Trends in the 30th-Hour Factor

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An analysis of automatic traffic recorder data for rural highways reveals that the 30th-hour factor exhibits a tendency to decline slightly with the passing of time, rather than to remain stable as past indications have suggested. Records for 160 traffic-recorder stations in continuous operation from 1956 through 1953 provided the basic data for the analysis. All classes of rural highways were represented and the coverage included 26 states. The average factor for these stations declined at the average rate of 0.11 per year over the 7-yr period but a wide variation in the rate of decline was found between different stations. Roads with volumes of more than 3,000 vehicles ADT experienced a more rapid rate of decline in the factor than the roads with lesser volumes. Also, factors of 15, or greater, experienced a more rapid rate of decline than factors of less than 15. A table which relates the annual change in the factor to both the magnitude of the factor and the ADT is included in the report.

● IN 1940 an investigation was made of the relation between traffic volumes during peak hours and the annual average daily traffic volumes on a number of rural highways. Records from automatic traffic recorders provided the basic material for this investigation. Comparatively few of these recorders were in use at that time and none had been in continuous service for longer than 3 or 4 years. Nevertheless, a striking correlation was found between peak-hour volumes and the average daily traffic on rural highways. The authors of a report (1) on these investigations recommended that highways be designed to accomodate a volume of traffic at least as great as that which would occur during the 50th highest hour of the year, but no greater than that for the 30th highest hour. The American Association of State Highway Officials adopted the policy that highways should be designed for the 30th highest hourly volume of the year for which the highway was being built.

The work was reviewed in 1945 when better counter coverage had been established and the period of continuous operation had been extended. The results of this review (2) strengthened the recommendations of the 1940 study, and drew the additional conclusion that for any particular facility the ratio of the 30th highest hourly volume to the average annual daily volume changed very little, if at all, from year to year. This ratio, normally expressed as a percentage figure, is often referred to as the 30th-hour factor. It is a coefficient which, if known for a particular road, will yield the 30th highest hourly volume when applied to the average annual daily traffic on that road.

The present reexamination of traffic data is for the purpose of detecting any trends that may exist in the magnitude of the 30th-hour factor. If the factor for any road is indeed fixed or stable, as indications in the past have suggested, then a means is assured for estimating design-hour volumes with a degree of confidence as great as that for the estimate of the average daily traffic. If there is any tendency for the factor to become either larger or smaller with the passing of time, then the rate of change should be determined so that appropriate adjustment can be made in the design-hour volume for any future year. Unless proper adjustment of the factor is made, facilities designed for future traffic will be either overdesigned for their traffic load or they will become congested in a shorter period of time than anticipated, even though the future daily traffic is accurately predicted.

RECORDS COVER 7-YEAR PERIOD

Records for 160 counters that were in continuous operation during the period 1946-53 are used in this analysis. All of these counters were located on rural highways and covered 26 states distributed from coast to coast. All classes of rural roads were represented and the range in traffic volume was from a few hundred vehicles per day on the

most lightly traveled roads to more than 25,000 vehicles per day on the more heavily traveled multi-lane roads.[1]

Wide Variation Between Factors at Different Locations

For the year 1946, the 30th-hour factors for the 160 locations ranged in magnitude from less than 9.0 to above 30.0. The frequency of occurrence of factors of various magnitudes is shown in Figure 1 for 2 years, 1946 and 1953. The similarity between the distributions of factors for the 2 years is very striking. The distribution curve for the year 1953 is located slightly to the left of the one for 1946 and this is an indication that the factors for the more recent year are somewhat smaller than they were in 1946. The fact that a reduction in the factor has occurred during the 7-yr period is more apparent in Figure 2. This figure shows the cumulative number of traffic counter locations for which the 30th-hour factors are equal to or less than the values specified. Data for 1946 and 1953 are again represented.

A fact not shown by Figure 2 is that factors for some stations changed by a far greater amount than others. Forty-six of the 160 stations actually experienced an increase in the factor during the 7-yr period. For the remaining 114 stations (71 percent of the total) the factor showed a decline. The average factor changed from 14.07 in 1946 to 13.25 in 1953, a decrease of 0.82.

