedded tables based on the grade of the subsection, the length of that grade, and the percent trucks and buses on the subsection. Interpolation is used for grade and percent trucks where necessary.

The passenger-car equivalency conversion factor is applied to the hourly flows. If the passenger-car equivalency conversion factor varies between subsections, the demands in

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passenger cars per hour will not be conserved throughout the entire analysis section.

8.2.2 Passenger-car equivalency tables embedded in model

The following passenger-car equivalency tables, taken from Chapter 7 (revised) of the HCM (8), are embedded in the model.

UPGRADE %	LENGTH mi	PERCENT TRUCKS AND BUSES 2	4	5	6	8	10	15	20	25
2	0 - 1/4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	1/4 - 1/3	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	1/3 - 1/2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	1/2 - 3/4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	3/4 - 1	2.5	2.0	2.0	2.0	1.5	1.5	1.5	1.5	1.5
	1 - 1 1/2	4.0	3.0	3.0	3.0	2.5	2.5	2.0	2.0	2.0
	>= 1 1/2	4.5	3.5	3.0	3.0	2.5	2.5	2.0	2.0	2.0
3	0 - 1/4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	1/4 - 1/3	3.0	2.5	2.5	2.0	2.0	2.0	2.0	1.5	1.5
	1/3 - 1/2	3.0	2.5	2.5	2.0	2.0	2.0	2.0	1.5	1.5
	1/2 - 3/4	6.0	4.0	4.0	3.5	3.5	3.0	2.5	2.5	2.0
	3/4 - 1	7.5	5.5	5.0	4.5	4.0	4.0	3.5	3.0	3.0
	1 - 1 1/2	8.0	6.0	5.5	5.0	4.5	4.0	4.0	3.5	3.0
	>= 1 1/2	8.5	6.0	5.5	5.0	4.5	4.5	4.0	3.5	3.0
4	0 - 1/4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	1/4 - 1/3	5.5	4.0	4.0	3.5	3.0	3.0	3.0	2.5	2.5
	1/3 - 1/2	5.5	4.0	4.0	3.5	3.0	3.0	3.0	2.5	2.5
	1/2 - 3/4	9.5	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5
	3/4 - 1	10.5	8.0	7.0	6.5	6.0	5.5	5.0	4.5	4.0
	>= 1	11.0	8.0	7.5	7.0	6.0	6.0	5.0	5.0	4.5
5	0 - 1/4	2.0	2.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	1/4 - 1/3	6.0	4.5	4.0	4.0	3.5	3.0	3.0	2.5	2.0
	1/3 - 1/2	9.0	7.0	6.0	6.0	5.5	5.0	4.5	4.0	3.5
	1/2 - 3/4	12.5	9.0	8.5	8.0	7.0	7.0	6.0	6.0	5.0
	>= 3/4	13.0	9.5	9.0	8.0	7.5	7.0	6.5	6.0	5.5
6	0 - 1/4	4.5	3.5	3.0	3.0	3.0	2.5	2.5	2.0	2.0
	1/4 - 1/3	9.0	6.5	6.0	6.0	5.0	5.0	4.0	3.5	3.0
	1/3 - 1/2	12.5	9.5	8.5	8.0	7.0	6.5	6.0	6.0	5.5
	1/2 - 3/4	15.0	11.0	10.0	9.5	9.0	8.0	8.0	7.5	6.5
	> 3/4	15.0	11.0	10.0	9.5	9.0	8.5	8.0	7.5	6.5

DOWNGRADE %	LENGTH mi	PERCENT TRUCKS AND BUSES 5	10	15	20
< 4	ALL	1.5	1.5	1.5	1.5
4	<= 4	1.5	1.5	1.5	1.5
4	> 4	2.0	2.0	2.0	1.5
5	<= 4	1.5	1.5	1.5	1.5
- 5	> 4	5.5	4.0	4.0	3.0
6	<= 2	1.5	1.5	1.5	1.5
6	> 2	7.5	6.0	5.5	4.5

Table 8.1 Passenger-car equivalency tables used by the FRELANE model.

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8.2.3 User supplied passenger-car equivalency values

If for a particular subsection the user knows that the values given in the embedded tables do not reflect actual conditions, the user may input a user supplied passenger-car equivalent for that subsection.

The user must first specify from option 3 of the MODIFICATION MENU that demands are vehicles per hour. Then the user should select option 4 from the MODIFICATION MENU and specify that user supplied passenger-car equivalent values for one or more subsections are to be entered.

For any subsection for which a passenger-car equivalent value is entered, the model will use that value to convert vehicles per hour to passenger-cars per hour.

If the default value of 1.0 is retained for any subsection, the program will make the conversion from vehicles per hour to passenger-car per hour using the embedded value based on percent trucks, percent grade, and length of that grade. A user supplied passenger-car equivalent value must between 1.0 and 30.0

8.3 Peak hour factors

A common practice for capacity analysis is to evaluate a peak 15 minute period and the associated flow rate. This model assumes all data is input not in 15 minute (or other intervals of less than an hour) but in hourly volumes. A user who wishes to investigate peak flow rates may apply a peak hour factor to those volumes. Peak hour factor is defined as the hourly flow divided by the peak rate of flow within the hour. The peak rate of flow within the hour is 4 times the peak 15 minute flow in the hour. The program default value of 1.0 for the peak hour factor may be changed by the user to any value between .6 and 1.0. In addition, the peak hour factor value may be changed for each origin and each destination. The peak hour factor for ramp to ramp demand and for the mainline destination are computed by the program based on all other demand data.

8.4 Valid input variable ranges for the major weaving sections.

8.4.1 Need for input limits.

The usefulness of a model is determined in part by the range of conditions over which it is valid. This is particularly true for a model in traffic analysis where traffic behavior in under- and over-capacity conditions can differ significantly. While some conditions may be observed in the field, it may be necessary to extend a model through extrapolation or simulation. It is desirable under such conditions to know where the boundaries exist between empirical and simulated data points.

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For this model two sets of ranges exist, one which covers the observed data and a second which includes the results of simulation. Use of the empirical data set does not guarantee that all possible combinations of empirical values may be run under the empirical analysis option. It merely indicates that the combination being evaluated could have been observed or that one very similar to it was. The simulation data ranges, which allow analysis under conditions which were clearly not observed in the field, can be accessed by the user by entering a password. They are intended to extend both the possible length of a weaving section and the input volumes.

Based on the manner in which the data was collected, common check points in capacity analysis, and table selection criteria in the model, a set of values was selected for range checking. They include freeway link volumes, ramp volumes, movement volumes, the weaving volume and length. The volumes have minimum and maximum values based on both empirical data and simulation results.

8.4.2 Empirical length ranges and extension of empirical length ranges

The first item to consider in setting ranges is length. There are three lengths embodied in the program. They are length upstream and downstream of the analyzed section and the length of the analyzed section itself. (For ON-ON sections and MULTIPLE WEAVE sections the analyzed section is actually made up of two subsections each of which has a length associated with it.) For the purposes of this program all sections are considered to be isolated sections on the freeway, irrespective of the actual length entered for upstream and downstream subsections. The maximum length is limited by the maximum integer allowed by the computer and exceeds 32,000 feet.

The length allowed for the various types of analyzed sections depends on the length of the actual sites surveyed and the simulations done to extend length. In the case of empirical data the model would be useless if only the exact section length were allowed as an empirical data point. To overcome this limitation the range for an empirical section length was taken to be the 250 foot analysis section in which the observed length fell. For simulation lengths for major weaves the values simulated in the original study (1) were used. The remaining sections in the model fall into two categories, fixed length and variable length. Straight Pipes, Isolated On-Ramps and Isolated Off-Ramps all constitute fixed length sections. Since the volume of a Straight Pipe is invariant over its length revisions of the length limits serve no useful purpose. With the other two sections in this category the critical area has been defined as the nearest 1500 feet upstream of an off-ramp or downstream of an on-ramp; investigation beyond these limits is not necessary. For the other sections the length dependence of the empirical equations precluded extension of lengths for simulation conditions. Such an extension would require additional point

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flow estimating equations along the entire section and not solely at the limits of a shorter or longer section. This work is beyond the scope of the current project.

8.4.3 Empirical volume ranges.

All volume ranges in this model are in passenger cars per hour (pcph). This allows for comparison of vehicle flows with a range of trucks and grades on facilities. The original empirical data was converted from vehicles per hour (vph) to pcph using a passenger car equivalency (PCE) of 1.7. The PCE values in the Highway Capacity Manual (7) have since been revised and the new PCE value for the same conditions is 1.5. All of the empirical data was transformed to the new base which narrowed the ranges of observed volumes.

The issue of volume ranges is split between empirical data and volumes used in simulations. In either case, the data for this model was collected in under capacity conditions which produces the obvious upper bound for various volumes and volume combinations. Even when empirical data exceeds capacity conditions, the theoretical capacity of the ramp or freeway link is the limiting condition. While defaults for per lane capacities are included in the program, the user may revise these. Beyond this first cut there were two ways to approach the setting of ranges, the first to group all the data and the second to segregate the data by the analysis tables used. The second approach has been implemented.

For each type of section the critical variable(s) for table selection was identified. The empirical data was then sorted by number of lanes in the analyzed section and that criteria and the minimums and maximums of each group identified. These are the ranges listed under empirical data.

8.4.4 Extension of empirical volume ranges.

The empirical volume ranges have been extended through simulation for the eight segment types. Due to differences in methodologies and origins of the data three different approaches were taken to extending the volume ranges. The groupings for the various approaches are the major weaving sections, the simple weave analyzed with the Level D methodology and all sections which are analyzed with the total point flow methodology.

Development of ranges for simulation analysis for major weaves relied heavily on the INTRAS sections calibrated in major weaving research.(1) The objective of the expansion was to increase all the input ranges without experiencing over-capacity conditions. This is an under-capacity model. The primary expansion criteria for this set of sections was to increase the boundaries for weaving volumes. In all cases but one, it was possible to meet this criteria. This allows the user to input any combination of empirical movement volumes for analysis. The development of these ranges was a three step iterative process.

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The three steps in the process were selection of minimum and maximum volume combinations to be tested, performance of an INTRAS simulation for each combination and evaluation of the simulation results.

Before the process began, minimum design volumes were set on a per lane basis and estimated for the various volume check points. Any input volumes would have to produce v/c ratios of 1 or less for the checkpoints. The value of 1 was used because the design volumes selected were less than the theoretical capacity at LOS E. The computed v/c ratios would be less than 1 if the theoretical capacity at LOS E were used. The verification of under-capacity conditions is part of the third step in the range development process.

INTRAS, a microscopic freeway simulation model, was used in the major weave study to do length extensions. The various input files calibrated for empirical data were available for use. The files run for checking extended volume limits were unmodified except for the volume inputs used. The runs were done for all volume input combinations for all of the lengths investigated in the major weave study.

The first step in the process was to see what combinations of upstream freeway volume and on-ramp volume produced the largest and smallest weaving volumes without violating any weaving volume constraint on a table. These two volumes were used because they are the INTRAS volume inputs. The ratio of through and off-ramp traffic which is the other possible volume variable in INTRAS was kept constant for all combinations.

Three volume combinations were selected in order to find maximum weaving volumes: volumes with equal v/c ratios, volumes where the upstream volume was at the design maximum, and volumes where the on-ramp volume was at the design maximum. The first option, equal v/c ratios, was selected to represent equally crowded conditions on both the freeway and the ramp at the merge point and potentially equal gap sizes in both flows. The second option, design maximum on the freeway, represented the case where on-ramp traffic would be limited in its ability to merge and therefore minimized. The third option, the on-ramp at design maximum, represented a situation in which the on-ramp dominated the pattern of flows at the merge point and on the freeway. It was not always possible to meet these conditions.

