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CAPACITY OF ARTERIAL NETWORK LINKS * * THE ABC METHOD OF CURRENT POPULATION ESTIMATION * O&D SURVEYS ACCURACY CHECKS

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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THE TECHNICAL RECORD

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A BACKWARD GLANCE

by Patricia J. Tegge, Editor

RAILROAD TRANSPORTATION IN SOUTHEASTERN WISCONSIN

Probably the most important event in the early history of many municipalities in southeastern Wisconsin was the coming of the railroad. The impact of the "iron horse" was felt immediately after construction of the first railroad in the state. It was begun in Milwaukee in 1851 and made its way westward through the Region toward its ultimate goal, the Mississippi River.

Transportation routes exercised a marked influence on regional settlement patterns. Early settlers had gravitated toward, and clustered along, the waterway routes. The new transportation routes in the form of the railroads were now to alter, sometimes drastically, the earlier settlement patterns and have a lasting effect on the development of the Region.

Steam railroad mileage developed most rapidly in southeastern Wisconsin during the latter half of the nineteenth century. (See Map 1, page 35) The zenith in passenger service was reached about 1920 and has declined sharply since then. Freight traffic, however, continues to be important in this populous and industrialized area of the state.

IN THE BEGINNING

It is an interesting historical parallel that the rise of the steam locomotive is almost exactly coincident with the rise of the American Republic and many attribute our rapid strides as a nation to the railroads which "linked East and West, one nation indivisible interlaced with iron. . . . "[1]

Railroading came to the United States in 1829 when a steam locomotive imported from England was first put into operation. Soon after that, the wheat farmers of southern Wisconsin began agitating for railroad transportation from Lake Michigan to the Mississippi River to meet the needs of the rapidly growing territory,[2] needs which were not being met by the toll plank roads or the partially completed canals.

Birth of State Railroading in Region

In 1847, the territorial legislature granted a charter to the Milwaukee and Waukesha Railway, which was renamed the Milwaukee and Mississippi Rail Road in 1850. Construction began with grading in the fall of 1849; and on February 25,

[1] Clarence P. Hornung, Wheels Across America, A.S. Barnes & Co. New York. 1959.

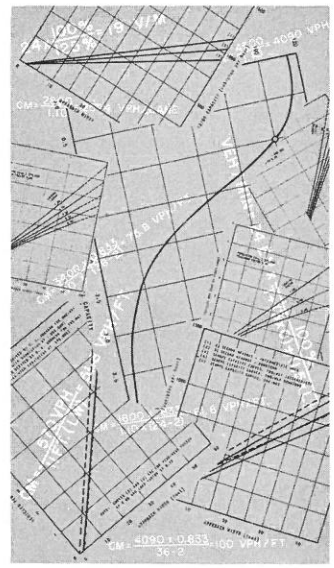
[2] In 1840, the population of the Territory of Wisconsin was 30,945. Statehood was attained in 1848, and by 1850, the population had grown to 305,391, with about 113,000 in the Region.

Continued on page 13

CAPACITY OF ARTERIAL NETWORK LINKS

by Richard B. Sheridan, Chief Transportation Planner

INTRODUCTION



A previous article in the Technical Record described the inventory of the arterial street network conducted as part of the SEWRPC regional land use-transportation study, discussed the need for this inventory in determining the capacity of the existing transportation system, defined the term "capacity," and discussed the factors affecting capacity.[1] This article will more specifically discuss the need for capacity data and the methods used to determine capacity from the arterial street network inventory for long-range transportation planning purposes.

The method of traffic assignment which will be used in the SEWRPC regional land use-transportation study is based on the assumption that each traveler desires to use the quickest route between his points of origin and destination. Therefore, it assigns trips between any two zones to the minimum time path between these zones. The time to travel over any route or path through the transportation network is the sum of travel times over every component link in that path. The travel time initially assigned to each link represents travel under conditions of tolerable congestion, i.e., under conditions wherein the traffic volumes approach the design capacity of the particular link. It is well known that when traffic volumes on streets and highways (more precisely, at their intersections) approach conditions of congestion, speed of travel decreases. Therefore, the time required to travel a link increases with increasing traffic on the link. Changes in link travel time, due to traffic congestion, can result in changes in the selection of minimum time paths between zones.