Greatest Changes on High-Volume Roads

On the average, the roads carrying relatively low volumes (below 2,000) had the highest factors, and those carrying the heaviest volumes had the lowest factors. This is illustrated in Figure 3, where the stations have been divided into three volume groups namely, those below 2,000, those between 2,000 and 3,000, and those over 3,000 ADT. These were the volumes in 1951.

Roads within the volume range of 2,000 to 3,000 vehicles per day had the least change in the factor between 1946 and 1953. In 1946 the factor for this group was 13.8 as compared with 13.6 in 1953. The trend throughout the 7-yr period was far from uniform and it is questionable whether the 18 stations in this group constitute a sufficient sample to justify conclusions. The sample is not only small but is biased in favor of stations having low factors.

For roads having a volume of 2,000 vehicles or less, the average factor declined from 16.2 in 1946 to 15.4 in 1953, a change of -0.8. There were 43 stations in this group. The group of roads having an average daily volume of over 3,000 showed the greatest change of all the groups. For these roads the average factor was 13.1 in 1946 and 12.0 in 1953. The difference between the factors for these years is 1.1. A total of 99 stations comprise this group and the trend over the years appears to be very consistent.

The curves in Figure 3 suggest that for roads carrying between 2,000 and 3,000 vehicles per day, the change in the factor with the passage of time is almost nil. As a class, roads carrying fewer than 2,000 vehicles ADT have shown a decline in the 30th-hour factor of about 0.11 per year. For roads carrying more than 3,000 vehicles ADT, the factor has shown the rather marked rate of decline of 0.16 per year.

Least Changes on Roads with Low Factors

If the apparent finding as stated above were applied indiscriminately, the 30th-hour factors for the most heavily traveled roads would rapidly be approaching the absolute minimum, which is theoretically 4.15, assuming the traffic volume is constant during all hours of the year. None of the stations in the sample had a factor anywhere near

[1] The traffic counter stations used in this analysis are listed according to state identification number in an appendix to this report. Individuals or agencies having a bona fide interest may obtain detailed traffic data for any station or group of stations identified in this list by addressing the U.S. Bureau of Public Roads, Highway Transport Research Division, Washington 25, D.C.

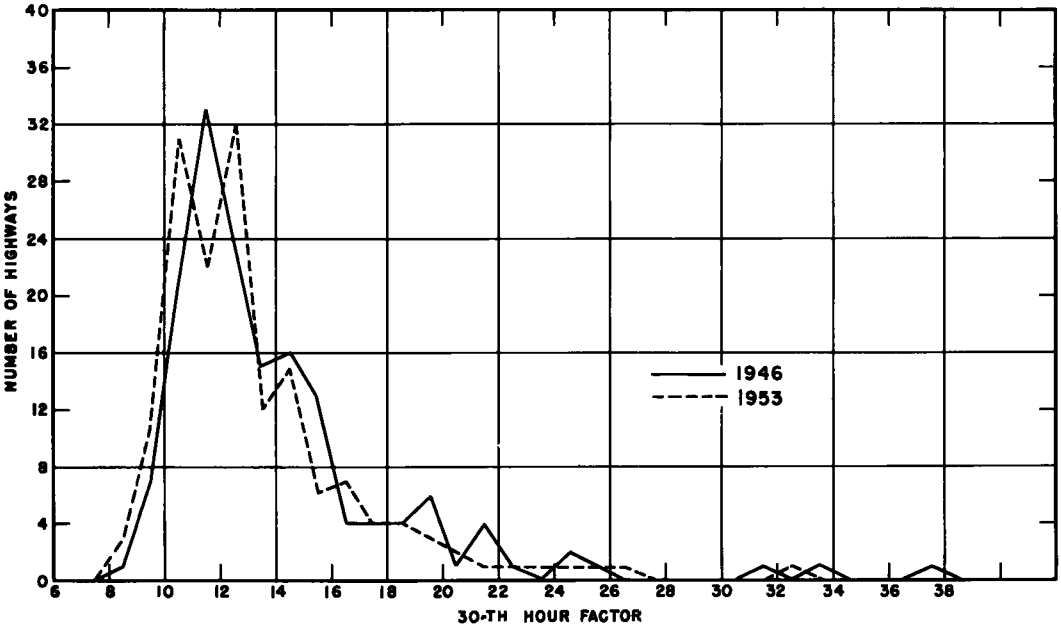

Figure 1. Distribution of 30th-hour factors for 160 rural highways of all classes in 29 states.

this small, the lowest one being 8.2 (in 1946) on a heavily traveled multi-lane facility, in a densely populated section of the country. Only 6 stations had factors in 1946 of less than 10.0. For this group of stations the change in the average factor during the 7-yr period has been almost imperceptible. This is illustrated by the lower curve in Figure 4, which shows the trend in the factor for five ranges in the values for the 30th-hour factor.