To find minimum input volumes, up to three combinations were tried. In the event a table had a lower bound, equal v/c ratios for the input volumes were used. In all cases, use of a v/c ratio of 0.20 for both input volumes was tried as well as 60 percent for the minimum observed value for the input volumes. The 0.20 v/c ratio was arbitrarily selected as representing a mid-level LOS B or better. The facilities being analyzed are not likely to be operating at such a high level of service. The 60 percent was an estimate to obtain the same table values for the lower volumes as are used in the models. While it may appear that very low volumes could be used, there were problems in

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getting an acceptable INTRAS simulation run at low volumes. In addition, the simulation runs should produce movement percentage estimates which are close to those applied in the model. The larger the volume difference from the empirical models, the less likely this is to be true and the less accurate the FRELANE prediction will be.

The second step was to create the necessary INTRAS batch files and run the simulations. This was done by identifying the calibrated INTRAS runs from the earlier work and modifying them. The calibrated runs were selected based on naming conventions, dates and internal file labels. None were checked against empirical data to confirm the choice.

The final step was to review the INTRAS outputs to verify the existence of under-capacity conditions. The definition of under-capacity conditions was less that 1 percent of the vehicles from either origin missing their destination. Generally if this failure occurred, it was at a weaving length of 750 feet under high volume conditions with equal v/c ratios. No check was made to insure that relatively the same proportions were observed at these volumes as the models would apply in analyzing them. If the under capacity condition was violated at any weaving length but 750 feet, the entire process was repeated. The exception was made because 750 feet represents an undesirable design. In the very low volume simulation tests warning messages were encountered indicating some type of internal failure in accumulating values. The source of the error was tentatively traced to the relatively low volumes being run since the use of alternative through and off-ramp percentages and different random number seeds did not eliminate the error messages in a consistent fashion.

In several cases simulation maximums were significantly lower than the associated empirical maximums due to the input assumptions for simulation. Similarly, a few simulation minimums were greater than the empirical minimums. In these cases the simulation range values were set equal to the empirical range values. There is no guarantee that these modified limits represent under-capacity conditions for the entire range. To flag possible problems, additional volume checks were implemented which alert the user when the average per lane volume in an analysis subsection or the average per lane volume in the critical area exceeds 1900 pcph.

The second group for range extension consists solely of the Simple Weave analysis using "Level D". Simulation limits for "Level D" were developed so that conditions beyond those under which the method was developed could be analyzed within the model. Ramp movement volumes were set to per lane design maximums (1800 pcph). Ramp and section maximums were set at 2200 pcphpl across the appropriate number of lanes. A slight reduction was taken in the weaving section where the auxiliary lane was limited to 2000 pcph. The weaving volume maximum was set to the sum of the component volumes as was done in developing the empirical limits. No simulation or other analysis was

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undertaken to verify these limits met the under-capacity condition.

The last group includes all sections but Major Weaves. For these sections where the Total Point Flow method is used a three step process was used. A basic decision was made early in the process that the simulation extension would be only for volumes under which the existing empirical equations still provided reasonable point flow estimates. For the purpose of this process "reasonable" was a set of limit conditions for which the percentage of simulation volumes within 100 and 180 pcph of the equation estimate was the same the empirical percentage within the same number of vehicles. The value of 100 was selected as an easy one to remember. The value of 180 is 10 percent of the design maximum and at conditions approaching capacity is sufficient to expect that an estimate of LOS D is no worse than LOS E if an estimation error has occurred.

The first step in the process was to determine how restrictive the various combination limits were in doing an analysis. These limits included the various section and ramp volumes and in some cases weaving volumes. The first priority as with the major weaves was to reduce or eliminate these restrictions on an analysis. The minimum limit expansion which would be tested in any case was one in which the only effective limits were those on the movement inputs.

The second step was to investigate the impact of a 20 percent increase in movement maximums and a 10 percent decrease in movement minimums. In no case was a simulation limit for a ramp movement allowed to exceed 1800 pcph or a freeway to freeway movement exceed 1900 pcph. Section limits were restricted to 2200 pcphpl for all lanes except auxiliary lanes which were restricted to 2000 pcphpl. Where empirical limits exceeded any of these values, the simulation maximums were set equal to empirical maximums. Using a basic property of regression analysis which allows for the estimation of the expected standard deviation for any set of inputs, any combination of inputs for which the expected standard deviation exceeded 100 vehicles was discarded. As might be expected in a case where trillions of input combinations exist only selected combinations could be checked. In this case it was every possible combination of empirical and simulation minima and maxima which generally reduced to less than a hundred cases to be evaluated.

Having obtained a set of limits thought to be feasible, a set of INTRAS simulation runs was done as the third step. The files used input parameters calibrated to the midpoint of the empirical data with an upstream straight pipe distribution. The former condition allowed for the testing of a match between the regression equation estimate and the simulation estimate since calibration parameters for a given empirical point were generally not transferable to other points in the same data set. The later condition is part of the stipulation that the sections are

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isolated and therefore fed by straight pipe sections. Two sections apparently could not be calibrated with upstream straight pipe conditions. The four-lane section, the paired on-ramps, has been annotated in the model as a site where the isolation assumption may not hold. No simulation expansion was done for the other exception, the three-lane on-off section without an auxiliary lane, since this model focuses on four-lane sections.

Sample data points were scattered over the entire feasible region, excluding the empirical region, in proportion to the sizes of the various sub-areas defined by input ranges and analysis section volumes. Sub-areas with analysis section volumes exceeding 1650 pcphpl (LOS C/D) had their sub-area sizes effectively doubled so they were twice as likely to be represented as low volume sections. Sub-areas with analysis section volumes exceeding the analysis section maximum had their areas reduced by the proportion of combinations which would produce such volumes. The results of the INTRAS simulations were reviewed and the proportions within 100 and 180 pcph determined. If the proportions were equivalent to the empirical proportions, the proposed limits were accepted and no further investigation done. If the proportions were not equivalent to the empirical proportions an attempt was made to identify problem areas. If a problem area was clear, new limits were set and the simulations redone. If no consistent problem area could be identified, the simulations were redone solely lifting the combination constraints and the resulting expected accuracies identified.

8.4.5 Tables of valid empirical and simulation ranges.

Table 8.2 - table 8.13 contain the valid input ranges for each of the freeway segments that can be analyzed by the FRELANE model. Simulation limits that have been replaced by empirical limits, as described in Section 8.4.4, appear in **bold type**. If any input falls outside the valid range for the specific section, the model will not be able to analyze that freeway segment.

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EMPIRICAL: TYPE B WEAVING SECTION ONE LANE ON-RAMP / TWO LANE OFF-RAMP
5 LANES IN WEAVING SECTION

	FR+RF <= 2000		2000 < FR+RF RF+RF <= 2300		FR+RF > 2300	
	MIN	MAX	MIN	MAX	MIN	MAX
UPSTRM SS LENGTH	10	32767	10	32767	10	32767
DWNSTRM SS LENGTH	10	32767	10	32767	10	32767
WEAVING SS LENGTH	1000	1500	1000	1500	1250	1500
ML VOL ENTERING SS2	3148	8249	4890	6973	6298	8799
FF VOLUME	2405	7670	3090	5691	4155	6299
FR VOLUME	445	1855	728	2084	2143	2603
RF VOLUME	59	1123	77	1314	125	320
RR VOLUME	0	218	59	202	71	216
ON-RAMP VOL	177	1272	205	1373	249	450
OFF-RAMP VOL	505	2001	787	2237	2226	2791
SECTION VOL	3521	9372	5269	7792	6548	9123
ML VOL EXITING SS2	2689	8793	3280	7005	4322	6424
WEAVING VOL FR+RF	758	1997	2017	2222	2310	2766

SIMULATION: TYPE B WEAVING SECTION ONE LANE ON-RAMP / TWO LANE OFF-RAMP
5 LANES IN WEAVING SECTION

	FR+RF <= 2000		2000 < FR+RF RF+RF <= 2300		FR+RF > 2300	
	MIN	MAX	MIN	MAX	MIN	MAX
UPSTRM SS LENGTH	10	32767	10	32767	10	32767
DWNSTRM SS LENGTH	10	32767	10	32767	10	32767
WEAVING SS LENGTH	750	2500	750	2500	750	2500
ML VOL ENTERING SS2	1700	8400	2934	7320	4043	**8799**
FF VOLUME	1530	**7670**	2024	**5691**	2749	**6299**
FR VOLUME	170	**1855**	**728**	2269	1294	2688
RF VOLUME	**59**	1620	31	**1314**	**125**	1008
RR VOLUME	**0**	**218**	20	702	**71**	792
ON-RAMP VOL	106	1800	50	1800	**249**	1800
OFF-RAMP VOL	199	**2001**	**787**	2289	2086	2831
SECTION VOL	1995	9375	4734	**7792**	5843	**9123**
DOWNSTREAM VOL	1796	**8793**	3122	**7005**	3757	**6424**
WEAVING VOL FR+RF	284	2000	2001	2300	2301	2870

Table 8.2 Valid ranges for five lane type B weaving sections with one lane on-ramp and two lane off-ramp.

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TIRICAL: TYPE B WEAVING SECTION TWO LANE ON-RAMP / TWO LANE OFF-RAMP
5 LANES IN WEAVING SECTION

	FR <= RF FR+RF <= 2000		FR <= RF FR+RF > 2000		FR > RF FR+RF <= 2000	FR > RF FR+RF >2000
	MIN	MAX	MIN	MAX		
STRM SS LENGTH	10	32767	10	32767	N	N
STRM SS LENGTH	10	32767	10	32767	O	O
AVING SS LENGTH	750	1000	750	1000		
V ENTERING SS2	3526	4766	4333	4866	D	D
VOLUME	3078	4554	3990	4641	A	A
VOLUME	142	590	142	521	T	T
VOLUME	893	1805	1658	2036	A	A
VOLUME	209	661	165	510		
RAMP VOL	1232	2148	1978	2411		
F-RAMP VOL	437	1060	307	841		
CTION VOL	5227	6700	6489	7163		
V EXITING SS2	4310	6158	5648	6642		
AVING VOL FR+RF	1389	1956	2030	2249		

SIMULATION: TYPE B WEAVING SECTION TWO LANE ON-RAMP / TWO LANE OFF-RAMP
5 LANES IN WEAVING SECTION

	FR <= RF FR+RF <= 2000		FR <= RF FR+RF > 2000		FR > RF FR+RF <= 2000		FR > RF FR+RF > 2000	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
STRM SS LENGTH	10	32767	10	32767	10	32767	10	32767
STRM SS LENGTH	10	32767	10	32767	10	32767	10	32767
AVING SS LENGTH	750	2000	750	2000	750	2000	750	2000
V ENTERING SS2	1230	6300	2599	6300	1250	5425	2850	6300
VOLUME	1119	5733	2443	5922	800	3472	1824	4032
VOLUME	111	**590**	**142**	**521**	450	1953	1026	2268
VOLUME	558	1887	1622	3096	47	999	338	1683
VOLUME	167	**661**	**165**	**510**	53	1126	382	1897
RAMP VOL	725	2450	1886	3600	100	2125	720	3580
F-RAMP VOL	277	**1060**	**307**	843	834	2127	2045	3616
CTION VOL	1955	8160	4744	9250	1975	5525	4925	8825
V EXITING SS2	1678	7165	4288	8407	1141	3519	2799	5219
AVING VOL FR+RF	669	2000	2001	3435	791	2000	2001	3455

le 8.3 Valid ranges for five lane type B weaving sections with two lane on-ramp and two lane off-ramp.

