Abridgment

Usage of Three Rest Areas in Vermont

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The purpose of the research reported here was to discover, or formulate, models for estimating usage of a welcome center and to estimate the parameters for such a model. The literature review revealed that each rest area should be modeled separately by a simple proportion of the traffic passing by the rest area. Examination of three rest areas in Vermont for which extensive data collection was undertaken revealed peaking patterns and model parameters. In general, the greatest peaks occur on summer and fall holiday weekends. On Fridays, traffic peaks from noon to 8:00 p.m. On Saturdays, a sharp, high peak occurs between 10:00 a.m. and noon. The proportion of vehicles stopping at each rest area studied is reasonably consistent. A further study of peak Saturday proportion stopping confirmed the model as formulated and estimated parameters for the model.

Design of a rest area or welcome center depends on accurate estimates of the usage of the facility. The purpose of the research reported here was to discover or formulate models for estimating usage of a welcome center and to estimate the parameters for such a model. An understanding of the peaking pattern of usage and its relationship with travel on the highway facility served by the rest area or welcome center is also necessary for accurate forecasting. Particular elements for which forecasts of future usage are necessary include sizes of automobile and truck parking lots and rest facilities. The overall design of the facility is also affected by the amount of expected usage.

LITERATURE REVIEW

Estimating welcome center and rest area usage has been the subject of several reports and papers. The earliest design guidelines are reported in *NCHRP Synthesis of Highway Practice 20* (*1*) and are based on a design procedure originated by the state of Oregon. Parking is based on design hourly traffic, which is found from average daily traffic using a *K* factor of 0.135 and a *D* factor of 0.6, which is a standard procedure with more or less standard values for *K* and *D*. From this, the number of vehicles stopping in the peak hour is estimated based on the proportion of vehicles stopping, which ranges from 5 percent to 13 percent of traffic.

Essentially the same procedure for estimating usage is used in the report *Safety Rest Area Planning, Location and Design*, prepared by the Minnesota Department of Transportation (*2*). Two factors further recognized in this report were that some peaking occurs during the summer and that the percentage of vehicles that stop varies by distance between rest areas.

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Two recent studies, one in Virginia and one in Washington, have estimated values of design parameters for rest areas and welcome centers. In the Virginia study (*3*) seven rest areas and four welcome centers were studied.

In Washington (*4*), a study of rest area design criteria was undertaken. Reported were values of the proportion of traffic entering rest area, description of vehicle types, vehicle occupancy, and vehicle lengths of stay. The proportion of traffic entering the site on average days varied from 6 to 21.5 percent. During peak periods, the values ranged from 7.5 to 44 percent.

The most comprehensive and recent report on rest areas was prepared under NCHRP Project 2-15 by KLD Associates (*5*). In this study, individual studies from 12 states and a 1971 nationwide study were examined. Also included in this study was an examination of models for predicting the percentage of mainline traffic using a rest area based on distance between rest areas. Reported was a model using an FHWA formulation, which was tested using data collected in the study, that was found to underrepresent the percentage stopping. Several models were developed in the study, but were not thought to have wide applicability. This study recommended that usage be based on stopping percentage calculated from existing rest areas.

On the basis of time studies, the general model can be formulated as follows:

$$V = A\,pk \qquad (1)$$

where

V = peak hour entering volume,
A = mainline daily volume in direction served by rest area,
p = proportion of traffic entering rest area, and
k = proportion of daily traffic in peak hour.

The problem then becomes one of estimating the factors p and k.

REST AREA DATA ANALYSIS

To estimate the stopping percentage, an extensive data collection effort was undertaken as part of a study of welcome centers in Vermont. The locations studied were Guilford, Derby, and Sharon. Guilford is a welcome center on I-91 approximately 0.1 mi north of the Massachusetts border. Derby is a rest area used as a part-year welcome center on I-91 approximately 3 mi south of the Canadian border. Sharon is a rest area on I-89, approximately 9 mi north of the New Hampshire border.

Near each of the rest area sites to be studied, and within each site's Interstate segment, Vermont has maintained a permanent counting station. Each station has a record of counts going back at least 20 years.