It is only for the groups of factors having values of 15.0 or more that any appreciable change in the average factor with passage of time is to be noted. The stations having the highest factors are those showing the greatest change. Average factors for stations having a 1946 factor of 30 or above have declined from 33.7 in 1946 to 27.4 in 1953, a reduction of 6.3. For stations having 1946 factors of between 20 and 30 the change in the average factor during the 7-yr period amounts to 3.0, while the corresponding change for stations having 1946 factors within the range 15.0-19.9 is 1.8. For factors of less than 15.0 (72 percent of the total), the change in the factor with passage of time is very small. This further accounts for the apparent stability of the average factor for roads having volumes of between 2,000 and 3,000 ADT (Figure 3) because of 14 of the 18 stations within this volume group had factors of less than 15.0.

The average of the factors for the 6 stations having 30th-hour factors of less than 10.0 suggests that as a practical matter the irreducible minimum value must be in the neighborhood of 9.5. There are, of course, exceptions to this rule but they are few in number and limited perhaps to facilities that are so heavily overladen that travel habits are influenced to an excessive extent by a high degree of congestion.

Average Rate of Change Affected by an Increase in Factor

It has been shown that if the stations are classified into groups according to either traffic volume or magnitude of factor, the average of the factors for any group shows at least a slight tendency toward decreasing with passage of time. It has also been stated that when the stations are considered individually, almost 30 percent of them experienced an increase in the 30th-hour factor. When the stations are grouped according to magnitude of factor some of the groups will include stations for which there was an increase in the factor, but it is evident that the effect of these stations is more than off-

set by the effect of the stations within the group that experienced a decrease in the factor. The groups of stations that showed the least change in the factor (factors of less than 15) were those that included most of the stations for which there was an increase in the factor. Figure 4 shows that the groups of stations having factors of less than 15 experienced very little change in the average factor. Of the 115 stations for which the factor in 1946 was less than 15.0, 41 stations experienced an increase and 74 experienced a decrease in the factor. Of the 45 stations having factors of 15 or more, only 5 experienced an increase in the factor. Thus, if the factor for any station is less than 15, there is better than one chance in three that the factor will increase rather than decrease with the passage of time. Also, if the factor is greater than 15, there is very little likelihood that it will increase at all.

A somewhat different and more refined interpretation can be made of Figure 3 after examination of Figure 4. It is apparent that the magnitude of the factor and the traffic volume act in combination to influence the trend in the factor with passage of time. Factors for roads carrying in excess of 3,000 ADT decline at a more rapid rate than those with lesser volumes, and factors of 15 or above will decline at a more rapid rate than smaller factors. The magnitude of the factor seems to exert a greater influence on the rate of change than does traffic volume. Roads with volumes in excess of 3,000 ADT in combination with factors of 15.0 or above experience the highest rate of decline in the factor. The lowest rate of decline in the factor is experienced by roads having factors of less than 15.0, regardless of the traffic volume. Perhaps there are numerous vari-