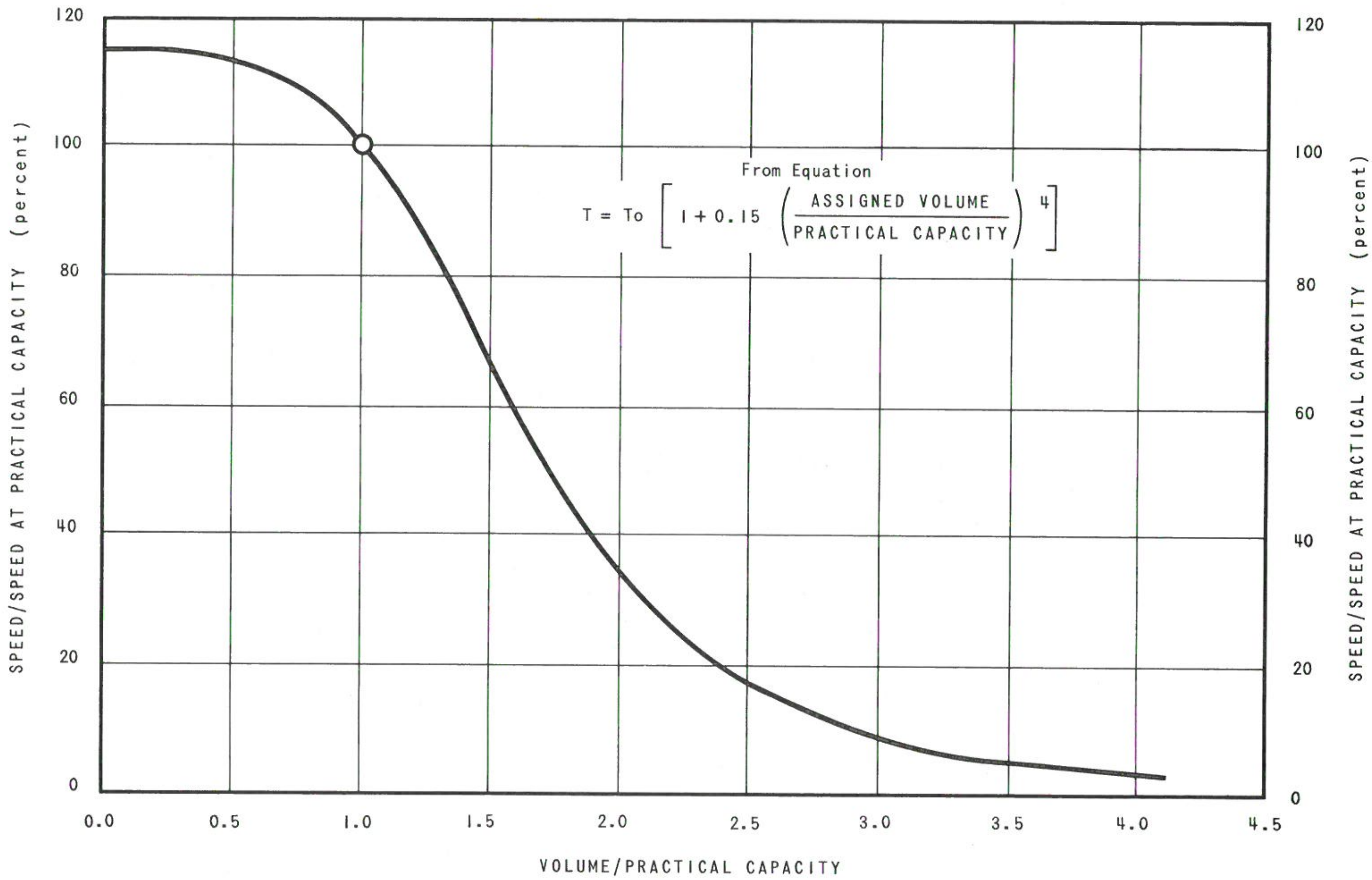
Observation of actual traffic under conditions of congestion have provided empirical relationships between speed and the ratio of volume to capacity where capacity is a measure of the ability of the intersection to accommodate traffic.[2] From such empirical studies, analytical relations have been derived which approximate the empirical data and which can be used to compute speeds and, hence, travel times corresponding to various volume to capacity ratios for links in a network. One of these, shown in Figure 1, is used in the United States Bureau of Public Roads (USBPR) Program 61 "Apply Capacity Restraint to Network Description."

