STREET AND MILEAGE STUDY IN NORTH CAROLINA MUNICIPALITIES

JAMES S. BURCH, *Engineer of Statistics and Planning*
EARL H. TYNDALL, *Research Analyst*
North Carolina State Highway and Public Works Commission

● BECAUSE OF increasing problems involved in the relationships between federal, state, and city governments in the field of financing streets and other traffic facilities, this division undertook in 1948 a rather comprehensive research project to obtain data and estimates on the vehicle miles which were travelled in all of the municipalities in the state. This report, "Total Travel In North Carolina Municipalities", was published September, 1950, and was a pioneer study in this field. (HRB Proceedings Vol. 30, 1950, page 314).

The report was based largely on estimated street mileage in municipalities, using known vehicle mileage in six selected sample towns as a basis for expansion. Most of the mileage estimates, especially in the towns in the lower population brackets, were of doubtful value; thus, the report was quite approximate, due to the preponderance of such towns and the almost complete lack of knowledge of total street mileage within these towns. Scores of other towns had no reliable maps, and very few had reliable street-mileage data.

During 1951, due to new state legislation, it became necessary for each active municipality to actually measure and catalog each mile of street. This was done by either a registered engineer or a registered land surveyor and was certified as correct to an accuracy of 99 percent, being reported on a uniform basis. It is very rare in any state for all street mileage to be carefully measured simultaneously in the same manner by reliable professional men and be certified to a central statistical agency. This study, by the authors, was made with the cooperation of the Bureau of Public Roads.

This new mileage data was set up on punch-card equipment, and an analysis was made (Table 1). This will be found to be a most comprehensive analysis and may prove of value in estimation work in many states.

It was deemed advisable to revise the original report to reflect data based on known mileage rather than on estimated mileage. This revision also employs final 1950 population data rather than preliminary 1950 estimates, on which the original report was based Except for the basic vehicle-mileage data in the six sample towns, all data was recomputed, substituting known mileage for estimated mileage, and using final population figures rather than preliminary population figures. Since only 386 municipalities were required to report their mileage, there were approximately 189 small inactive towns for which no mileage data was available. However, it was relatively simple to estimate mileage in these towns to a great degree of accuracy, since actual mileage was known for so many of the towns of similar population, and so much of the mileage involved was on known-mileage state-system streets.

For those towns in which no mileage data were available, a controlled estimation technique was employed to reduce the percentage of error to a minimum. These unknown towns were first divided into population groups by steps of 100. Constants in terms of miles per 1,000 population were obtained from towns of known mileage in similar population groups, and these constants were applied to the unknown population groups.

Tables 2 and 3 present computations of total mileage in these small towns, by type and system.

It will be noted that the miles-per-thousand population increases as the size of the town decreases (see figures in parenthesis). Having arrived at the above totals, minor population groupings were discarded for further estimation as to system. The vertical totals were then arbitrarily broken down into estimates of length as to system, based on known date in active small towns.

In revising the original report, only those towns which were used originally were tabulated. There were a few changes in the status of towns during the two year period, but this was of such minor significance as not to justify further readjustment of the report.

These estimates combined with known mileage data produced Table 4 showing system

and nonsystem streets in all towns used in the original report.

totals used in the original report and the revised totals.

TABLE 1

NORTH CAROLINA; MUNICIPAL STREET MILEAGE 386 TOWNS[a] BY POPULATION GROUP, SYSTEMS[b] AND SURFACING TYPE GROUPS[c]

Data as of July 1, 1951[*]