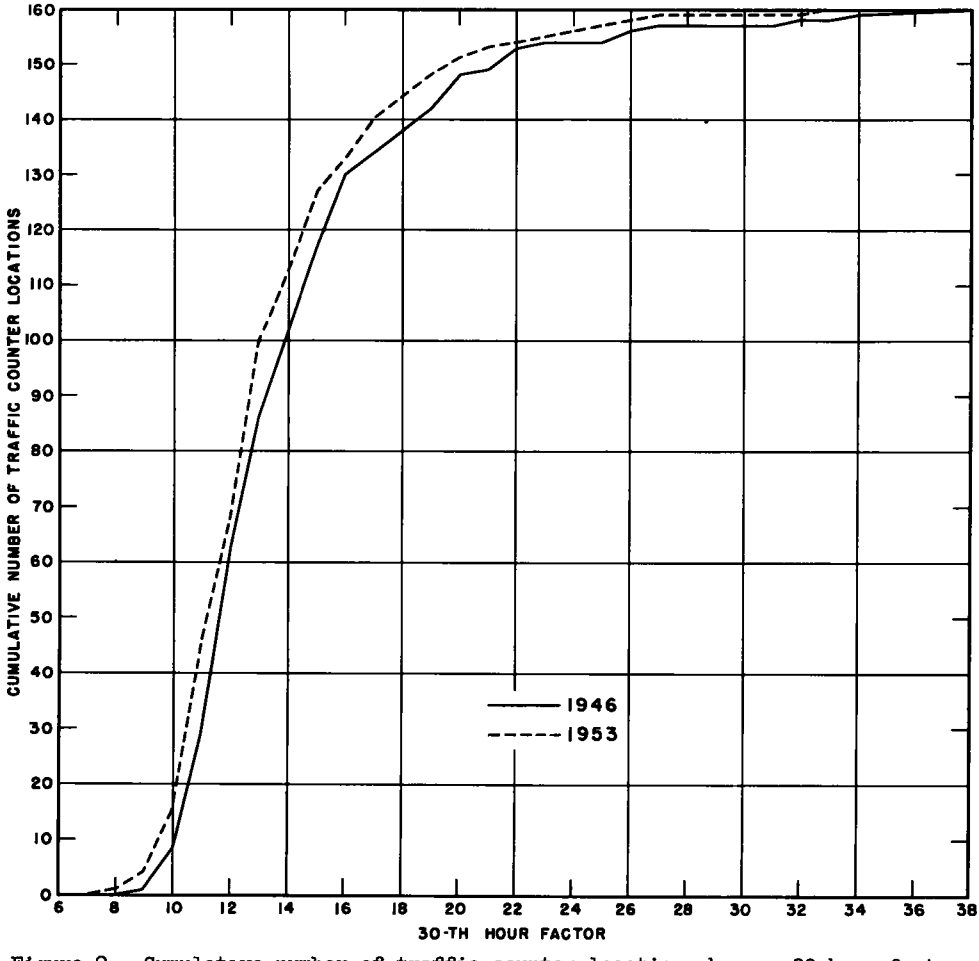

Figure 2. Cumulative number of traffic counter locations having 30-hour factors of various values.