[1] "Inventory of the Arterial Street Network," Technical Record; SEWRPC, Vol. 1-No. 5.

[2] Campbell, E. W., Keefer, L. E., and Adams, R., "A Method for Predicting Speeds Through Signalized Street Intersections," HRB Bulletin 230, January 1959.

Figure 1

CAPACITY RESTRAINT RELATIONSHIPS
RELATIVE SPEED VS VOLUME/PRACTICAL CAPACITY



Source: *Traffic Assignment Manual*, *p. V-20 (Washington, D.C.: U.S. Bureau of Public Roads, June 1964).*

It should be noted that the effect of capacity restraint in the traffic assignment computation is only to modify link travel time or speed as the traffic volume on a given link changes. The use of capacity in the assignment procedure does not affect relative attractiveness between routes in any other way. As can be seen in Figure 1, the analytical relationship is based upon a given initial speed which is then adjusted for the ratio of volume to capacity. It is, therefore, important that realistic speeds at which traffic volumes approach design volumes be entered as the initial speed.

In addition to application in traffic assignment, there is another important use for link capacity in transportation planning. Link capacity may be compared with existing or assigned volume on each link to determine whether the traffic capacity of existing or proposed roadways is adequate. Wherever capacity at the design (desirable) level of service is inadequate to meet the traffic demand, a roadway deficiency is indicated. The remedy for this may be to provide more or better roadways, to reduce travel demand along the "corridor," or both.

The reasons for calculating link capacity, then, may be summarized as follows:

1. In a restrained traffic assignment, the ratio of volume to capacity on each link is used as a basis for modifying the impedance of that link during the course of the assignment procedure.

2. On any network link, the present counted volumes or the assigned future volumes may be compared with the calculated link capacity. A volume to capacity ratio greater than 1.0 is an indication of inadequate roadway or excessive travel demand. Average weekday non-directional 24-hour values are used for comparing the volume assigned or counted with the calculated capacity.

SOURCE OF CAPACITY DATA FOR ARTERIAL STREETS

Source of Primary Factors

The following sources were carefully reviewed for data relating the basic measure of pavement width to capacity: 1) the 1958 revision of the 1950 USBPR Highway Capacity Manual, 2) "Variations in Flow at Intersections as Related to Size of City, Type of Facility and Capacity Utilization," by O. K. Normann, Highway Research Board Bulletin 352, 3) a relation derived from headway calculations, and 4) the State Highway Commission of Wisconsin design standards. In reviewing these sources with members of the O & D Subcommittee of the SEWRPC Technical Advisory Committee on Regional Land Use-Transportation Planning, it was judged that curves and tables developed by Normann, relating capacity to pavement width, should be used as the basic source for capacity data. This judgment was based, in part, on the fact that the width-capacity relationships developed by Normann were derived from more current data and from a larger sample than had been available for any previously published work on traffic capacity of intersections.

In the SEWRPC capacity calculation procedure, it is really intersection capacity that is analyzed because this, in general, is the controlling constraint. Since network links are defined as sections of roadway between nodes or designated intersections, link capacity really becomes the capacity of the link at the point where traffic exits from it, i.e., where traffic enters the intersection(s) upon leaving the link.