Systems		Population Groups 1950 Census								Total
	No. towns	192	106	35	23	20	4	5	1	386
	Surf. Type Groups	Under 1,000 100,907	1,000 to 2,500[d] 170,258	2,500 to 5,000 126,865	5,000 to 10,000 158,886	10,000 to 25,000 318,782	25,000 to 50,000 147,428	50,000 to 100,000 352,190	Over 100,000 134,042	1,509,358
State Highways (State Primary)	Unsurf.	0	0	0	0	2.69	0.10	0	0	2.79
	Soil	1.24	0 37	0	0	0	1.06	0	0	2.67
	HS	238.11	225.08	108.47	98.03	154.70	47.34	105.72	27.54	1004.99
	Total	239.35	225.45	108.47	98.03	157.39	48.50	105.72	27.54	1010.45
County Road Exten. (State Secondary)	Unsurf.	58.69	36.69	11.31	5.80	14.08	1 86	6.15	0.69	135.27
	Soil	108.25	66.69	24.98	13.38	23.84	3.10	8.96	1.57	250.77
	HS	192.03	152.78	71.75	67.76	91.85	38.02	72.58	25.84	712 61
	Total	358.97	256.16	108.04	86.94	129 77	42.98	87.69	28.10	1098.65
Local Streets (Non System)	Unsurf.	243.06	287.68	133.02	117.21	208.94	94.70	134.44	2.51	1221.56
	Soil	206.38	277.15	164.48	195.89	312 74	90.56	262.67	103.19	1613.06
	HS	110.36	244.01	201.60	290.86	558.45	204.43	568.67	200.48	2378.86
	Narrow	45.11	47.46	19.66	22.53	32.78	9.32	7.49	0	184.35
	Total	604.91	856.30	518.76	626.49	1112.91	399.01	973.27	306.18	5397.83
Total Streets	Unsurf.	301.75	324 37	144.33	123.01	225.71	96.66	140.59	3.20	1359.62
	Soil	315.87	344.21	189.46	209.27	336.58	94.72	271.63	104.76	1866.50
	HS	540.50	621.87	381.82	456 65	805.00	289.79	746.97	253.86	4096.46
	Narrow	45.11	47.46	19 66	22.53	32.78	9.32	7.49	0	184.35
	Total	1203.23	1337.91	735.27	811.46	1400.07	490.49	1166.68	361.82	7506.93

[*] North Carolina State Highway & Public Works Commission, Division of Statistics and Planning, September 1951.
[a] All towns eligible under Powell Bill, ie incorporated and active. Does not include 189 small inactive incorporated places.
[b] Classified on State Systems, regardless of F.A. or F.A.S. Status.
[c] Unsurf.: types A, B, C; Soil: types D, E; HS: types F, G, H, I, J, K, L.
[d] Population estimated for Spring Lake: 1,500.
[e] Less than 16 ft. travelled width.

TABLE 2

ESTIMATED MILEAGE, AND MILES PER 1000 POP. CONSTANTS USED FOR ESTIMATION IN 189 INACTIVE TOWNS

No. Towns	Pop. Group	Total Pop. in Group[a]	Unsurfaced	Soil Stone Gravel	Hard Surface	Narrow	Total
45	0–100	2,677	10 15 (3 79)	7.76 (9 01)	24.12 (9.01)	3 48 (1.30)	45.51 (17.00)
73	100–200	9,924	34.03 (3.43)	25.50 (2.57)	82 27 (8.29)	12.31 (1.24)	154.11 (15 53)
35	200–300	8,604	35.19 (4.09)	28.48 (3.31)	58 59 (6.81)	3.61 (0.42)	125 87 (14.83)
17	300–400	5,821	17.40 (2 99)	18 05 (3.10)	32 77 (5 63)	2 15 (0 37)	70.37 (12.09)
8	400–500	3,562	12.04 (3.38)	10.97 (3 08)	18.02 (5 06)	1.46 (0 41)	42 49 (11 93)
3	500–600	1,579	6.57 (4.16)	4 44 (2 81)	7.85 (4.97)	0.90 (0.57)	19 76 (12 51)
2	600–700	1,200	3 31 (2 76)	3 62 (3 02)	7 44 (6.20)	0 65 (0 54)	15 02 (12 52)
0	700–800	0	—	—	—		
2	800–900	1,644	4.55 (2 77)	3 49 (2 12)	7 55 (4 59)	0.20 (0.12)	15 79 (9 60)
0	900–1000	0	—	—	—		
3	1000–Up	3,424	5.82 (1.70)	4.79 (1 40)	13.94 (4 07)	2 33 (0 68)	26.88 (7.85)
189		32,199	129.06	107.10	252.55	27.09	515.80

[a] Based on assignment estimates for each town separately on general local knowledge.