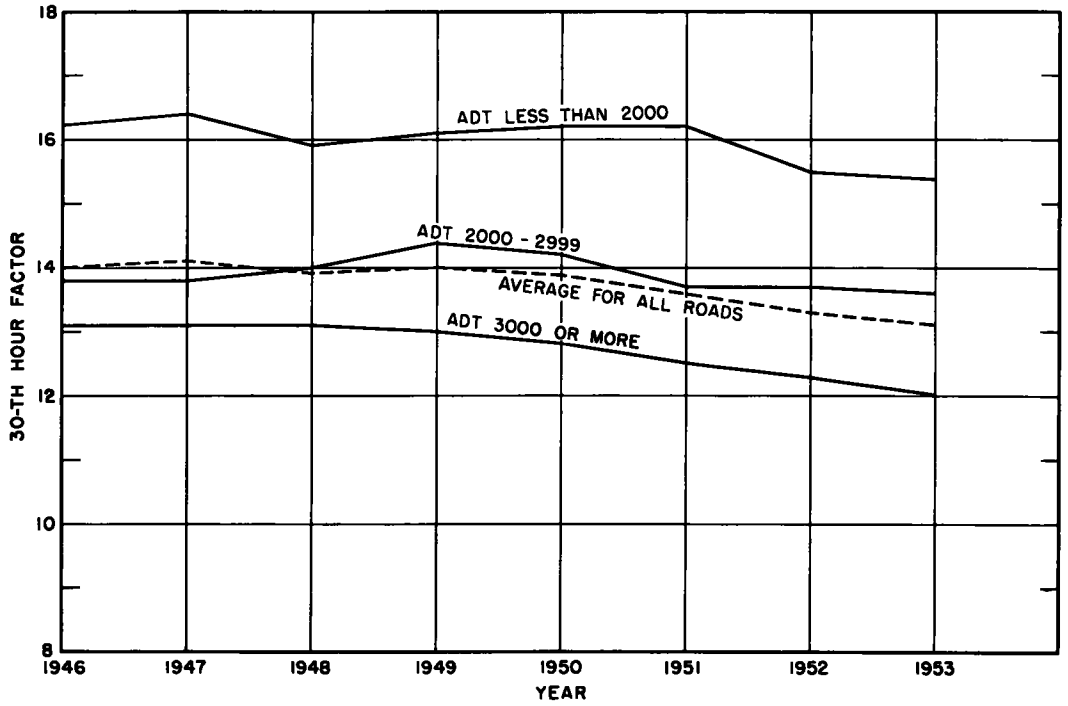

Figure 3. Trends in the magnitude of the 30th-hour factor for roads carrying various volumes of traffic.

ables other than traffic volume and magnitude of factor which influence the trend, but the amount of information available for this analysis imposes stringent limitations on their detection and evaluation.

With the passing of years, the number of stations having high factors will diminish and the average rate of decline will be reduced. When the factor for a particular faci-

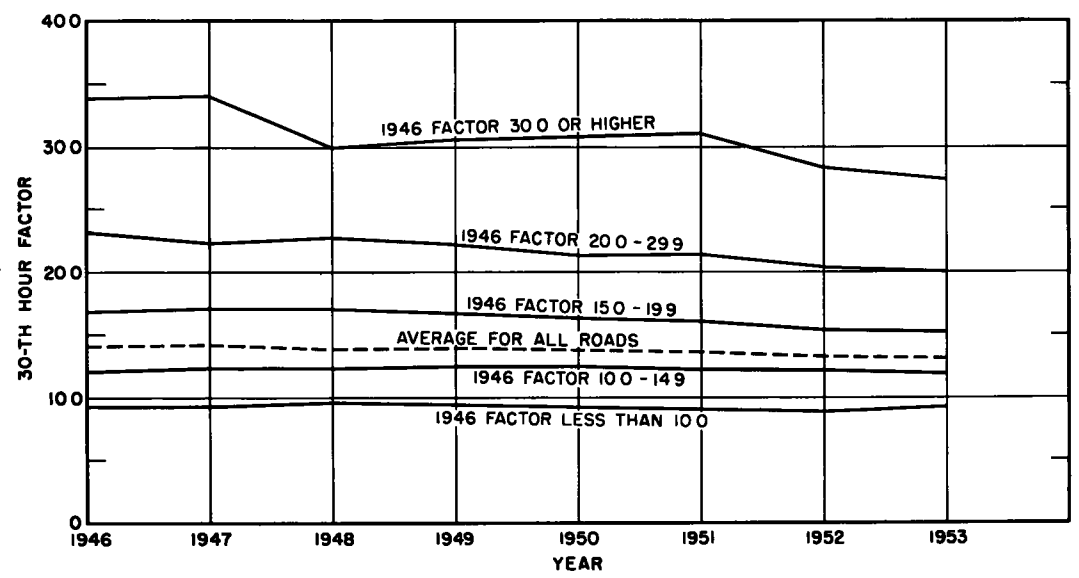

Figure 4. Trend in the 30th-hour factor for roads having factors of various magnitudes.

lity reaches a value somewhere between 9.5 and 15.0, depending upon such things as the character of traffic and geographic location, the decline in the factor will be arrested and very little change may be expected thereafter. If the conditions surrounding the minimum values lying within the range of 9.5 to 15.0 could be ascertained, the results of this analysis would be more valuable, but the data at hand does not make this possible.