The width of the street, the load factor, the peak-hour factor, and the population of the urbanizing area, in which the particular facility under consideration is located, are the four primary factors that influence the hourly traffic volume which an intersection approach can accommodate.[3] Other variables, such as percent of trucks and buses, right and left turning lanes, location of bus stops, and signal timing, are secondary variables, and the effect of these secondary variables must be taken into consideration after the effect of the primary variables has been determined.

[3] The concept of the peak-hour factor, load factor, and urban population as primary factors influencing traffic capacity are set forth in "Variations in Flow at Intersections as Related to Size of City, Type of Facility and Capacity Utilization," by O. K. Normann, HRB Bulletin 352. The peak-hour factor is defined as: "The ratio between the number of vehicles entering the intersection during the peak hour divided by four times the number of vehicles entering the intersection during the peak 15-min. period." Normann notes: "At most locations, however, the peak-hour factor was in the neighborhood of 0.85 with 75 percent of the locations between 0.80 and 0.95."

Load factor is defined as: "The ratio between the total number of green phases that were fully utilized during the peak hour divided by the total number of green phases for that approach during the same period."

To calculate existing intersection capacity for current operational purposes, good engineering practice requires a detailed determination of existing width of pavement, load factor, peak-hour factor, size of urbanizing area (i.e., population group), signal setting, approach grade, percent turns in each direction, turn lanes, parking, directional imbalance, percent buses, location of bus stops, percent trucks, and amount of pedestrian traffic. Pavement width is taken as the basic measure of capacity and all other factors are applied as modifiers to this basic measure. In attempting to determine the future capacity of an existing street intersection, however, only general assumptions can be realistically made about most of the modifying factors. Moreover, if these general assumptions can validly be assumed to apply throughout a large area, the capacity computation procedure is greatly facilitated.

Source of Secondary Factors

The assumption with respect to these modifying factors used in this study are similar to those developed by the Pittsburgh Area Transportation Study.[4] However, the numerical values used for percent of average weekday traffic occurring in the peak hour and for directional imbalance ("K" factor and "D" factor, respectively, in traffic engineering terminology) were selected after compilation and analysis of traffic count data at selected intersections within the Region which were considered to be operating at a volume near good design capacity. Based on this analysis a K factor of 10 percent was selected as appropriate for southeastern Wisconsin, rather than 11 percent as used in the Pittsburgh area. This resulted in the stated capacity of any arterial link being 10 percent higher than would be the case for an 11 percent K factor.

Secondary Factors Assumed for Planning

The general assumptions for determining future capacity, which were derived from a review of local and national data, are as follows:

1. Ten percent of the traffic volume for the average weekday will occur in the peak hour on arterial streets and highways except freeways. (It follows that average weekday 24-hour capacity is ten times peak-hour capacity.)

2. Eight percent of the traffic volume for the average weekday will occur in the peak hour on freeways.

3. Sixty percent of the peak-hour traffic on a two-way arterial street or highway, or the combined total for a pair of one-way arterial streets, will be in one direction, except in central business district areas, where it will be 50 percent each way. (This "60/40 split" requires provision of more street capacity than if peak hour two-way volume were directionally balanced.)

4. The intersection pavement will be shared equally in time with traffic entering from the cross street. (Differences in the entering volumes of the streets are assumed to be accommodated by appropriate pavement widths.)

5. Left and right turn movements will each comprise 10 percent of each of the total entering volumes.

[4] Interim Technical Report IV, Measurement of Highway Capacity, PATS, 1960.

6. Commercial vehicles (trucks and buses) will comprise 10 percent of the total entering volumes.

7. No additional allowance will be made for capacity reduction due to bus stops.

8. No parking will be permitted at or near intersections.

9. Pedestrian interference will be heavier at "downtown" intersections. It will decrease through categories of "type of area,"[5] defined as "intermediate," "outlying," and "rural." The "type of area" is really descriptive of pedestrian activity at each intersection and not of location within the Region.