At each of the rest areas studied, hourly entering volumes were collected from mid-May to the end of October. Also collected were directional hourly volumes at each of the permanent counting stations. From these data, the percentage entering the rest area and peaking characteristics were studied. The overall percentage entering the rest area was 14.4 percent for Guilford, 10.7 percent for Derby, and 7.7 percent for Sharon.

The data for each of the rest areas were accumulated and summarized. Only the summary for Guilford is shown; data for the other rest areas are similar. Table 1 illustrates entering traffic, total mainline traffic in the counting direction, and percentage entering by month and day of the week for Guilford. The highest months are July and August; October and May are lower but do not include the entire month. By day of the week, Friday and Saturday show the highest traffic levels and numbers using the rest area. The percentage entering remains remarkably consistent by both month and by day of the week.

Peaking characteristics were also examined. In general, for these months, the peak days of travel were Fridays and Saturdays for the directions serving the rest area (i.e., northbound in Guilford and Sharon, southbound in Derby).

For Guilford, Figure 1 shows total daily entering traffic for Fridays and Saturdays from May 19 to October 28, 1989. As illustrated in the figure, the peak weekends are Memorial Day, the weekend preceding the Fourth of July, Labor Day, and fall foliage season. The highest peak was experienced June 30 through July 1, the weekend preceding the Fourth of July. Weekends in July and August were also high but not as high as the peak weekends. For the most part, total daily traffic on Fridays and Saturdays was approximately equal, although peak Saturday traffic on July 1 far exceeds June 30 Friday traffic. The pattern of mainline daily traffic closely follows the entering traffic pattern in Figure 1, although total daily Saturday traffic tends to be lower than total Friday traffic volumes. In general, Saturday peak hours tend to be much higher, a fact borne out by the hourly variation patterns, which will be discussed later. A similar set of graphs was plotted for Derby and Sharon.

For each rest area, the hourly variation of traffic for the peak weekends described above was examined to ascertain peaking characteristics. The hourly variation in entering traffic for Fridays for Guilford is shown in Figure 2. In general traffic volumes reached a peak by 10:00 a.m. and remained at that level until 8:00 p.m. They decline to their minimum level by midnight. The highest volume on a Friday was observed on June 30. Volumes, except for two instances, did not exceed 200 vehicles per hour. The hourly variation in mainline traffic for Fridays shows a consistent pattern for all the peak Fridays, which varies from the pattern for entering traffic. The hourly volumes increase steadily throughout the day and peak between 6:00 and 8:00 p.m., then decline precipitously toward midnight. The implication is that during the earlier part of the day, a higher percentage of vehicles stop than during the peak hours of 6:00 to 8:00 p.m. Figure 3 shows the hourly variation in entering traffic for Saturdays. This illustrates a sharper peak, and a higher peak, than that shown for Fridays. The peak occurs generally at 10:00 a.m. and remains high until noon, then declines through the rest of the day. This

TABLE 1 DAY OF WEEK SUMMARY SHOWING MAINLINE TRAFFIC, ENTERING TRAFFIC, AND PERCENTAGE ENTERING FOR GUILFORD

MONTH	MON.	TUES.	WED.	THURS.	FRI.	SAT.	SUN.	MONTHLY TOTALS
May	1,603	1,330	1,220	889	3,306	3,306	2,056	13,710
	10,368	9,502	10,084	6,211	22,466	20,887	14,482	94,000
	15.5	14.0	12.1	14.3	14.7	15.8	14.2	14.6
June	3,315	2,780	2,938	4,166	8,289	5,104	4,323	30,915
	20,559	20,272	22,416	30,478	57,613	32,952	28,490	212,780
	16.1	13.7	13.1	13.7	14.4	15.5	15.2	14.5
July	5,490	3,490	3,489	3,122	7,114	10,623	7,116	40,444
	35,154	23,823	26,598	28,782	51,620	63,296	46,369	275,642
	15.6	14.6	13.1	10.8	13.8	16.8	15.3	14.7
August	4,415	5,001	5,183	5,785	8,099	7,401	5,461	41,345
	28,478	33,936	35,770	41,343	56,044	46,343	36,563	278,477
	15.5	14.7	14.5	14.0	14.5	16.0	14.9	14.8
September	3,971	2,977	3,024	3,376	8,916	8,115	4,695	35,074
	24,940	22,421	23,538	26,021	66,073	54,275	32,813	250,071
	15.9	13.3	12.9	13.0	13.5	15.0	14.3	14.0
October	3,526	1,673	1,276	1,322	2,486	4,685	4,895	19,863
	22,035	15,568	11,387	12,410	21,939	31,385	33,740	148,464
	16.0	10.7	11.2	10.7	11.3	14.9	14.5	13.4
TOTAL	22,320	17,251	17,130	18,660	38,210	39,234	28,546	181,351
	141,534	125,522	129,783	145,245	275,755	249,138	192,457	1,259,434
	15.8	13.7	13.2	12.8	13.9	15.7	14.8	14.4