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EMPIRICAL: TYPE C WEAVING SECTION ONE LANE ON-RAMP / TWO LANE OFF-RAMP
5 LANES IN WEAVING SECTION

	FR+RF <= 3000		FR+RF > 3000	
	MIN	MAX	MIN	MAX
UPSTRM SS LENGTH	10	32767	10	32767
DWNSTRM SS LENGTH	10	32767	10	32767
WEAVING SS LENGTH	750	1000	750	1000
MAINLINE VOL ENTERING SS2	4252	6169	8275	10633
FF VOLUME	2534	4227	5038	6262
FR VOLUME	1455	2393	2912	4371
RF VOLUME	85	573	92	329
RR VOLUME	195	589	151	339
ON-RAMP VOL	494	1004	261	660
OFF-RAMP VOL	1650	2808	3199	4710
SECTION VOL	5020	6816	8702	11293
MAINLINE VOL EXITING SS2	2900	4532	5212	6583
WEAVING VOL FR+RF	1798	2773	3027	4692

SIMULATION: TYPE C WEAVING SECTION ONE LANE ON-RAMP / TWO LANE OFF-RAMP
5 LANES IN WEAVING SECTION

	FR+RF <= 3000		FR+RF > 3000	
	MIN	MAX	MIN	MAX
UPSTRM SS LENGTH	10	32767	10	32767
DWNSTRM SS LENGTH	10	32767	10	32767
WEAVING SS LENGTH	750	2500	750	2500
MAINLINE VOL ENTERING SS2	1700	8265	5715	**10633**
FF VOLUME	1088	5290	3486	**6262**
FR VOLUME	612	2975	2229	**4371**
RF VOLUME	24	846	**92**	774
RR VOLUME	27	954	**151**	1026
ON-RAMP VOL	50	1800	**261**	1800
OFF-RAMP VOL	805	3107	3052	**4710**
SECTION VOL	2065	8316	7515	**11293**
MAINLINE VOL EXITING SS2	1260	5313	4260	**6583**
WEAVING VOL FR+RF	784	3000	3001	**4692**

Table 8.4 Valid ranges for five lane type C weaving sections with one lane on-ramp two lane off-ramp.

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EMPIRICAL: TYPE C WEAVING SECTION ONE LANE ON-RAMP / TWO LANE OFF-RAMP
6 LANES IN WEAVING SECTION

	FR+RF <= 3000		FR+RF > 3000
	MIN	MAX	
UPSTRM SS LENGTH	10	32767	N
DWNSTRM SS LENGTH	10	32767	O
WEAVING SS LENGTH	1500	1750	
MAINLINE VOL ENTERING SS2	4656	7630	D
FF VOLUME	3796	5873	A
FR VOLUME	778	2006	T
RF VOLUME	203	888	A
RR VOLUME	89	295	
ON-RAMP VOL	403	1130	
OFF-RAMP VOL	964	2183	
SECTION VOL	5786	8186	
MAINLINE VOL EXITING SS2	4301	6563	
WEAVING VOL FR+RF	1458	2385	

SIMULATION: TYPE C WEAVING SECTION ONE LANE ON-RAMP / TWO LANE OFF-RAMP
6 LANES IN WEAVING SECTION

	FR+RF <= 3000		FR+RF > 3000	
	MIN	MAX	MIN	MAX
UPSTRM SS LENGTH	10	32767	N	
DWNSTRM SS LENGTH	10	32767	O	
WEAVING SS LENGTH	1000	2500		
MAINLINE VOL ENTERING SS2	2100	10325	S	
FF VOLUME	1701	8363	I	
FR VOLUME	399	**2006**	M	
RF VOLUME	38	1350	U	
RR VOLUME	13	450	L	
ON-RAMP VOL	50	1800	A	
OFF-RAMP VOL	490	**2183**	T	
SECTION VOL	2465	10515	I	
MAINLINE VOL EXITING SS2	1975	8425	O	
WEAVING VOL FR+RF	673	3000	N	

Table 8.5 Valid ranges for six lane type C weaving sections with one lane on-ramp two lane off-ramp.

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EMPIRICAL: TYPE C WEAVING SECTION TWO LANE ON-RAMP / ONE LANE OFF-RAMP
6 LANES IN WEAVING SECTION

	FR+RF <= 3000 UPST V <=5500		FR+RF <= 3000 UPST V > 5500	FR+RF > 3000 UPST V <=5500	FR+RF > 3000 UPST V >5500	
	MIN	MAX			MIN	MAX
UPSTRM SS LENGTH	10	32767	N	N	10	32767
DWNSTRM SS LENGTH	10	32767	O	O	10	32767
WEAVING SS LENGTH	1250	1500			1250	1500
ML V ENTERING SS2	2266	5073	D	D	5620	6754
FF VOLUME	2136	4856	A	A	5257	6200
FR VOLUME	66	334	T	T	327	400
RF VOLUME	1078	2153	A	A	3065	3696
RR VOLUME	38	254			87	404
ON-RAMP VOL	1245	2276			3341	3925
OFF-RAMP VOL	118	511			499	795
SECTION VOL	3895	7089			9337	10671
ML V EXITING SS2	3582	6709			8636	9951
WEAVING VOL FR+RF	1335	2353			3417	4176

SIMULATION: TYPE C WEAVING SECTION TWO LANE ON-RAMP / ONE LANE OFF-RAMP
6 LANES IN WEAVING SECTION

	FR+RF <= 3000 UPST V <=5500		FR+RF <= 3000 UPST V > 5500		FR+RF > 3000 UPST V <=5500		FR+RF > 3000 UPST V >5500	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
UPSTRM SS LENGTH	10	32767	10	32767	10	32767	10	32767
DWNSTRM SS LENGTH	10	32767	10	32767	10	32767	10	32767
WEAVING SS LENGTH	750	2000	750	2000	750	2000	750	2000
ML V ENTERING SS2	1680	5500	5501	8400	5040	5500	5501	8400
FF VOLUME	1546	5060	5171	7896	4738	5170	5171	7896
FR VOLUME	66	440	330	504	302	330	327	504
RF VOLUME	674	2864	670	2669	2674	3348	2581	3348
RR VOLUME	38	254	50	201	201	252	87	252
ON-RAMP VOL	725	3080	720	2870	2875	3600	2775	3600
OFF-RAMP VOL	118	633	380	692	506	582	499	582
SECTION VOL	2425	8252	6221	11084	7942	9100	8376	11084
ML V EXITING SS2	2238	7619	5841	10392	7436	8518	7845	10392
WEAVING VOL FR+RF	810	3000	1000	3000	3001	3678	3001	4176

Table 8.6 Valid ranges for six lane type C weaving sections with two lane on-ramp one lane off-ramp.

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IRICAL: SIMPLE WEAVING SECTION WITH AUXILIARY LANE ONE LANE ON-RAMP/ ONE LANE OFF-RAMP 5 LANES IN WEAVING SECTION

	TOTAL POINT FLOW METHOD		LEVEL D METHOD	
	MIN	MAX	MIN	MAX
STRM SS LENGTH	10	32767	10	32767
WNSTRM SS LENGTH	10	32767	10	32767
AVING SS LENGTH	1000	2000	1000	3000
INLINE VOL ENTERING SS2	4816	7788	4001	7200
F VOLUME	4242	7392	4000	6500
VOLUME	330	856	1	1480
VOLUME	214	1924	1	1480
VOLUME	4	148	0	1799
N-RAMP VOL	222	2072	1	1800
FF-RAMP VOL	338	1004	1	1800
TION VOL	5914	9128	4000	9000
INLINE VOL EXITING SS2	5378	8180	4000	7200
AVING VOL FR+RF	544	2780	950	2960

MULATION: SIMPLE WEAVING SECTION WITH AUXILIARY LANE ONE LANE ON-RAMP/ ONE LANE OFF-RAMP 5 LANES IN WEAVING SECTION

	TOTAL POINT FLOW METHOD		LEVEL D METHOD	
	MIN	MAX	MIN	MAX
STRM SS LENGTH	10	32767	10	32767
STRM SS LENGTH	10	32767	10	32767
AVING SS LENGTH	1000	2000	1000	3000
INLINE VOL ENTERING SS2	4542	8248	4001	8800
F VOLUME	4242	7392	4000	7300
VOLUME	300	856	1	1800
VOLUME	214	1924	1	1800
VOLUME	4	148	0	1799
RAMP VOL	218	2072	1	2200
F-RAMP VOL	304	1004	1	2200
TION VOL	4760	10320	4000	10800
INLINE VOL EXITING SS2	4456	9316	4000	8800
AVING VOL FR+RF	514	2780	950	3600

le 8.7 Valid ranges for 5 lane simple weaving section with auxiliary lane, one lane on-ramp, and one lane off-ramp.

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EMPIRICAL: ON OFF SECTION WITH NO AUXILIARY LANE
ONE LANE ON-RAMP / ONE LANE OFF-RAMP

	3 LANES		4 LANES	
	MIN	MAX	MIN	MAX
UPSTRM SS LENGTH	10	32767	10	32767
DWNSTRM SS LENGTH	10	32767	10	32767
WEAVING SS LENGTH	1800	2000	900	1100
MAINLINE VOL ENTERING SS2	3447	5637	3715	7596
FF VOLUME	2913	4759	3410	7056
FR VOLUME	342	878	305	545
RF VOLUME	369	878	468	1025
RR VOLUME	12	111	24	230
ON-RAMP VOL	382	964	492	1182
OFF-RAMP VOL	380	964	402	776
SECTION VOL	4049	6600	4689	8544
MAINLINE VOL EXITING SS2	3627	5636	4287	7908

SIMULATION: ON OFF SECTION WITH NO AUXILIARY LANE
ONE LANE ON-RAMP / ONE LANE OFF-RAMP

	3 LANES		4 LANES	
	MIN	MAX	MIN	MAX
UPSTRM SS LENGTH	10	32767	10	32767
DWNSTRM SS LENGTH	10	32767	10	32767
WEAVING SS LENGTH	1800	2000	900	1100
MAINLINE VOL ENTERING SS2	3447	5637	3715	7700
FF VOLUME	2913	4759	3410	7056
FR VOLUME	342	878	305	600
RF VOLUME	369	878	214	1025
RR VOLUME	12	111	4	230
ON-RAMP VOL	382	964	218	1255
OFF-RAMP VOL	380	964	309	830
SECTION VOL	4049	6600	3933	8800
MAINLINE VOL EXITING SS2	3627	5636	3624	8300

Table 8.8 Valid ranges for three and four lane on off sections with no auxiliary lane, one lane on-ramp, and one lane off-ramp.

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EMPIRICAL: ISOLATED ON SECTION ONE LANE ON-RAMP
4 LANES

	MIN	MAX
PSTRM SS LENGTH	10	32767
WNSTRM SS LENGTH	10	32767
ECTION LENGTH	1500	1750
INLINE VOL ENTERING SS2	4905	6089
VOLUME	4905	6089
VOLUME	462	1084
N-RAMP VOL	462	1084
ECTION VOL	5367	6817
TNLINE VOL EXITING SS2	5367	6817

SIMULATION: ISOLATED ON SECTION ONE LANE ON-RAMP
4 LANES

	MIN	MAX
PSTRM SS LENGTH	10	32767
WNSTRM SS LENGTH	10	32767
ECTION LENGTH	1500	1750
TNLINE VOL ENTERING SS2	4400	6600
VOLUME	4400	6600
VOLUME	300	1100
N-RAMP VOL	300	1100
ECTION VOL	4700	7700
TNLINE VOL EXITING SS2	4700	7700

le 8.9 Valid ranges for four lane isolated on section with one lane on-ramp.

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EMPIRICAL: ISOLATED OFF SECTION ONE LANE OFF-RAMP
4 LANES

	MIN	MAX
UPSTRM SS LENGTH	10	32767
DWNSTRM SS LENGTH	10	32767
SECTION LENGTH	1500	1750
MAINLINE VOL ENTERING SS2	5166	6625
FF VOLUME	4271	5488
FR VOLUME	617	1236
OFF-RAMP VOL	617	1236
SECTION VOL	5166	6625
MAINLINE VOL EXITING SS2	4271	5488

SIMULATION: ISOLATED OFF SECTION ONE LANE OFF-RAMP
4 LANES

	MIN	MAX
UPSTRM SS LENGTH	10	32767
DWNSTRM SS LENGTH	10	32767
SECTION LENGTH	1500	1750
MAINLINE VOL ENTERING SS2	4350	8400
FF VOLUME	3850	6700
FR VOLUME	500	1700
OFF-RAMP VOL	500	1700
SECTION VOL	4350	8400
MAINLINE VOL EXITING SS2	3850	6700

Table 8.10 Valid ranges for four lane isolated off section with one lane off-ramp.