TABLE 1

ANNUAL CHANGE IN 30TH-HOUR FACTOR

30th-Hour Factor	Annual Change in 30th-Hour Factor, ADT 1,200*	2,500*	6,500*
Pct. of ADT	Pct. of ADT	Pct. of ADT	Pct. of ADT
Below 10.0	0.00	0.00	-0.08
10.0 - 10.9	0.00	0.00	-0.10
11.0 - 11.9	0.00	0.00	-0.12
12.0 - 12.9	0.00	0.00	-0.15
13.0 - 13.9	0.00	-0.01	-0.18
14.0 - 14.9	-0.01	-0.02	-0.22
15.0 - 15.9	-0.02	-0.04	-0.27
16.0 - 16.9	-0.03	-0.07	-0.31
17.0 - 17.9	-0.05	-0.10	-0.36
18.0 - 18.9	-0.08	-0.13	-0.41
19.0 - 19.9	-0.10	-0.17	-0.48
20.0 - 20.9	-0.14	-0.20	-0.53
21.0 - 21.9	-0.18	-0.24	-0.59
22.0 - 22.9	-0.21	-0.29	-0.65
23.0 - 23.9	-0.25	-0.34	-0.71
24.0 - 24.9	-0.30	-0.39	-0.79
25.0 - 25.9	-0.35	-0.44	-0.83
26.0 - 26.9	-0.40	-0.50	-0.90
27.0 - 27.9	-0.46	-0.55	
28.0 - 28.9	-0.52	-0.61	
29.0 - 29.9	-0.58	-0.67	
30.0 - 30.9	-0.63	-0.74	
31.0 - 31.9	-0.70	-0.81	
32.0 - 32.9	-0.78	-0.90	
33.0 - 33.9	-0.83		
34.0 - 34.9	-0.90		

* Volumes shown in column headings are average volumes for groups of stations exhibiting annual changes in 30th-hour factor as shown in the respective columns. For volumes other than these average values interpolation between columns is recommended, as follows:

(a) For volumes of less than 1,500 ADT, use values shown in column headed "1,200";

(b) For volumes in the range of 1,500 to 2,500, interpolate between the values shown in the columns headed "1,200" and "2,500";

(c) For volumes in the range of 2,500 to 3,500, interpolate between the values in the columns headed "2,500" and "6,500";

(d) For volumes of 3,500 or over, use values in column headed "6,500."

APPLICABILITY

As in the case of many investigations of this type the best that can be hoped for is the development of broad indications which, if applied, will provide results that are more nearly correct than would have been possible of accomplishment in the absence of the study. To be of maximum value to the user, the findings of the investigation must be accurate and in considerable detail. When measured against this standard this study is somewhat deficient because it does not fully answer the question as to why traffic patterns for some roads behave differently from others in the course of time. If applied wisely, however, such facts as have been brought to light should permit a far more accurate estimate of future 30th-hour factors than would otherwise be possible.

As an aid in applying the results of the study, a table of suggested annual changes in the 30th-hour factor for various combinations of factors and traffic volumes has been prepared. These suggested annual changes (Table 1) approximate the average changes found in the statistical analysis.

EXAMPLES OF APPLICATION OF TABLE 1

Example 1

The 1956 volume on a rural road is 5,300 ADT. The 30th highest hourly volume in 1956 was 778 vph, yielding a 30th-hour factor of 14.30. It is estimated that the ADT in 1970 will be 10,600, or double the present volume. Estimated volumes for the intervening years between 1956 and 1970 are as shown in column 2 of the accompanying table. What will be the 30th-hour factor for 1970?

Year	ADT	30th-Hour Factor	Annual Change
1956	5,300	14.30	-0.22
1957	5,560	14.08	-0.22
1958	5,850	13.86	-0.18
1959	6,150	13.68	-0.18
1960	6,460	13.50	-0.18
1961	6,790	13.32	-0.18
1962	7,130	13.14	-0.18
1963	7,500	12.96	-0.15
1964	7,880	12.81	-0.15
1965	8,280	12.66	-0.15
1966	8,700	12.51	-0.15
1967	9,140	12.36	-0.15
1968	9,600	12.21	-0.15
1969	10,100	12.06	-0.15
1970	10,600	11.91	

Solution. Since the volume for all years is above 3,500, note (d) for Table 1 applies to this example. No interpolation is required. The annual change for the year 1956 is found in column 4 of Table 1. The change, which is -0.22, is applied to the 1956 factor of 14.30 to yield a 1957 factor of 14.08. Thirtieth-hour factors for succeeding years are obtained in a similar manner. The rate of change diminishes as the factor becomes smaller.

Example 2

The 1956 volume on a rural road is 1,400 ADT. The 30th-hour volume in 1956 was 259 vph, yielding a 30th-hour factor of 18.50. The estimated rate of traffic growth is about 10 percent per year for each of the next 14 years (column 2 in the accompanying table). What will be the 30th-hour factor for the year 1970?