10. A 5 percent reduction in capacity is made for an adverse approach grade of 3-6 percent; a 10 percent reduction for an adverse approach grade over 6 percent.

11. Capacity determinations based on the foregoing assumptions will apply only to through traffic lanes at intersections. Turn refuges will serve to increase this capacity as follows:

    Left turn refuge lane, 10 percent
    Right turn refuge lane, 5 percent
    Both lanes, 15 percent

It was further assumed that, for any given intersection, none of the modifying factors except "type of area" would change for any given link over the planning period unless changed by construction work. It should be noted that existing on-street parking regulations and signal settings are not explicitly taken into account since it was judged logical to assume for long range planning purposes that the traffic capacity of all available pavement width at arterial street intersections together with optimal signal settings would, in the public interest, be utilized before a recommendation is made to construct additional highway facilities or to widen and improve existing intersection approaches. It is, therefore, implicitly assumed that at any arterial intersection where traffic congestion is a problem, traffic engineers or other local officials having jurisdiction will restrict or prohibit parking as necessary to obtain full utilization of existing pavement width, and will optimize signal settings to obtain maximum capacity from the existing intersections. The increment of future traffic demand beyond what can thereby be accommodated at desirable levels of service is the traffic for which improved or added facilities must be planned.

---

[5] "Type of Area" is a classification describing conditions around an intersection which cause different degrees of pedestrian interference with vehicular traffic and interference from vehicles parking. The four categories used, namely, downtown, intermediate, outlying, and rural, are defined on page 20 of the _Highway Capacity Manual_. These terms can be somewhat misleading in that, for example, "intermediate" type intersection can occur farther away from the central business district of an urban area ("downtown") than several "outlying" type intersections and may be assigned at shopping centers, industrial sites, or other concentrations of land use activities anywhere in a geographic area, such as the Region, where pedestrian and parking activity warrant. To avoid possible misunderstanding about the type of intersection and its location in the urban area, numerical designations were used in the SEWRPC inventory to designate by type each intersection as: 1, 2, 3, or 4, the numerals corresponding respectively to the manual's "downtown," "intermediate," "outlying," and "rural" categories. The numerical designation is actually a ranking by degree of pedestrian and parking interference developed from a concensus of commission and local traffic engineering staff.

Primary Factors Assumed for Planning

Figure 30 of Normann's paper (see Figure 2) presents an empirically derived graph which establishes a relationship between approach width of pavement and traffic capacity expressed in vehicles per hour of green. Curves are drawn for load factors of 1.00, 0.40, and 0.00. All of these curves are for a peak-hour factor of 0.85 and city size in range 4 (population 250,000 to 499,999). Another graph has been developed by Normann showing, in addition to the published curves, other curves for load factors of 0.70 and 0.20 as shown in Figure 3. The curve for a load factor of 0.70 is drawn as a straight line lying midway between the published curves for load factors 0.40 and 1.00. A similar graph has been developed by Normann for one-way streets with parking prohibited. (See Figure 4.) The graph for one-way streets is also drawn for a peak-hour factor of 0.85 but for a city size range of one million population.

In comparing the curves developed by Normann with local capacity curve data, it was noted that the curves developed by Normann for a load factor of 0.70 were parallel to an intersection capacity curve developed and used by the engineering staff of the City of Milwaukee.[6] (See Figure 5.)

[6] The City of Milwaukee curve was developed by assuming that traffic would operate through an intersection under good design conditions at an average headway of 2 1/2 seconds and then calculating the curve as follows: 2 1/2 second headway = 24 equivalent vehicles per minute. Adjusting for 10 percent commercial vehicles, with each assumed equivalent to three autos, and 10 percent of traffic turning left, with each left turning vehicle equivalent to 1.5 through vehicles, yields

$$\text{actual veh/min.} = 24 \text{ equiv. veh.} \times \frac{100\%}{T + (3 \times C) + (1.5 \times L)} = 24 \times \frac{100\%}{125\%} = 19 \text{ veh/min}$$

where

T = 80% (through vehicles)
C = 10% (commercial vehicles)
L = 10% (vehicles turning left)

hourly capacity = 19 veh/min. x 60 min/hr. x 1/2 green time = 570 vph

$$\text{capacity multiplier} = \frac{570 \text{ vph}}{11 \text{ ft. (lane width)}} = 51.8 \text{ vph/ft. of width}$$