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EMPIRICAL: STRAIGHT PIPE SECTION

	3 LANES		4 LANES	
	MIN	MAX	MIN	MAX
STRM SS LENGTH	10	32767	10	32767
WNSTRM SS LENGTH	10	32767	10	32767
CTION LENGTH	5000	21120	5000	21120
TNLINE VOL ENTERING SS2	1853	6773	2569	8593
VOLUME	1853	6773	2569	8593
CTION VOL	1853	6773	2569	8593
TNLINE VOL EXITING SS2	1853	6773	2569	8593

SIMULATION: STRAIGHT PIPE SECTION

	3 LANES		4 LANES	
	MIN	MAX	MIN	MAX
STRM SS LENGTH	10	32767	10	32767
WNSTRM SS LENGTH	10	32767	10	32767
CTION LENGTH	5000	21120	5000	21120
TNLINE VOL ENTERING SS2	1853	6773	500	8750
VOLUME	1853	6773	500	8750
CTION VOL	1853	6773	500	8750
TNLINE VOL EXITING SS2	1853	6773	500	8750

le 8.11 Valid ranges for three and four lane straight pipe section.

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EMPIRICAL: ON ON SECTION 1 LANE ON-RAMP FOLLOWED BY 1 LANE ON-RAMP
4 LANES

	MIN	MAX
UPSTRM SS LENGTH	10	32767
DWNSTRM SS LENGTH	10	32767
SECTION LENGTH	550	650
MAINLINE VOL ENTERING SS 2	3696	6653
FF VOLUME	3696	6653
R1F VOLUME	350	777
ON-RAMP VOL IN SS 2	350	777
VOLUME OF SS 2	4211	7409
LENGTH OF SS 3	1500	1750
R2F VOLUME	156	577
ON-RAMP VOL IN SS 3	156	577
VOLUME OF SS 3	4462	7850
MAINLINE VOL EXITING SS 3	4462	7850

SIMULATION: ON ON SECTION 1 LANE ON-RAMP FOLLOWED BY 1 LANE ON-RAMP
4 LANES

	MIN	MAX
UPSTRM SS LENGTH	10	32767
DWNSTRM SS LENGTH	10	32767
SECTION LENGTH	550	650
MAINLINE VOL ENTERING SS 2	3500	6900
FF VOLUME	3500	6900
R1F VOLUME	150	1100
ON-RAMP VOL IN SS 2	150	1100
VOLUME OF SS 2	3650	8000
LENGTH OF SS 3	1500	1750
R2F VOLUME	150	1100
ON-RAMP VOL IN SS 3	150	1100
VOLUME OF SS 3	3800	8400
MAINLINE VOL EXITING SS 3	3800	8400

Table 8.12 Valid ranges for four lane on on section with one lane on-ramp followed by one lane on-ramp.

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EMPIRICAL: MULTIPLE WEAVE SECTION 1 LANE ON-RAMP / 1 LANE OFF-RAMP / 1 LANE OFF-RAMP 4 LANES WITH 5 LANES IN WEAVING SECTION

	MIN	MAX
UPSTRM SS LENGTH	10	32767
DWNSTRM SS LENGTH	10	32767
SECTION LENGTH OF SS2	1000	1250
MAINLINE VOL ENTERING SS2	3095	5486
RF VOLUME	2558	4945
RR1 VOLUME	185	340
FR VOLUME	474	987
RF1 VOLUME	0	61
ON-RAMP VOL IN SS2	498	1072
OFF-RAMP VOL IN SS2	222	361
VOLUME IN SS2	3781	6495
WEAVING VOL FR + RF + RR2	973	1565
SECTION LENGTH OF SS3	1150	1400
RR2 VOLUME	227	357
RF2 VOLUME	0	50
OFF-RAMP VOL IN SS3	227	392
VOLUME OF SS 3	3507	6261
MAINLINE VOL EXITING SS3	3182	5917

SIMULATION: MULTIPLE WEAVE SECTION 1 LANE ON-RAMP / 1 LANE OFF-RAMP / 1 LANE OFF-RAMP 4 LANES WITH 5 LANES IN WEAVING SECTION

	MIN	MAX
UPSTRM SS LENGTH	10	32767
DWNSTRM SS LENGTH	10	32767
SECTION LENGTH OF SS2	1000	1250
MAINLINE VOL ENTERING SS2	2900	5725
RF VOLUME	2500	5000
RR1 VOLUME	175	350
FR VOLUME	450	1000
RF1 VOLUME	0	75
ON-RAMP VOL IN SS2	450	1150
OFF-RAMP VOL IN SS2	175	425
VOLUME IN SS2	3350	6875
WEAVING VOL FR + RF + RR2	850	1800
SECTION LENGTH OF SS3	1150	1400
RR2 VOLUME	225	375
RF2 VOLUME	0	75
OFF-RAMP VOL IN SS3	225	450
VOLUME OF SS 3	3175	6450
MAINLINE VOL EXITING SS3	2950	6000

Table 8.13 -Valid ranges for four lane multiple weave section with one lane on-ramp connected by auxiliary lane to one lane off- ramp, followed by one lane off-ramp.

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8.5 Ranges for determining Level of Service

The model uses the following equation to compute the density at up to 7 points for each lane in the conflict area. (1)

$$D = 0.42 + 0.02(V/N) - 1.19*10^{-5}(V/N)^2 + 5.36*10^{-9} * (V/N)^3$$

where D = Density, passenger cars per mile per lane
V/N = Flow per lane, pcph

Using the computed density value at a particular point, the model selects the appropriate LOS value from the table of Level of Service Boundary conditions that are embedded in the program.

Table 8.14 lists the Level of Service boundary conditions that are used by the model as well as the approximate point demands that are associated with each LOS.

DENSITY RANGES pass-cars/mi/lane	LOS		APPROXIMATE POINT DEMAND RANGES pcph/lane				
DENSITY < 2.0	A+	--	29	<=	PT DEMAND	<	140
DENSITY < 8.0	A	--	140	<=	PT DEMAND	<	560
DENSITY < 10.0	A-	--	560	<=	PT DEMAND	<	700
DENSITY < 12.0	B+	--	700	<=	PT DEMAND	<	839
DENSITY < 17.0	B	--	839	<=	PT DEMAND	<	1232
DENSITY < 19.0	B-	--	1232	<=	PT DEMAND	<	1355
DENSITY < 21.0	C+	--	1355	<=	PT DEMAND	<	1463
DENSITY < 26.0	C	--	1463	<=	PT DEMAND	<	1686
DENSITY < 28.0	C-	--	1686	<=	PT DEMAND	<	1764
DENSITY < 30.0	D+	--	1764	<=	PT DEMAND	<	1832
DENSITY < 35.0	D	--	1832	<=	PT DEMAND	<	1980
DENSITY < 37.0	D-	--	1980	<=	PT DEMAND	<	2036
DENSITY < 39.0	E+	--	2036	<=	PT DEMAND	<	2087
DENSITY < 44.0	E	--	2087	<=	PT DEMAND	<	2202
DENSITY < 46.0	E-	--	2202	<=	PT DEMAND	<	2246
DENSITY < 48.0	F+	--	2246	<=	PT DEMAND	<	2286
DENSITY < 53.0	F	--	2286	<=	PT DEMAND	<	2382
DENSITY >=53.0	F-	--	2382	<=	PT DEMAND		

Table 8.14 Boundary conditions for determining Level of Service.

8.6 Major Weave movement proportion tables.

8.6.1 Table development .

Tables were developed in two stages for major weaving sections using the tables and graphs contained in the original report (1). The tables were developed in the spreadsheet models and the second set transferred directly into the program. The first stage of development was a direct utilization of the tables as they appeared in the research with corrections for problems with sums of percentages. The second stage used the tables and the graphs to create a standard table of values for fixed points and weaving lengths. From

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experience with the first stage values, it was believed that a more finely divided table would reduce the incidence of odd answers.

The table format was selected since none of the curves developed are straight lines, and most cannot be described by simple formulas. An increment of 250 feet was selected for both analysis points and weaving section length because it is the length of the smallest analysis interval. The tables have proportion estimates at 250 foot intervals. The longest lengths are the result of simulation.

To actually develop the tables, additional curves were sketched in on the basic report graphs for use in interpolation. These provided the basic values for any weaving section length other than the shortest (750 feet) and the longest (2000 or 2500 feet). This visual interpolation was essentially linear in nature, evenly spacing the curves in the absence of additional simulation information. The second phase was to adjust the values bounding an empirical length. When the model is run, the movement proportions calculated for an empirical length should be essentially the same as the reported values for that length. Therefore the proportions used for interpolation of an empirical length should be related to each other and the empirical length in such a way that the interpolation will produce the empirical proportion. These modifications were done maintaining the basic table constraints; additionally, the next section length on either side of those being modified was used as a check on the changes.

In order for the model to calculate a two way interpolation at the end of the section length, a value for the shorter length was entered at the next 250 foot interval in the tables. In most cases this value was the proportion at the upstream interval. In a few cases, this value had to be modified so that the sum of the proportions across all lanes would equal 1.

8.6.2 Table types

Data tables may be lane dependent, section width dependent, section length dependent, volume dependent or be dependent on a set of criteria. All tables are lane dependent in that they apply to a specific analysis lane. A section width dependent table has different values depending on whether there are five or six lanes in the weaving section. A length dependent table is dependent on the length of the weaving section for its values. A volume dependent table is selected generally on the basis of weaving volume.

The simplest tables are purely lane dependent. Most tables for ramp to ramp movements fall into this category. For all lengths of weaving section, the proportion of ramp to ramp traffic in each lane doesn't vary. The proportions total 100 percent across both lanes.

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Tables which are section width dependent are only possible in this model for Type C weaving sections. The only movement which demonstrates this width dependency is the freeway to freeway movement.

All of the freeway to ramp and ramp to freeway tables are section length dependent. The length dependency is found within a table rather than defining a complete table. The length of the section influences how soon drivers must make the necessary lane changes in their weaving maneuvers. Shorter sections tend to force more lane changing at the beginning of the section. Two constraints are imposed on the tables for both of these movements in terms of volume totals and trends for proportions. Freeway to ramp vehicles should have a constant or continuously increasing proportion of vehicles in the critical area and no vehicles may miss the diverge. No ramp to freeway vehicles may merge prematurely and their proportion in the critical area should be constant or continuously decreasing. A third basic constraint is that no sum of proportions must be greater than 100 percent.

Freeway to ramp and ramp to freeway tables are also volume dependent. Differences in weaving behavior have been found to vary most frequently with weaving volume. Generally there are two sets of tables for each movement as a function of weaving volume. Upstream volume has also been found to be a determinant of ramp to freeway behavior.

The following sections contain the tables used for each type of major weave along with an explanation for their development. The data tables are of varying types. They are labeled with any selection criteria which apply in addition to the lane in question.

8.6.3 Tables for a Type B section: 1 lane on-ramp/2 lane off-ramp

The freeway to freeway movement proportions for a type B12 weaving section, shown in Table 8.15, exist only for Lane 2. Lane 3 is not in the conflict section for this type of major weave.

ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
	.098	.094	.094	.093	.093	.095	.097	.097	.097	.097	.097

Table 8.15 TYPE B12 Freeway to freeway movement proportions for Lane 2.

The freeway to ramp movement proportions are dependent on the weaving volume in the section. There are three ranges for the weaving volume: less than or equal to 2000 pcph, greater than 2000 pcph but less than or equal to 2300 pcph and greater than 2300 pcph. Values for Lane 1 are shown in Table 8.16; values for Lane 2 are displayed in Table 8.17.