With the completion of the estimated miles for unknown towns, tables were prepared substituting true values for unknown values, for the sake of comparison, and for use in developing ratios. Table 5 shows the comparison of

As in the original report, the only state-wide data generally available were: (1) 1940 population; (2) 1950 population (final instead of preliminary); (3) Total street miles (much more accurate than in original report); (4) Miles on

TABLE 3
ESTIMATED MILEAGE IN 189 INACTIVE INCORPORATED TOWNS

		Under 1000	1000 to 2500	Total
State Highways	Soil	1.30	0	1.30
	Unsurf.	1.54	0	1.54
	H. S.	99 41	5.35	104.76
	Total	102.25	5.35	107.60
Country Road Ext.	Unsurf.	23.84	1.31	25.15
	Soil	30.56	1.30	31.86
	H. S.	83.01	4.29	87.30
	Total	137.41	6.90	144.31
Local Streets	Unsurf.	97 86	4.51	102.37
	Soil	70.45	3.49	7?.94
	H. S.	56.19	4.30	60.49
	Narrow	24.76	2.33	27.09
	Total	249 26	14 63	263.89
Total	Unsurf.	123.24	5 82	129.06
	Soil	102.31	4 79	107.10
	II. S.	238.61	13.94	252.55
	Narrow	24 76	2.33	27.09
	TOTAL	488.92	26.88	515.80

three of these methods using the revised, more-reliable data.

Except for the smallest towns (F and G) it is noted in Method III that there is remarkable stability in the vehicle-miles per street-mile, regardless of town size, and with a normal value of about 995 for the average traffic count. This would indicate that street mileage may be a more reliable expansion factor than population.

These ratios were applied to state-wide totals to develop 24-hr. daily vehicle miles in all towns, by population groups (see Tables 7 and 8).

It is noted that the totals fall very close to each other in these four methods, indicating that there may be merit in all these methods.

While it is indicated (see Table 9) that Method III may be a more reliable expansion

TABLE 4

		Population		1951 Mileage			
		1940	1950	Non-system	S. H.[a]	C. R.[b]	Total
A	Over 45,000	443,435	531,275	1361.3	142.9	132.0	1636.2
B	22,000–45,000	116,063	126,945	381.1	50.6	41.6	473.3
C	12,000–22,000	159,456	186,345	619.8	86.1	47.1	753.0
D	7,000–12,000	142,515	166,937	611.6	92.1	93.0	796.7
E	2,500– 7,000	163,335	186,956	712.8	137.4	135 8	986.0
F	1,000– 2,500	143,825	176,095	789.5	207.1	246.6	1243.2
G	Under 1,000	133,134	152,845	800.3	366 4	568.7	1735.4
	Totals	1,301,763	1,527,398	5,276.4	1,082.6	1,264.8	7,623.8

[a] S. H. = State Highway Streets, State Primary.
[b] C. R. = County Road Extension (State System) Streets.

TABLE 5
COMPARISON OF POPULATION AND MILEAGE, ORIGINAL REPORT AND REVISED REPORT

		Original Report		Revised Report	
1949 population group		1940 Population	1949 Mileage	1950 Population	1951 Total Mileage
A	Over 45,000	443,435	1525 3	531,275	1636.2
B	22,000–45,000	116,063	475.3	126,945	473.3
C	12,000–22,000	159,456	710 2	186,345	753.0
D	7,000–12,000	142,515	698.5	166,937	796 7
E	2,500– 7,000	163,335	983.2	186,956	986 0
F	1,000– 2,500	143,825	1126.9	176,095	1243.2
G	Under 1,000	133,134	1414.3	152,845	1735.4
	Totals	1,301,763	6,933 7	1,527,398	7,623 8

TABLE 6
FACTORS USED IN THREE METHODS OF EXPANSION

Town Size Group	Method I Veh. Miles per Cap. 1940	Method II Veh. Miles Per Cap. 1950	Method III Veh. Miles per Street Mile
A	4.75	3.79	1,131
B	3.93	3.63	1,015
C[a]	5.56	5.16	1,199
D	3.92	3.47	949
E	5.63	4.54	1,048
F	7.08	5 78	817
G	8.31	7.24	802

[a] Average values used for Concord and Hickory, both being in the same population group.

state highways in towns; and (5) Miles on county road extensions in towns.