Legend:

Line 1 Rest Area Entering Traffic
Line 2 Northbound Mainline Traffic
Line 3 Percentage Entering

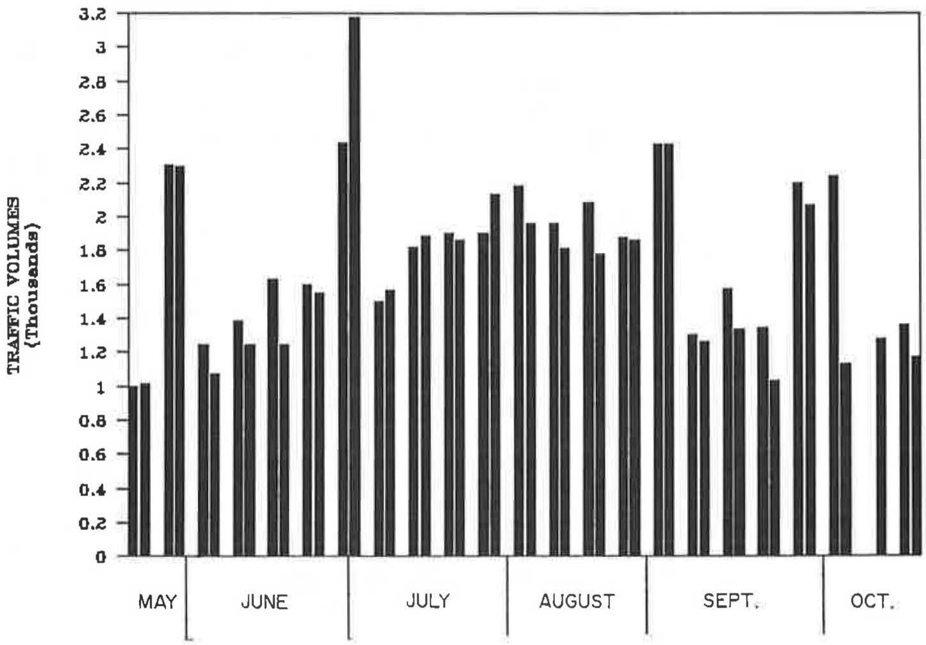

FIGURE 1 Total daily entering traffic for Guilford for Fridays and Saturdays, summer through fall 1989.

peaking phenomenon mirrors the peaking illustrated for the mainline traffic.

For Derby, the peak for Fridays and Saturdays tends to be less prominent, and the variation in hourly volumes tends to be greater. Volumes tend to be much less than for Guilford.

The Sharon rest area shows a pattern similar to that of Guilford. Volumes build in the morning, remain high through the afternoon, and decline after about 8:00 p.m. The hourly variation on Fridays for mainline traffic tends to peak in the afternoon, somewhat earlier than Guilford. Entering Saturday traffic volumes tend to peak at about noon, whereas the mainline volumes tend to remain constant from 10:00 a.m. to 2:00 p.m. and then decline gradually through the afternoon.