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In creating these tables, conflicts between the table values and the graphs were found for the 750 foot weaving section in the low volume range. The proportions at 0', 250' and 500' were modified to reflect the information provided in the graphs for both lanes. A similar problem was identified and corrected for the 2500 foot section at 2500'.

Vw <= 2000

AVING TION TH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.150	.570	.612	.634	.634						
1000	.149	.330	.524	.595	.674	.701					
1250	.136	.300	.493	.590	.676	.731	.696				
1500	.005	.286	.446	.532	.619	.632	.655	.670			
1750	.005	.320	.480	.550	.600	.630	.650	.660	.660		
2000	.020	.300	.440	.520	.580	.600	.620	.630	.640	.640	
2250	.010	.280	.400	.500	.550	.580	.600	.610	.620	.630	.630
2500	.000	.234	.347	.469	.529	.560	.573	.580	.609	.610	.623

2000 < Vw < =2300

AVING TION TH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.050	.470	.580	.640	.640						
1000	.047	.420	.560	.610	.650	.650					
1250	.045	.380	.540	.600	.630	.660	.660				
1500	.043	.328	.510	.567	.628	.631	.668	.670			
1750	.030	.310	.480	.560	.600	.630	.640	.650	.650		
2000	.020	.290	.450	.530	.570	.600	.620	.630	.630	.630	
2250	.010	.270	.410	.500	.550	.580	.590	.610	.610	.620	.620
2500	.000	.267	.374	.483	.529	.560	.573	.590	.601	.610	.616

Vw > 2300

AVING TION TH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.075	.480	.570	.610	.610						
1000	.075	.450	.560	.601	.630	.630					
1250	.070	.400	.541	.587	.630	.654	.665				
1500	.070	.388	.516	.573	.630	.640	.662	.664			
1750	.060	.390	.510	.570	.620	.630	.640	.650	.650		
2000	.040	.380	.500	.560	.610	.620	.630	.630	.640	.640	
2250	.020	.380	.490	.550	.600	.610	.620	.620	.630	.630	.630
2500	.000	.374	.484	.538	.592	.600	.605	.605	.609	.610	.612

le 8.16 TYPE B12 Freeway to ramp movement proportions for Lane 1.

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Vw <= 2000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.760	.410	.388	.366	.366						
1000	.747	.656	.470	.390	.326	.308					
1250	.730	.602	.423	.380	.313	.309	.285				
1500	.718	.521	.447	.395	.346	.346	.346	.330			
1750	.620	.550	.460	.390	.340	.350	.350	.340	.340		
2000	.540	.470	.440	.390	.350	.350	.350	.370	.360	.360	
2250	.450	.390	.420	.400	.360	.360	.360	.360	.380	.370	.370
2500	.398	.344	.430	.400	.369	.360	.352	.354	.356	.377	.377

2000 < Vw < =2300

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.750	.430	.390	.360	.360						
1000	.740	.450	.390	.370	.350	.350					
1250	.730	.480	.390	.360	.340	.340	.340				
1500	.718	.504	.389	.360	.337	.337	.337	.337			
1750	.650	.460	.390	.390	.360	.350	.350	.350	.350		
2000	.600	.440	.400	.400	.380	.370	.360	.360	.370	.370	
2250	.550	.420	.410	.410	.400	.390	.370	.370	.380	.380	.380
2500	.509	.394	.415	.409	.403	.400	.394	.390	.385	.380	.384

Vw > 2300

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.780	.420	.370	.390	.390						
1000	.760	.420	.370	.370	.370	.370					
1250	.738	.437	.380	.368	.342	.342	.341				
1500	.717	.440	.392	.365	.340	.340	.338	.338			
1750	.690	.440	.400	.370	.340	.340	.340	.350	.350		
2000	.660	.430	.410	.380	.350	.350	.350	.360	.360	.360	
2250	.630	.420	.420	.380	.370	.370	.370	.370	.370	.370	.370
2500	.616	.413	.430	.411	.393	.390	.392	.390	.388	.388	.388

Table 8.17 TYPE B12 Freeway to ramp movement proportions for Lane 2.

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The ramp to freeway tables are only lane and section length dependent. Values for Lane 1 are shown in Table 8.18; values for Lane 2 are shown in Table 8.19.

AVING ECTION ETH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.850	.360	.170	.000	.000						
1000	.880	.436	.190	.060	.000	.000					
1250	.982	.642	.248	.087	.010	.000	.000				
1500	.997	.696	.257	.147	.020	.017	.000	.000			
1750	1.000	.700	.380	.220	.100	.050	.030	.000	.000		
2000	1.000	.720	.480	.320	.200	.130	.080	.040	.000	.000	
2250	1.000	.740	.520	.440	.290	.200	.140	.080	.040	.000	.000
2500	1.000	.750	.520	.470	.350	.270	.210	.140	.060	.030	.000

ble 8.18 TYPE B12 Ramp to freeway movement proportions for Lane 1.

AVING ECTION ETH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.150	.640	.770	.830	.830						
1000	.120	.560	.744	.800	.809	.812					
1250	.018	.357	.726	.776	.786	.744	.712				
1500	.003	.304	.710	.736	.772	.706	.690	.690			
1750	.000	.290	.590	.700	.730	.704	.690	.650	.650		
2000	.000	.270	.500	.640	.680	.680	.670	.660	.610	.610	
2250	.000	.260	.470	.540	.630	.660	.660	.650	.610	.570	.570
2500	.000	.240	.450	.460	.600	.620	.630	.650	.670	.630	.520

ble 8.19 TYPE B12 Ramp to freeway movement proportions for Lane 2.

The ramp to ramp movement tables are purely lane dependent. The values for Lane 1 are shown in Table 8.20; the values for Lane 2 are shown in Table 8.21.

AVING ECTION THS	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
	.997	.951	.917	.889	.876	.871	.871	.871	.871	.871	.871

ble 8.20 TYPE B12 Ramp to ramp movement proportions for Lane 1.

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ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
	.003	.049	.083	.111	.124	.129	.129	.129	.129	.129	.129

Table 8.21 TYPE B12 Ramp to ramp movement proportions for Lane 2.

8.6.4 Tables for a Type B section: 2 lane on-ramp/2 lane off-ramp.

The freeway to freeway movement tables are solely lane dependent for this weave type. Values for Lane 2 are shown in Table 8.22; values for Lane 3 are shown in Table 8.23.

ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
	.000	.020	.050	.069	.080	.090	.090	.090	.090

Table 8.22 TYPE B22 Freeway to freeway movement proportions for Lane 2.

ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
	.250	.230	.220	.202	.180	.170	.170	.170	.160

Table 8.23 TYPE B22 Freeway to freeway movement proportions for Lane 3.

The freeway to ramp movement tables are selected on the basis of two volume criteria and are also length dependent. One is the common absolute numbers basis of weaving volumes. Here the cutoff point is a volume less than or equal to 2000 pcph. The second criteria is relational in nature. The choice is made based on whether the ramp to freeway or freeway to ramp movement is the larger of the two weaving movements. In any of the possible combinations, the volume in Lane 3 is forced to 0 at the end of the section to meet the criteria of no missing diverges. This can create problems with interpolation at the end of a section. In making modifications to these table for empirical matching it was considered more important to have no traffic in Lane 3 than to match the proportion at the next analysis point upstream. The shorter this distance the worse the match.

Values for Lane 1 are shown in Table 8.24; values for Lane 2 are shown in Table 8.25; and values for Lane 3 are shown in Table 8.26.

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FR <= FR and Vw <= 2000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION 0	250	500	750	1000	1250	1500	1750	2000
750	.000	.120	.573	.661	.661				
1000	.000	.120	.540	.646	.660	.660			
1250	.000	.120	.510	.630	.660	.660	.670		
1500	.000	.120	.490	.627	.660	.660	.660	.660	
1750	.000	.120	.480	.610	.660	.660	.660	.660	.660
2000	.000	.120	.460	.593	.660	.660	.660	.660	.660

FR <= RF and Vw > 2000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION 0	250	500	750	1000	1250	1500	1750	2000
750	.000	.120	.472	.452	.452				
1000	.000	.120	.448	.430	.440	.440			
1250	.000	.120	.430	.410	.410	.410	.410		
1500	.000	.120	.400	.379	.390	.410	.420	.420	
1750	.000	.120	.390	.360	.380	.380	.390	.380	.380
2000	.000	.120	.380	.326	.370	.370	.370	.365	.360

FR > RF and Vw <= 2000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION 0	250	500	750	1000	1250	1500	1750	2000
750	.000	.060	.487	.617	.617				
1000	.000	.060	.470	.600	.600	.600			
1250	.000	.060	.460	.580	.600	.620	.620		
1500	.000	.040	.450	.520	.590	.605	.620	.620	
1750	.000	.040	.400	.500	.570	.590	.610	.620	.620
2000	.000	.020	.360	.440	.520	.580	.600	.610	.620

FR > RF and Vw > 2000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION 0	250	500	750	1000	1250	1500	1750	2000
750	.000	.071	.500	.620	.620				
1000	.000	.060	.496	.618	.620	.620			
1250	.000	.050	.480	.590	.610	.620	.620		
1500	.000	.060	.480	.550	.620	.620	.620	.620	
1750	.000	.040	.430	.540	.590	.600	.620	.620	.620
2000	.000	.020	.390	.475	.560	.590	.620	.625	.630

Table 8.24 TYPE B22 Freeway to ramp movement proportions for Lane 1.

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FR <= FR and Vw <= 2000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION 0	250	500	750	1000	1250	1500	1750	2000
750	.060	.710	.409	.339	.339				
1000	.060	.690	.420	.350	.342	.342			
1250	.060	.680	.450	.360	.340	.340	.340		
1500	.060	.670	.470	.363	.330	.340	.340	.340	
1750	.060	.660	.470	.370	.330	.340	.340	.340	.340
2000	.060	.630	.470	.385	.330	.340	.340	.340	.340

FR <= RF and Vw > 2000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION 0	250	500	750	1000	1250	1500	1750	2000
750	.060	.712	.499	.550	.550				
1000	.060	.690	.512	.550	.560	.560			
1250	.060	.680	.520	.570	.580	.590	.590		
1500	.060	.670	.520	.589	.600	.590	.580	.580	
1750	.060	.660	.530	.630	.620	.620	.610	.620	.620
2000	.060	.650	.540	.663	.630	.630	.630	.635	.640

FR > RF and Vw <= 2000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION 0	250	500	750	1000	1250	1500	1750	2000
750	.091	.821	.515	.384	.384				
1000	.084	.807	.510	.394	.400	.390			
1250	.080	.790	.460	.380	.390	.380	.380		
1500	.070	.780	.435	.417	.400	.390	.380	.380	
1750	.070	.640	.400	.410	.400	.400	.390	.380	.380
2000	.040	.500	.390	.420	.450	.400	.390	.385	.380

FR > RF and Vw > 2000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION 0	250	500	750	1000	1250	1500	1750	2000
750	.100	.840	.500	.380	.380				
1000	.095	.835	.496	.380	.380	.380			
1250	.080	.780	.470	.380	.380	.380	.380		
1500	.070	.800	.460	.420	.380	.380	.380	.380	
1750	.070	.670	.440	.400	.410	.400	.380	.380	.380
2000	.040	.540	.420	.430	.440	.410	.380	.375	.370

Table 8.25 TYPE B22 Freeway to ramp movement proportions for Lane 2

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FR <= FR and Vw <= 2000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION 0	250	500	750	1000	1250	1500	1750	2000
750	.922	.159	.018	.000	.000				
1000	.900	.170	.035	.004	.000	.000			
1250	.900	.190	.035	.010	.000	.000	.000		
1500	.910	.200	.030	.010	.010	.000	.000	.000	
1750	.910	.210	.040	.018	.010	.000	.000	.000	.000
2000	.920	.240	.050	.021	.010	.000	.000	.000	.000

FR <= RF and Vw > 2000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION 0	250	500	750	1000	1250	1500	1750	2000
750	.920	.159	.020	.000	.000				
1000	.920	.170	.020	.002	.000	.000			
1250	.920	.190	.040	.010	.010	.000	.000		
1500	.920	.200	.070	.032	.010	.000	.000	.000	
1750	.920	.200	.070	.010	.000	.000	.000	.000	.000
2000	.920	.220	.070	.011	.000	.000	.000	.000	.000

FR > RF and Vw <= 2000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION 0	250	500	750	1000	1250	1500	1750	2000
750	.893	.119	.000	.000	.000				
1000	.860	.130	.004	.000	.000	.000			
1250	.820	.150	.080	.040	.010	.000	.000		
1500	.790	.180	.115	.063	.010	.005	.000	.000	
1750	.680	.240	.180	.090	.030	.010	.005	.000	.000
2000	.560	.300	.240	.135	.030	.020	.010	.005	.000

FR > RF and Vw > 2000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION 0	250	500	750	1000	1250	1500	1750	2000
750	.880	.089	.000	.000	.000				
1000	.875	.102	.000	.000	.000	.000			
1250	.830	.120	.000	.000	.000	.000	.000		
1500	.790	.140	.000	.000	.000	.000	.000	.000	
1750	.690	.240	.080	.060	.000	.000	.000	.000	.000
2000	.580	.300	.190	.095	.000	.000	.000	.000	.000

Table 8.26 TYPE B22 Freeway to ramp movement proportions for Lane 3.