There is no guide available in completed research indicating whether population or miles would be more reliable as a basis for expansion. Several methods were used in the original report, and Table 6 shows ratios obtained by

method, this has not been proved. Due to the relatively small deviation from the mean in the case of all methods, and there appearing to be merit in each, the average was adopted, *i.e.*, the figure of 7,219,384 as the total 24-hr. daily vehicle-miles travelled in all incorporated places in North Carolina on the average day

of 1949. This is compared to the figure of 6,921,498 vehicle-miles per day as shown in the original report. Thus, using known population and known mileage, the estimate becomes

TABLE 7
ALL TOWNS 1949 24-HR. DAILY VEHICLE MILES

Class	I Vm/Pop 1940	II Vm/Pop. 1950	III Vm/Tot. Miles
A	2,106,316	2,013,532	1,850,542
B	456,128	460,810	480,400
C	885,938	961,540	902,847
D	558,659	579,271	756,068
E	919,576	848,780	1,033,328
F[a]	1,018,281	1,017,829	1,015,694
G[a]	1,107,009	1,106,598	1,391,791
Totals	7,051,907	6,988,360	7,130,670

[a] Derivation of these values are explained in original report.

TABLE 8
COMBINATION METHOD OF EXPANSION USING SYSTEM STREETS AND OTHER STREETS

Class	Method IV		
	All State Highway Streets	All Other Streets	Total All Towns
A	583,704	1,261,689	1,845,393
B	252,570	254,085	506,655
C	497,417	462,556	959,973
D	334,995	488,782	823,777
E	451,345	411,971	863,316
F[a]			1,015,694
G[a]			1,391,791
Total			7,406,599

[a] Method III used since reliable V/M data is lacking.

TABLE 9
COMPARISON OF METHODS

Method	Basis	Total Vehicle Miles	Percent Deviation
I	Pop. 1940	7,051,907	−2 32
II	Pop. 1950	6,988,360	−3 20
III	Total miles	7,430,670	+2.93
IV	Mileage by systems	7,406,599	+2.59
Mean		7,219,384	2.76

and the like. Using gasoline-tax data as a control, as in the original report, this additional incidental travel was estimated and the above tabulation is shown in Table 11.

TABLE 10
TOTAL DAILY VEHICLE-MILEAGE TRAVELLED ON MEASURED SYSTEMS, 1949

			Percent
(X)	Rural state highways	12,320,610	51.00
(Y)	Rural county roads	4,620,400	19.12
(Z)	All city and town streets	7,219,384	29.88
		24,160,394	100.00

TABLE 11
TOTAL VEHICLE-MILES OF TRAVEL ON THE AVERAGE 24-HR. DAY OF 1949 ON ALL SYSTEMS

Millions VM Daily			Percent
(X)	12.321	Rural state highways	45.28
(Y)	4.620	Rural county roads	16.98
(Z)	7.219	All city-town streets	26.53
(Other)	3.051	Elsewhere (other)	11 21
	27.211		100.00

TABLE 12

Travel On	Rate mpg.	VM	Thousands Daily	
			Gallons	Percent
State highways, rural	13 774	12 321	894.511	42.139
County roads, rural	13.774	4 620	335.415	15.801
All city-town streets	11.019	7.219	655.141	30.863
Other (elsewhere)	12 836	3 051	237 691	11 197
		27.211	2,122.758	100.000

TABLE 13

		Daily Thousand Gal.	Percent
All city-town streets		655.141	34.75
State highways	(outside towns)	894.511	47.45
County roads	(outside towns)	335 415	17.80
		1,885.067	100.00

increased by 4.3 percent. This is also a rough measure of net error of mileage estimate in the original report.