To summarize, in general, on Fridays, peak hourly volumes are reached by noon and continue, more or less level, to 8:00 p.m. On Saturdays, peak hours occur between 10:00 a.m. and noon. These hourly volumes were greater than the Friday peak hour volumes, but other hourly volumes tended to be

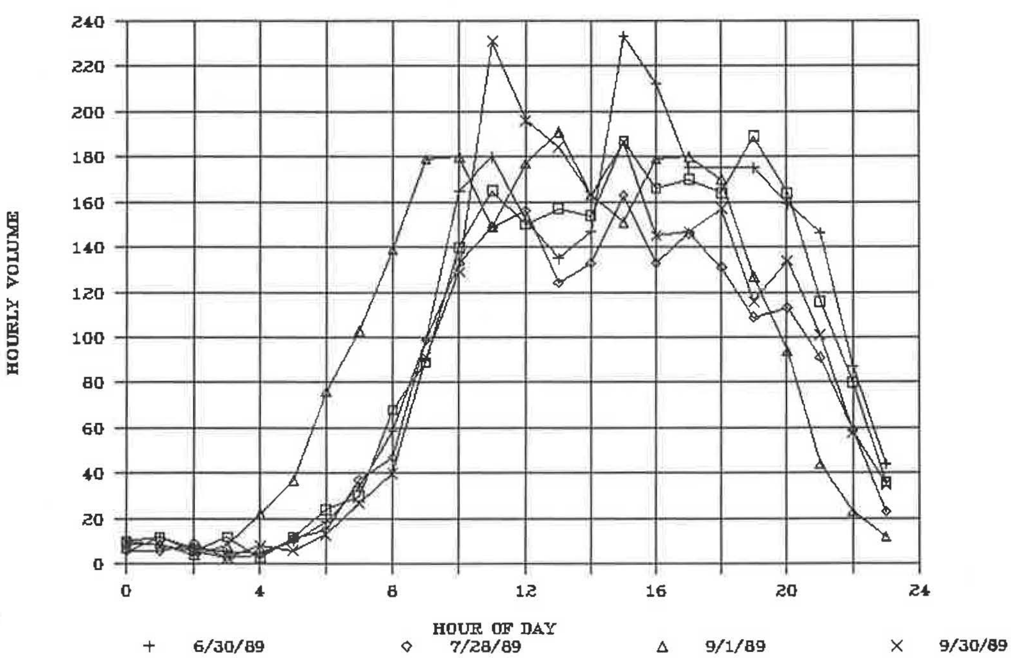

FIGURE 2 Hourly variation in entering traffic on peak Fridays for Guilford.

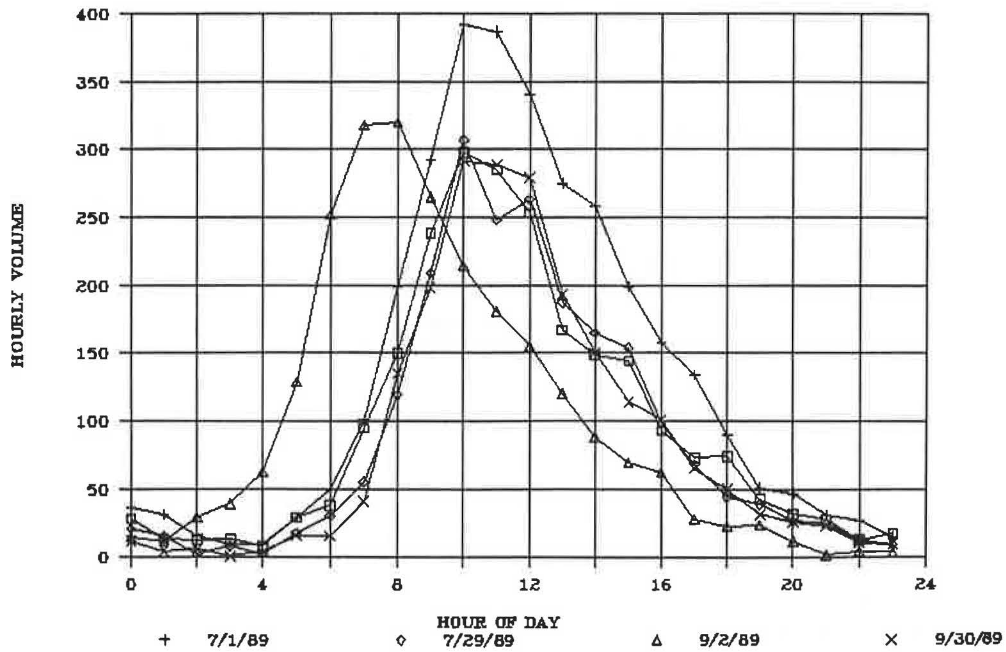

FIGURE 3 Hourly variation in entering traffic on peak Saturdays for Guilford.

lower, thus making Friday and Saturday daily volumes nearly equal in all cases.