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The ramp to freeway movement tables are section length dependent. The forcing condition on these tables is that the Lane 1 proportion must be zero at the end of the section. Values for Lane 1 are shown in Table 8.27; values for Lane 2 are shown in Table 8.28; and values for Lane 3 are shown in Table 8.29.

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.310	.098	.007	.000	.000				
1000	.310	.120	.040	.020	.000	.000			
1250	.320	.140	.100	.030	.010	.000	.000		
1500	.320	.160	.110	.063	.030	.015	.000	.000	
1750	.330	.170	.110	.070	.040	.020	.000	.000	.000
2000	.330	.190	.110	.084	.040	.020	.000	.000	.000

Table 8.27 TYPE B22 Ramp to freeway movement proportions for Lane 1.

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.680	.652	.532	.441	.441				
1000	.680	.630	.516	.436	.410	.410			
1250	.680	.600	.500	.430	.410	.390	.390		
1500	.680	.580	.480	.426	.370	.350	.330	.330	
1750	.670	.570	.490	.390	.370	.340	.330	.300	.300
2000	.670	.570	.500	.361	.350	.320	.290	.280	.260

Table 8.28 TYPE B22 Ramp to freeway movement proportions for Lane 2.

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.010	.240	.391	.420	.420				
1000	.010	.240	.380	.420	.450	.450			
1250	.000	.240	.350	.430	.450	.450	.450		
1500	.000	.240	.340	.428	.450	.455	.460	.460	
1750	.000	.230	.330	.430	.450	.460	.480	.500	.500
2000	.000	.220	.330	.439	.450	.475	.500	.505	.510

Table 8.29 TYPE B22 Ramp to freeway movement proportions for Lane 3

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The ramp to ramp tables are only lane dependent. Values for Lane 1 are shown in Table 8.30; values for Lane 2 are shown in Table 8.31.

ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
	.780	.810	.820	.775	.820	.820	.810	.810	.800

Table 8.30 TYPE B22 Ramp to ramp movement proportions for Lane 1.

ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
	.220	.190	.180	.225	.180	.180	.190	.190	.200

Table 8.31 TYPE B22 Ramp to ramp movement proportions for Lane 2.

8.6.5 Tables for a Type C section: 1 lane on-ramp/2 lane off-ramp.

A peculiarity of the C12 tables is that the actual shortest length is the empirical section length of 715 feet. Due to the decisions made on table structure, the shortest allowed analysis length is 750 feet. The values for a 750 foot section are actually those observed for the empirical site at 715 feet. The differences induced by this decision are essentially undetectable.

The freeway to freeway movement has a forcing condition on the Lane 2 volume. Since Lane 2 is dropped at the exit ramp, the proportion of through traffic in that lane must be zero at the end of the section. The Lane 2 proportions are section length dependent. The freeway to freeway volume for Lane 3 is both section width and volume dependent. In this case the critical volume is a weaving volume of 3000 pcph. Values for Lane 2 are shown in Table 8.32; values for Lane 3 are shown in table 8.33.

AVING TION TH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.004	.004	.000	.000	.000						
1000	.010	.005	.000	.000	.000	.000					
1250	.010	.005	.005	.000	.000	.000	.000				
1500	.013	.012	.011	.010	.010	.011	.000	.000			
1750	.014	.013	.012	.012	.011	.011	.002	.000	.000		
2000	.016	.015	.020	.015	.015	.010	.010	.010	.000	.000	
2250	.018	.020	.025	.020	.019	.015	.010	.005	.000	.000	.000
2500	.020	.025	.035	.030	.022	.018	.010	.005	.000	.000	.000

le 8.32 TYPE C12 Freeway to freeway movement proportions for Lane 2.

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Five lane weaving section Vw <= 3000											
ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
	.248	.242	.248	.248	.249	.249	.249	.249	.249	.249	.249
Five lane weaving section Vw > 3000											
ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
	.145	.150	.160	.165	.165	.165	.165	.165	.165	.165	.165
Six lane weaving section Vw <= 3000											
ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
	.168	.170	.172	.175	.177	.180	.185	.192	.192	.192	.192
Six lane weaving section Vw > 3000											
ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
	.145	.150	.160	.165	.165	.165	.165	.165	.165	.165	.165

Table 8.33 TYPE C12 Freeway to freeway movement proportions for Lane 3.

The freeway to ramp movement is section length and volume dependent. The weaving volume break point is less than or equal to 3000 pcph as in the freeway to freeway case. The specific forcing condition here is that the Lane 3 volume is 0 at the end of the section.

Values for Lane 1 are shown in Table 8.34; values for Lane 2 are shown in Table 8.35; and values for Lane 3 are shown in Table 8.36.

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Vw <= 3000

AVING CTION NGTH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.002	.321	.367	.382	.382						
1000	.000	.194	.357	.368	.384	.384					
1250	.000	.150	.250	.290	.340	.360	.360				
1500	.012	.089	.169	.230	.301	.354	.362	.362			
1750	.013	.070	.150	.196	.279	.332	.337	.359	.359		
2000	.013	.050	.130	.180	.260	.300	.320	.340	.340	.340	
2250	.013	.020	.080	.120	.240	.280	.310	.320	.330	.330	.330
2500	.013	.006	.050	.113	.196	.250	.281	.300	.310	.310	.310

Vw > 3000

AVING CTION NGTH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.002	.399	.437	.454	.454						
1000	.000	.350	.380	.410	.420	.420					
1250	.000	.310	.330	.370	.380	.390	.390				
1500	.000	.260	.310	.332	.360	.370	.373	.373			
1750	.000	.253	.308	.330	.360	.360	.370	.371	.371		
2000	.000	.250	.300	.330	.360	.360	.360	.360	.360	.360	
2250	.000	.250	.290	.320	.350	.360	.360	.360	.360	.360	.360
2500	.000	.233	.293	.322	.360	.360	.372	.374	.376	.375	.374

ble 8.34 TYPE C12 Freeway to ramp movement proportions for Lane 1.

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Vw <= 3000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.879	.610	.617	.618	.618						
1000	.857	.734	.613	.614	.616	.616					
1250	.820	.720	.700	.670	.640	.640	.640				
1500	.810	.785	.739	.709	.660	.640	.628	.628			
1750	.798	.781	.726	.694	.667	.642	.642	.642	.642		
2000	.700	.680	.660	.640	.660	.660	.660	.660	.660	.660	
2250	.600	.650	.630	.650	.670	.670	.660	.660	.670	.670	.670
2500	.545	.603	.628	.650	.679	.673	.667	.670	.684	.680	.690

Vw > 3000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.773	.438	.552	.546	.546						
1000	.750	.480	.580	.580	.580	.580					
1250	.720	.520	.580	.600	.610	.610	.610				
1500	.690	.532	.581	.606	.625	.625	.627	.627			
1750	.690	.550	.602	.608	.628	.629	.628	.629	.628		
2000	.690	.550	.596	.620	.620	.630	.630	.640	.640	.640	
2250	.700	.550	.590	.610	.620	.630	.630	.630	.640	.640	.640
2500	.688	.548	.596	.605	.616	.630	.626	.625	.624	.625	.626

Table 8.35 TYPE C12 Freeway to ramp movement proportions for Lane 2.

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Vw <= 3000

AVING TION GTH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.104	.064	.011	.000	.000						
1000	.093	.045	.019	.011	.000	.000					
1250	.140	.060	.040	.030	.010	.000	.000				
1500	.151	.120	.090	.060	.030	.005	.000	.000			
1750	.156	.127	.095	.080	.046	.030	.001	.000	.000		
2000	.170	.150	.110	.090	.060	.030	.010	.000	.000	.000	
2250	.170	.150	.115	.100	.060	.040	.020	.000	.000	.000	.000
2500	.175	.156	.126	.101	.068	.050	.025	.010	.005	.000	.000

Vw > 3000

AVING TION GTH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.216	.159	.011	.000	.000						
1000	.216	.160	.040	.010	.000	.000					
1250	.216	.160	.080	.020	.010	.000	.000				
1500	.217	.160	.106	.056	.014	.000	.000	.000			
1750	.217	.160	.085	.061	.012	.005	.002	.000	.000		
2000	.200	.160	.080	.030	.010	.010	.010	.000	.000	.000	
2250	.188	.160	.090	.065	.020	.010	.002	.000	.000	.000	.000
2500	.188	.156	.095	.065	.023	.010	.002	.000	.000	.000	.000

ble 8.36 TYPE C12 Freeway to ramp movement proportions for Lane 3.

The ramp to freeway volumes are section length dependent. In this case both the Lane 1 and 2 volumes must be zero at the end of the section since neither lane is a through freeway lane. Values for Lane 1 are shown in Table 8.37; values for Lane 2 are shown in Table 8.38; and values for Lane 3 are shown in Table 8.39.

AVING TION TH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	1.000	.180	.000	.000	.000						
1000	1.000	.320	.100	.040	.000	.000					
1250	1.000	.600	.220	.100	.030	.000	.000				
1500	1.000	.688	.324	.200	.058	.028	.000	.000			
1750	1.000	.728	.352	.200	.062	.032	.005	.000	.000		
2000	1.000	.730	.360	.210	.070	.034	.010	.000	.000	.000	
2250	1.000	.740	.370	.220	.080	.050	.010	.000	.000	.000	.000
2500	1.000	.750	.380	.250	.110	.060	.020	.000	.000	.000	.000

ble 8.37 TYPE C12 Ramp to freeway movement proportions for Lane 1.

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WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.000	.730	.230	.000	.000						
1000	.000	.580	.500	.150	.000	.000					
1250	.000	.340	.600	.430	.200	.000	.000				
1500	.000	.303	.570	.542	.438	.280	.000	.000			
1750	.000	.262	.570	.556	.476	.390	.160	.000	.000		
2000	.000	.260	.560	.540	.480	.370	.220	.050	.000	.000	
2250	.000	.250	.550	.540	.480	.370	.230	.070	.000	.000	.000
2500	.000	.240	.550	.540	.440	.370	.240	.100	.000	.000	.000

Table 8.38 TYPE C12 Ramp to freeway movement proportions for Lane 2.