This upward revision of travel in municipalities changed the percentage of travel for the three systems: rural state highways, rural county roads, and all city and town streets (see Table 10).

There was, of course, other travel on wood and farm trails, lumber trails, private property,

In order to refine the estimates of the amounts of gasoline consumed on the various systems, some adjustment in gasoline consumption rates should be made, since available research indicates that the consumption rate is different in rural and in urban areas.

Utilizing the same formula as in the original report the following miles-per-gallon consumption rates are employed: Rural 13.774; Urban 11.019; elsewhere 12.836.

If these rates are applied to the X, Y, Z, and "Other" vehicle-miles above, the results are as shown in Table 12.

Since so little is known about the "Other" travel, and following the course of the original report, this "Other" travel is eliminated, and the final conclusion is expressed as follows:

(1) Taxed gasoline consumed by motor vehicles on public roads and streets in North Carolina on the average 24-hour day of 1949, was as shown in Table 13, within the limits of this study.

This compares with the following findings of the original report:

	Daily Thousand Gal.	Percent
All city-town streets	628.097	33 80
State highways (outside towns)	894 511	48.14
County roads (outside towns)	335.415	18.06
	1,858.023	100.00

(2) In spite of the many changes due to improved mileage and population data, it is apparent that the indications of the original report remain substantially the same in the final report, with very little change in the relationship of total travel on the three systems.

(3) There still remains a possibility of error due to the relatively small number of sample towns, and the lack of more extensive traffic data in the town of the smallest sizes, of which there are so many in North Carolina.

(4) It would appear, however, from a comparison of the two reports that the final results are generally corroborative, this report materially reducing the degree of probable error.

(5) The major value of this report lies in the availability of new, complete, certified, recent street mileage data in all towns, and more reliable computations as to vehicle-miles of travel in all towns, and corroboration of previously computed percentages.

TESTING A TRAFFIC CIRCLE FOR POSSIBLE CAPACITY

E. B. SHROPE, Principal Civil Engineer, Bureau of Highway Planning, New York State Department of Public Works

SYNOPSIS

THE LATHAM, New York, traffic circle has a 200-ft. diameter central island, with two 15-ft. lanes and four entering highways. These highways enter so as to give two 210-ft. and two 105-ft. weaving sections measured on the center line and from center-to-center of the entering highways.

A preliminary check of the volumes, from the annual August counts, showed less than 1,000 vph. This was not enough to load the circle for testing capacity. It was therefore decided to use 30 test cars on a 3-min. schedule, in addition to regular traffic. The plan scheduled the test cars with 50 to 50, 75 to 25, 90 to 10 percent weaving action with two separate test routings.

The circle was divided into four segments for studying the weaving actions in the shorter and the longer weaving sections. Three tests were taken for periods of 30 min. and two for 15 min. On the shorter Segments A and C with all cars weaving on a 50 to 50 ratio, the possible capacity was about 1,200 vph. and 1,300 vph. with 70 to 30 weaving ratio. The maximum speeds recorded in traveling through the shorter weaving sections ranged from 16 to 21 mph.—through lane movements, also were recorded. On the longer Segments B and D with all cars weaving on a 50 to 50 ratio, the possible capacity was found to be about 1,500 vph. with a one-lane operation and about 2,000 vph. for two-lane operation, (two-abreast). On a 70 to 30 ratio and above, with all cars weaving, the capacity of the weaving sections were increased to 1,700 vph. for one-lane operation and 2,200 vph. for two-lane operation.

The maximum speeds recorded at which vehicles passed through the longer weaving sections, during the test, varied from 17 to 24 mph.

● IN 1949, the New York State Department of Public Works scheduled an annual highway-traffic-research program in coöperation with the Bureau of Public Roads. Several types of