Because Saturday peak hourly volumes were the highest in almost all cases, a further analysis of Saturday peak hour volumes was undertaken for each of the following set of dependent and independent variables.

Dependent Variables	*Independent Variables*
Rest area peak hour volume (k factor)	Rest area daily volumes
Rest area peak hour volume	Mainline volume at rest area peak hour
Rest area peak hour volume	Mainline daily volume
Rest area daily volume (p factor)	Mainline daily volume
Mainline volume at rest area peak hour	Mainline daily volume

A preliminary examination of the data suggested that a linear model may be applicable to describe rest area stopping behavior.

Regression analyses for each rest area were conducted to ascertain prediction equations for the several sets of possible variables. The equations are of the form

$$y = a + bx$$

where

y = dependent variable,
x = independent variable,
a = constant, and
b = coefficient.

The analyses were conducted to predict the values of a and b based on multiple sets of x and y values.

For each model developed, the a value was tested to determine if it was significantly different from zero. In nearly every case this did not prove to be true, so the model to be used was changed to the following:

$$y = bx$$

This model is the one that would normally be experienced because a zero volume on the mainline should lead to a zero volume in the rest area and confirms the original model formulation. These models may be interpreted as the proportion of independent variable that the dependent variable represents (Table 2). Along with each coefficient is shown, in parenthesis, the R^2 value, which indicates the strength of the relationship. The closer R^2 is to 1, the stronger the relationship between independent and dependent variables. As can be seen from the table, strong relationships are established for Guilford. Those established for Derby were somewhat less strong. Those for Sharon were weaker but not entirely valueless. These relationships were used for predicting peak usage in future years.

CONCLUSION

The traffic at these rest areas can be regarded as largely recreational in nature because of its peaking nature in summers, on holidays, and in the fall foliage season. In general, the higher peaks occurred on summer holiday weekends, and the highest peak on the Fourth of July weekend. On peak weekends, daily volumes on Friday and Saturday tend to be similar; however, the nature of the peaking differs. On Fridays, volumes remain high from noon to 8:00 p.m., but on Saturdays, a much sharper peak occurs around noon, so the highest hour of volume on a weekend tends to occur on a Saturday.

TABLE 2 RESULTS OF PEAK SATURDAY ANALYSES

Dependent Variable	Rest Area Peak Hour Volume	Rest Area Peak Hour Volume	Rest Area Peak Hour Volume
Independent Variable	Rest Area Daily Volume	Mainline Volume at Rest Area Peak Hour	Mainline Daily Volume
Coefficient			
Guilford	0.1355 (0.94)	0.2211 (0.76)	0.0217 (0.85)
Derby	0.1112 (0.83)	0.1552 (0.52)	0.0130 (0.72)
Sharon	0.1120 (0.93)	0.1219 (0.54)	0.0102 (0.27)
Dependent Variable	Rest Area Daily Volume	Mainline Volume at Rest Area Peak Hour	
Independent Variable	Mainline Daily Volume	Mainline Daily Volume	
Coefficient			
Guilford	0.1599 (0.91)	0.0964 (0.66)	
Derby	0.1168 (0.85)	0.0806 (0.58)	
Sharon	0.0912 (0.33)	0.0843 (0.84)	

NOTE: Figure in parenthesis following coefficient is R^2 value.

Using the basic approach reached by the KLD reports (i.e., preparing an individual model for each rest area), the basic model formulation in the literature, as shown in Equation 1, has been confirmed by the research reported herein. Additionally, values for p and k parameters were estimated. Later these were applied to estimating traffic at the rest area.

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