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
750	.000	.090	.740	.930	.930						
1000	.000	.070	.340	.700	.880	.880					
1250	.000	.040	.160	.440	.630	.820	.820				
1500	.000	.009	.085	.218	.433	.570	.710	.710			
1750	.000	.010	.076	.187	.410	.510	.600	.680	.680		
2000	.000	.010	.060	.180	.390	.510	.700	.640	.580	.580	
2250	.000	.010	.060	.190	.390	.510	.620	.570	.450	.450	.450
2500	.000	.010	.050	.150	.370	.510	.600	.450	.300	.280	.260

Table 8.39 TYPE C12 Ramp to freeway movement proportions for Lane 3.

The ramp to ramp tables are similar in nature to the type B weaves. Values for Lane 1 are shown in Table 8.40; values for Lane 2 are shown in Table 8.41.

ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
	.998	.992	.971	.958	.941	.937	.929	.927	.925	.925	.925

Table 8.40 TYPE C12 Ramp to ramp movement proportions for Lane 1.

ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION										
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500
	.002	.008	.029	.042	.059	.063	.071	.073	.075	.075	.075

Table 8.41 TYPE C12 Ramp to ramp movement proportions for Lane 2.

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8.6.6 Tables for a Type C section: 2 lane on-ramp/1 lane off-ramp.

The freeway to freeway tables are section width dependent in the case of Lane 3. This is reasonable since the weave adds a through lane to the section. The Lane 2 proportion is only lane dependent.

Values for Lane 2 are shown in Table 8.42; values for Lane 3 are shown in Table 8.43.

ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
	.248	.242	.248	.248	.249	.249	.249	.249	.249

Table 8.42 TYPE C21 Freeway to freeway movement proportions for Lane 2.

Five lane weaving section									
ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
	.240	.235	.230	.232	.235	.235	.235	.235	.235
Six lane weaving section									
ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
	.100	.097	.099	.099	.099	.099	.099	.099	.099

Table 8.43 TYPE C21 Freeway to freeway movement proportions for Lane 3.

The freeway to ramp tables are weaving volume and section length dependent. The tables are selected on whether or not the weaving volume is less than or equal to 3000 pcph. Both the Lane 2 and 3 volumes are forced to 0 at the end of the section.

Values for Lane 1 are shown in Table 8.44; values for Lane 2 are shown in Table 8.45; and values for Lane 3 are shown in Table 8.46.

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Vw <= 3000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.000	.400	.800	1.000	1.000				
1000	.000	.370	.745	.934	1.000	1.000			
1250	.000	.358	.727	.852	1.000	1.000	1.000		
1500	.000	.360	.690	.850	.990	1.000	1.000	1.000	
1750	.000	.360	.670	.840	.980	1.000	1.000	1.000	1.000
2000	.000	.360	.650	.820	.990	1.000	1.000	1.000	1.000

Vw > 3000

WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.000	.300	.700	1.000	1.000				
1000	.000	.192	.642	.821	1.000	1.000			
1250	.000	.130	.550	.790	1.000	1.000	1.000		
1500	.000	.120	.550	.785	.980	.990	1.000	1.000	
1750	.000	.100	.500	.780	.940	.990	.990	1.000	1.000
2000	.000	.090	.460	.715	.970	.980	.990	.995	1.000

Table 8.44 TYPE C21 Freeway to ramp movement proportions for Lane 1

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Vw <= 3000									
WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.060	.330	.190	.000	.000				
1000	.050	.380	.190	.048	.000	.000			
1250	.038	.416	.202	.110	.000	.000	.000		
1500	.036	.420	.168	.080	.000	.000	.000	.000	
1750	.030	.450	.130	.060	.000	.000	.000	.000	.000
2000	.030	.470	.100	.055	.010	.000	.000	.000	.000

Vw > 3000									
WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.060	.500	.290	.000	.000				
1000	.041	.410	.309	.134	.000	.000			
1250	.040	.410	.322	.165	.000	.000	.000		
1500	.040	.410	.325	.168	.020	.010	.000	.000	
1750	.040	.420	.330	.170	.040	.010	.010	.000	.000
2000	.030	.420	.340	.180	.020	.020	.010	.005	.000

Table 8.45 TYPE C21 Freeway to ramp movement proportions for Lane 2.

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Vw <= 3000									
WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.870	.270	.010	.000	.000				
1000	.860	.191	.064	.018	.000	.000			
1250	.860	.178	.071	.038	.000	.000	.000		
1500	.870	.170	.140	.057	.010	.000	.000	.000	
1750	.880	.150	.170	.080	.000	.000	.000	.000	.000
2000	.870	.140	.230	.115	.000	.000	.000	.000	.000

Vw > 3000									
WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.870	.200	.010	.000	.000				
1000	.860	.344	.044	.019	.000	.000			
1250	.860	.375	.075	.038	.000	.000	.000		
1500	.860	.380	.100	.040	.000	.000	.000	.000	
1750	.860	.390	.150	.030	.010	.000	.000	.000	.000
2000	.860	.400	.200	.105	.010	.000	.000	.000	.000

Table 8.46 TYPE C21 Freeway to ramp movement proportions for Lane 3.

The ramp to freeway tables are section length and volume dependent. The volume dependency is not weaving volume but upstream freeway volume. The critical volume is 5500 pcph. The forcing condition in this set of tables is that the Lane 1 volume must be 0 at the end of the section.

Values for Lane 1 are shown in Table 8.47; values for Lane 2 are shown in Table 8.48; and values for Lane 3 are shown in Table 8.49.

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Volume upstream of weaving section Vup <= 5500									
WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.260	.070	.000	.000	.000				
1000	.284	.079	.009	.005	.000	.000			
1250	.310	.090	.019	.010	.000	.000	.000		
1500	.330	.100	.040	.020	.000	.000	.000	.000	
1750	.340	.130	.040	.030	.010	.000	.000	.000	.000
2000	.350	.140	.040	.025	.010	.005	.000	.000	.000

Volume upstream of weaving section Vup > 5500									
WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.290	.160	.030	.000	.000				
1000	.299	.180	.055	.020	.000	.000			
1250	.310	.199	.080	.040	.000	.000	.000		
1500	.310	.210	.090	.050	.010	.000	.000	.000	
1750	.320	.220	.120	.060	.030	.010	.000	.000	.000
2000	.300	.220	.140	.095	.050	.030	.010	.000	.000

Table 8.47 TYPE C21 Ramp to freeway movement proportions for Lane 1.

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Volume upstream of weaving section Vup <= 5500									
WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.650	.520	.520	.420	.420				
1000	.659	.525	.491	.417	.396	.396			
1250	.670	.530	.459	.415	.370	.370	.370		
1500	.660	.520	.480	.430	.390	.380	.380	.380	
1750	.660	.520	.500	.460	.410	.400	.380	.380	.380
2000	.650	.520	.520	.470	.420	.415	.410	.390	.370

Volume upstream of weaving section Vup > 5500									
WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.670	.550	.480	.490	.490				
1000	.670	.541	.471	.453	.432	.432			
1250	.670	.530	.460	.415	.370	.370	.370		
1500	.670	.540	.450	.400	.370	.370	.370	.370	
1750	.670	.540	.440	.400	.360	.360	.360	.360	.360
2000	.670	.510	.440	.400	.360	.370	.380	.380	.380

Table 8.48 TYPE C21 Ramp to freeway movement proportions for Lane 2

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Volume upstream of weaving section Vup <= 5500									
WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.090	.400	.460	.480	.480				
1000	.056	.380	.445	.458	.460	.460			
1250	.020	.360	.431	.436	.440	.440	.440		
1500	.010	.350	.410	.420	.430	.440	.440	.440	
1750	.000	.330	.380	.410	.410	.430	.450	.460	.460
2000	.000	.320	.370	.385	.400	.400	.400	.425	.450

Volume upstream of weaving section Vup > 5500									
WEAVING SECTION LENGTH	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
750	.040	.290	.360	.400	.400				
1000	.030	.275	.336	.368	.380	.380			
1250	.020	.260	.310	.336	.360	.360	.360		
1500	.020	.250	.300	.324	.350	.350	.340	.340	
1750	.010	.240	.300	.320	.340	.340	.330	.330	.330
2000	.030	.260	.290	.305	.320	.320	.320	.345	.370

Table 8.49 TYPE C21 Ramp to freeway movement proportions for Lane 3.

The ramp to ramp tables are somewhat unusual for this case, the only single lane off-ramp condition. This results in forcing the Lane 2 ramp to ramp volume to 0 at the end of the section. Values for Lane 1 are shown in Table 8.50; values for Lane 2 are shown in Table 8.51.

ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
	.834	.942	.968	1.000	1.000	1.000	1.000	1.000	1.000

Table 8.50 TYPE C21 Ramp to ramp movement proportions for Lane 1.

ALL WEAVING SECTION LENGTHS	POINT ALONG WEAVING SECTION								
	0	250	500	750	1000	1250	1500	1750	2000
	.166	.058	.032	.000	.000	.000	.000	.000	.000

Table 8.51 TYPE C21 Ramp to ramp movement proportions for Lane 2.

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8.7 Simple weave: a UCB modification of "Level D"

The "Level D" analysis that was originally incorporated into the FRELANE model was the method described in CALTRANS Traffic Bulletin No. 4. However, because this method consistently underestimates the total point flows for Lane 2, research was conducted to improve the estimates of the freeway to freeway percentages in that lane. (9) The estimates for all other movements in Lane 2 and all movements in lane 1 are those determined from the CALTRANS "Level D" tables.

8.7.1 FF percentages calculated by FRELANE for "Level D"

The estimates of the freeway to freeway percentage in Lane 2 have been modified for ramp weaving sections on a 4-lane freeway section operating under various flow ranges. The modifications were undertaken to improve the point flow estimates in the right-most through lane. The improvement process involved a calibration effort and a validation effort.

The total point flow methodology has been demonstrated to predict point flows in critical area of the analysis section more accurately that the "Level D" methodology. The calibration process derived an expected FF percentage by forcing the estimates obtained by "Level D" to agree with those for the Total Point Flow method in the right-most through lane for identical input volumes. So that the resulting estimating equation could be checked using both analysis methodologies the range of inputs used was restricted to those under which both analysis methodologies were valid for empirical conditions. Those ranges are:

Weaving Section Length:	1000 - 2000 ft (LENGTH)
Upstream Volume Demand:	4816 - 7200 pcph (S1)
Freeway to Freeway Demand:	4242 - 6500 pcph
Freeway to Ramp Demand:	330 - 856 pcph
Ramp to Freeway Demand:	214 - 1480 pcph
Ramp to ramp Demand:	4 - 148 pcph
On-ramp Demand:	222 - 1800 pcph (ON)
Off-ramp Demand:	338 - 1004 pcph (OFF)
Subsection 2 Demand:	5914 - 9000 pcph
Downstream Volume Demand:	5378 - 7200 pcph
Weaving Volume:	950 - 2780 pcph

The calibration stage assumed not only that the Total Point Flow estimates were correct but that the freeway to ramp and ramp to freeway estimates in "Level D" were correct. The expected FF percentages derived were used to develop an

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equation to estimate an FF percentage. The following equation was found to be the best estimator for the FF percentage as a function of weaving section length, upstream section demand (S1), on-ramp demand (ON) and off-ramp demand (OFF).

$$FF\% = 7.92 + 0.0117*(LENGTH) - 0.0021*(S1) - 0.0051*(ON) + 0.0155*(OFF)$$

In the validation process, the performance of the "Level D" methodology using the derived FF percentage estimating equation was checked. The validation process utilized the empirical data from four freeway ramp weaving sections used to develop the Total Point Flow method. It produced significant improvements in the point flow prediction when used with the "Level D" methodology.

8.7.2 Simple weave movement proportion tables: "Level D".

The following tables were provided by CALTRANS for their Traffic Bulletin No.4 "Level D" simple weave analysis method. These values, with the exception of freeway to freeway volume in lane 2, have been incorporated into the model for the "Level D" alternative method for analyzing four lane simple weaving sections.