Year	ADT	30th-Hour Factor	Annual Change
1956	1,400	18.50	-0.08
1957	1,550	18.42	-0.08
1958	1,700	18.34	-0.09
1959	1,875	18.25	-0.10
1960	2,050	18.15	-0.11
1961	2,250	18.04	-0.12
1962	2,500	17.92	-0.10
1963	2,750	17.82	-0.17
1964	3,000	17.65	-0.23
1965	3,300	17.42	-0.31
1966	3,600	17.11	-0.36
1967	3,950	16.75	-0.31
1968	4,400	16.44	-0.31
1969	4,800	16.13	-0.31
1970	5,300	15.82	

Solution. Since the ADT changes from an ititial value of less than 1,500 to a final value of over 3,500, notes (a), (b), (c) and (d) for Table 1 apply in this example. The factor for the year 1957 is obtained by subtracting the annual change for 1956 (0.08, column 2, Table 1) from the 30th-hour factor for 1956 (18.50). The annual change is here obtained in accordance with note (a). The procedure is repeated for each succeeding year to 1970, with the resulting 30th-hour factor for 1970 being 15.82. During the years 1957 through 1961 the ADT is between 1,500 and 2,500 and the annual change is obtained by interpolating between 0.08 in column 2 of Table 1 and 0.13 in column 3, in accordance with note (b). During the years 1963 through 1965 the ADT is between 2,500 and 3,500 and the annual change is determined by interpolating between 0.10 in column 3 and 0.36 in column 4, in accordance with note (c). For the years 1966 through 1969 the volume is greater than 3,500 and no interpolation is required. For these years the annual change is taken directly from column 4 of Table 1 in accordance with note (d).

SUMMARY

1. The trend in the 30th-hour factor for 160 stations in continuous operation over a 7-yr period has been a decline of 0.11 per year, on the average, but the rate of decline varied widely between different roads.
2. Roads having volumes of more than 3,000 ADT in combination with factors of 15 or above are those which, as a class, experience the most rapid rate of decline in the factor.
3. The lowest average rate of decline (almost zero) is experienced by roads having 30th-hour factors of less than 15.0, regardless of traffic volume.
4. The fact that there is little change in the average factors for the groups of roads having factors of less than 15.0 is due in part to the phenomenon that within these categories there is almost a one-in-three chance that any given station will experience an increase rather than a decrease in the factor with passage of time.
5. The irreducible minimum value for the 30th-hour factor may be about 9.5 for rural highways. In some geographical areas, and under certain conditions yet to be defined, the minimum value of the factor may be as high as 15.0, but a factor lower than 9.5 may be accepted as a definite indication that travel desires are being supressed.

REFERENCES

1. Peabody, L. E., and Normann, O. K., "Application of Automatic Traffic Recorder Data in Highway Planning," Public Roads, Vol. 21, No. 11 (January, 1941).
2. "Highway Capacity Manual," Part VIII, U. S. Dept of Commerce, 1950.

Appendix

STATIONS USED IN ANALYSIS OF TRENDS IN 30TH-HOUR FACTOR

State	No. of Stations	Identification of Stations
Conn.	18	1,3,4,5,6,8,9,10,11,13,15,16,18,20,21,22,25,27.
Del.	6	1A,2B,3C (N+S),4D,5E,7G.
Ga.	4	1,3,4,12.
Idaho	2	3,7.
Ind.	6	34A,42A,47A,59A,72A,73A.
Ill.	3	2,7,8.
Iowa	4	601,604,614,616.
Maine	5	2,3,4,7,9.
Md.	16	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,18.
Mass	5	1,2,10,12,13.
Miss	4	3,8,10,4A.
Mich.	5	600,603,606,607,617.
Mo.	6	1,2,5,12,22,26.
Neb.	5	A2,A4,A5,A8,A12.
Nev.	4	101,107,109,110.
N. H.	5	1,2,4,6,15A
N. C.	6	1,2,3,4,22,24.
Ohio	4	25,28,31,38.
Okla.	16	1,4,5,6,8,9,10A,11,12,13,14,15,17,18,19,20.
Pa.	7	4,5,10,17,21,22,31.
Tenn.	2	3,11.
Texas	5	1,4,5,8,17.
Utah	7	301,302,305,308,312,313,315.
Vt.	3	A12-1,C14-2, PR110.
Wash	9	1,2,3,6,7,8,12,14,15.
W. Va.	3	1,3,4.
Total	160	