The freeway to freeway movement proportions for lane 2 which are incorporated in CALTRANS Traffic Bulletin No. 4 are dependent solely on the total freeway to freeway volume. The proportion value is independent of the length of the section and is uniform throughout the section. The values in the table below are those included in CALTRANS Traffic Bulletin No. 4; as described above, they have been replaced in the FRELANE model by a calculated freeway to freeway value. They are included here for reference and can be entered as a user-supplied freeway to freeway value if desired (see Section 8.8).

TOTAL FREEWAY TO FREEWAY VOLUME											
< 1500	1500 TO < 2000	2000 TO < 2500	2500 TO < 3000	3000 TO < 3500	3500 TO < 4000	4000 TO < 4500	4500 TO < 5000	5000 TO < 5500	5500 TO < 6000	6000 TO < 6500	<= 6500
.08	.08	.08	.08	.08	.08	.08	.08	.09	.10	.10	.10

Table 8.52 "Level D" freeway to freeway movement proportions for Lane 2.

The freeway to ramp movement proportions and the ramp to freeway movement proportions are dependent on the weaving section length and the location of the analysis point along the section.

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WEAVING SECTION LENGTH	POINT ALONG SIMPLE WEAVING SECTION												
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
1000	.00	.38	.76	.86	1.00	1.00							
1250	.00	.34	.68	.83	.92	1.00	1.00						
1500	.00	.32	.63	.74	.89	.93	1.00	1.00					
1750	.00	.27	.54	.69	.79	.90	.94	1.00	1.00				
2000	.00	.25	.50	.59	.73	.80	.91	.94	1.00	1.00			
2250	.00	.22	.44	.55	.63	.74	.81	.91	.95	1.00	1.00		
2500	.00	.19	.37	.48	.58	.64	.75	.81	.91	.95	1.00	1.00	
2750	.00	.15	.29	.40	.50	.58	.64	.75	.81	.91	.95	1.00	1.00
3000	.00	.11	.23	.31	.41	.50	.59	.64	.75	.81	.91	.95	1.00

Table 8.53 "Level D" freeway to ramp movement proportions for Lane 1.

WEAVING SECTION LENGTH	POINT ALONG SIMPLE WEAVING SECTION												
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
1000	.95	.60	.24	.12	.00	.00							
1250	.87	.64	.40	.16	.08	.00	.00						
1500	.79	.56	.32	.20	.08	.04	.00	.00					
1750	.71	.54	.40	.26	.17	.08	.04	.00	.00				
2000	.63	.46	.29	.24	.19	.14	.08	.04	.00	.00			
2250	.55	.45	.35	.24	.22	.19	.14	.08	.04	.00	.00		
2500	.46	.36	.26	.23	.19	.19	.19	.14	.08	.04	.00	.00	
2750	.38	.35	.29	.23	.21	.19	.19	.19	.14	.08	.04	.00	.00
3000	.29	.27	.24	.22	.20	.20	.19	.19	.19	.14	.08	.04	.00

Table 8.54 "Level D" freeway to ramp movement proportions for Lane 2.

WEAVING SECTION LENGTH	POINT ALONG SIMPLE WEAVING SECTION												
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
1000	1.00	.60	.20	.10	.00	.00							
1250	1.00	.63	.28	.16	.04	.00	.00						
1500	1.00	.67	.35	.21	.07	.04	.00	.00					
1750	1.00	.71	.43	.27	.11	.07	.02	.00	.00				
2000	1.00	.75	.50	.32	.14	.09	.03	.02	.00	.00			
2250	1.00	.78	.56	.38	.19	.13	.06	.04	.02	.00	.00		
2500	1.00	.81	.62	.43	.23	.16	.09	.06	.03	.02	.00	.00	
2750	1.00	.84	.69	.49	.28	.20	.12	.09	.05	.04	.02	.00	.00
3000	1.00	.87	.75	.54	.32	.24	.15	.11	.07	.05	.03	.02	.00

Table 8.55 "Level D" ramp to freeway movement proportions for Lane 1.

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AVING SECTION LENGTH	POINT ALONG SIMPLE WEAVING SECTION												
	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
1000	.00	.40	.80	.74	.68	.68							
1250	.00	.37	.72	.71	.68	.56	.56						
1500	.00	.33	.65	.66	.67	.55	.43	.43					
1750	.00	.29	.57	.63	.67	.57	.46	.37	.37				
2000	.00	.25	.50	.58	.66	.57	.48	.39	.30	.30			
2250	.00	.22	.44	.54	.64	.57	.49	.40	.32	.27	.27		
2500	.00	.19	.38	.50	.62	.56	.49	.41	.33	.28	.23	.23	
2750	.00	.16	.31	.46	.60	.55	.50	.42	.35	.30	.24	.22	.22
3000	.00	.13	.25	.42	.58	.54	.50	.43	.36	.31	.25	.23	.20

'le 8.56 "Level D" ramp to freeway movement proportions for Lane 2.

8.8 User-supplied freeway to freeway percentages.

FRELANE allows the user to enter user-specified freeway to freeway (FF) percentages for Major Weaving sections and for "Level D" analysis of Simple Weaves. This selection can be accessed from the Optional Data item of the Modification Menu.

The decision to enter user-supplied FF percentages should be made only it it is known that the embedded values do not properly reflect the conditions being analyzed. Because the use of this option has such a profound effect on the results of the the analysis, the user is required to enter a password in order to activate the user-supplied FF percentages input option or to analyze a weaving section which contains user-supplied FF percentages entered in a previous session.

The model displays FF percentage defaults when the user-supplied FF percentages option is first requested. The default screen depends on whether a Major Weave or a Simple Weave is being analyzed.

The defaults for a major weave being analyzed are those embedded in the model for that particular analysis and can be found in Appendix Section 8.6 of the User's Guide. The input screen for the B12 Major Weave will have only one row of FF default values since it has only one lane in the conflict area that includes the FF movement. The other Major Weaves that can be analyzed by this model will have two rows of FF default values, one for each of the two lanes in the conflict area that includes the FF movement. The entry screen for FF percentages for the sample B12 1460 foot Major Weaving section described in Section 3 of the User's Guide is shown in Figure 8.1 below. Notice that there is one row of possible user input, that

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FRELANE requires a value at 1500 feet (the next evaluation point downstream of the end of the weaving section), and that the default values are those that are embedded in the Model for a type B12 Major Weave.

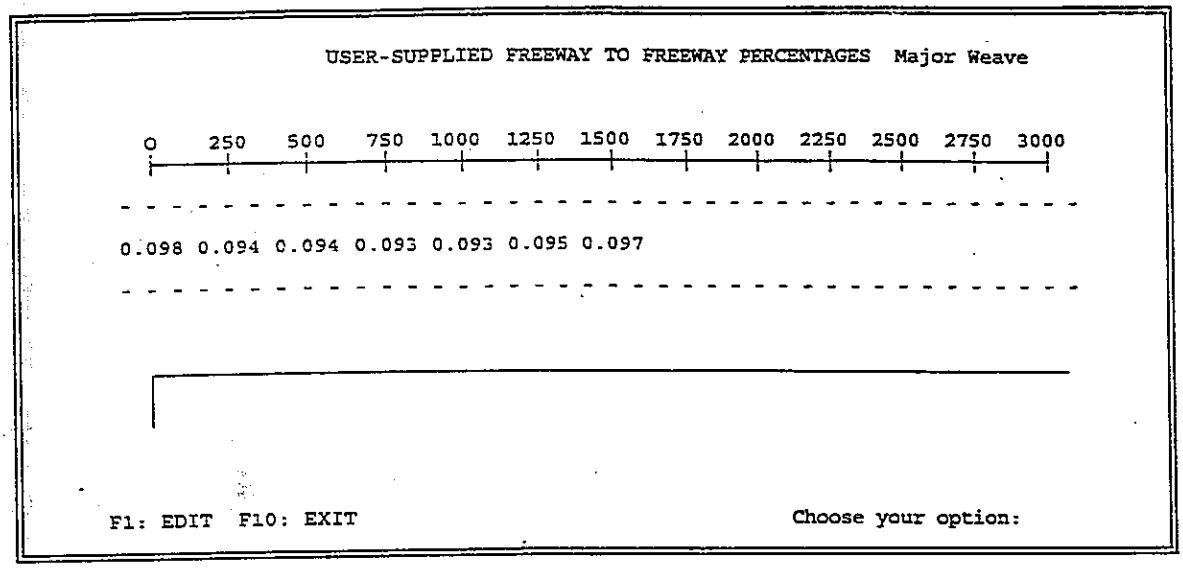

Figure 8.1 Input screen for User-Supplied Freeway to Freeway Percentages for Major Weaves.

If the section being analyzed is a Simple Weave, the default is the FF percentage estimated by the equation discussed in Section 8.7 of the User's Guide. As shown in Figure 8.2, the FF percentage for a Simple Weave is constant throughout the section. Two possible values are suggested to the user in the lower part of the screen, the first is the embedded default, the second is the value that would be used in an analysis which conformed strictly to CALTRANS Traffic Bulletin No. 4. It should be noted that while the upper limit for the embedded estimated percentage is 0.35 based on the validation ranges discussed earlier, the user's choice of a value is not similarly restricted.

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```
USER-SUPPLIED FREEWAY TO FREEWAY PERCENTAGES  Simple Weave

0    250   500   750  1000  1250  1500  1750  2000  2250  2500  2750  3000
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
0.207 0.207 0.207 0.207 0.207 0.207 0.207 0.207 0.207
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

                    ITS-UCB computed FF value: 0.207
CALTRANS Level D (Traffic Bulletin 4) value: 0.090

F1: EDIT  F10: EXIT                          Choose your option:
```

Figure 8.2 Input screen for User-Supplied Freeway to Freeway Percentages for Simple Weaves "Level D" analysis.

The user may change any of the values that are displayed. If the user exits the user-supplied FF percentage input screen without changing any of the default values, the program will automatically disengage the user-supplied FF percentages option. If any of the default values are changed, the user should save the new set of FF percentages by saving the data set from the Main Menu. Once the user-supplied FF percentages have been entered and saved, the user may disengage them and re-engage them at a later time without having to enter the percentages again.

Whenever the user-supplied FF percentages are engaged, they will be used by the model. The user will be alerted to their use by a message that appears on the analysis screens and the appropriate hardcopy output. The actual percentage used will be included in the message.

8.9 Printing specifications.

The FRELANE model assumes that the printer has been set to 60 lines per page in Portrait mode. This setting will minimize the printer changes required while running the FRELANE model.

In order for the three subsection geometry maps to be printed on just one page, several non-critical lines were removed from the first and last subsection during printing. No lines were removed from analyzed section. Thus, the printed and screen renditions of the analyzed section remain identical.

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The four subsection segments (On On and Multiple Weaves) will require two pages for printing.

To print the rotated graphic of the analyzed section, the user need only change to Landscape mode. The number of lines will automatically change to 45 per page as long as the printer was set to 60 line per page in Portrait mode. Rotated graphics for all of the analyzed sections can be printed within the 45 line requirement.

8.10 File extensions used by the FRELANE model

The FRELANE model automatically appends a file extension to each data set as it is saved. The file extension is specific to the type of freeway segment the data set represents. When the user chooses to retrieve a data set in the list mode, only those data sets with the appropriate extension for the selected freeway segment will be displayed. Thus users need not be concerned with determining which of their data sets were developed for which segment type.

The following file extensions are appended as specified:

1.	Major Weaves	.frw	consistent with files created by the FREWEV model
2.	Simple Weaves	.fsw	
3.	On-Off no aux	.fnf	
4.	Straight Pipe	.fsp	
5.	Isolated On	.fon	
6.	Isolated Off	.fof	
7.	On-On	.foo	
8.	Multiple Weave	.fmw	

In addition, a file extension of .fas is appended to the user-specified file name for capturing rotated graphic output for the analyzis sections.

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