Figure 2
INTERSECTION APPROACH CAPACITIES[a]
(two-way streets, no parking)

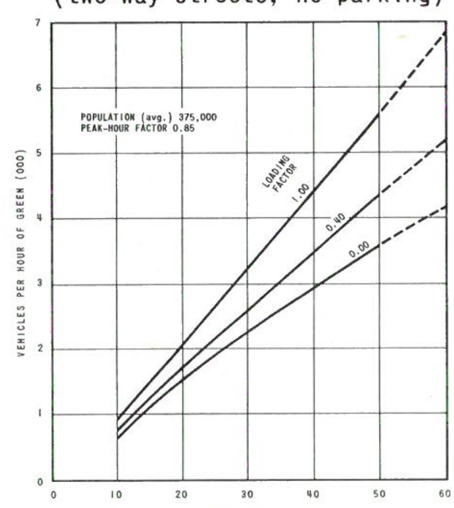


Figure 3
INTERSECTION APPROACH CAPACITIES[b]
(two-way streets, no parking)

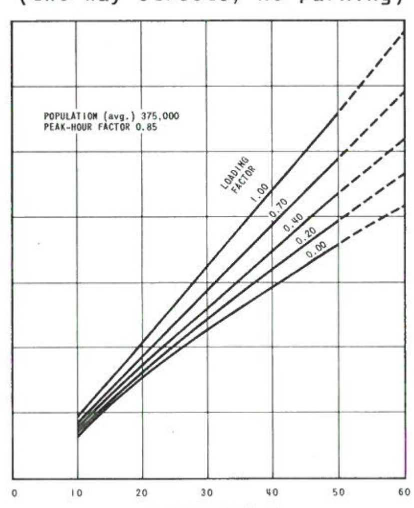
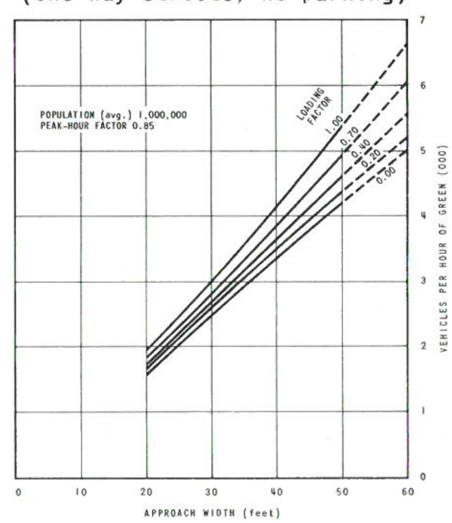


Figure 4
INTERSECTION APPROACH CAPACITIES[b]
(one-way streets, no parking)



[a] *Source:* *O. K. Normann, "Variations in Flow at Intersections as Related to Size of City, Type of Facility and Capacity Utilization," p. 78, Figure 30, Highway Research Board Bulletin 352 (Washington, D. C., 1962).*

[b] *Source:* *Correspondence from O. K. Normann.*

It was also noted that the capacity curves derived by Normann for one-way streets, city size range of one million, and for two-way streets, city size of 375,000, are coincident except at approach widths of over 55 feet. It should be noted that this does not mean that intersection capacity is the same for one-way streets as for two-way streets. (A street of given width, when operated as a two-way street, has a capacity at each intersection approach less than half the capacity of the entire width when operated as a one-way street.) A load factor of 0.70 is higher than average and closely approximates the condition which under older practice was called "possible" capacity. (The terms "possible" and "practical" capacity are not used under the methodology developed by Normann, et al.) It was further noted that the only difference between the capacity curves developed by Normann and the capacity curve developed by the City of Milwaukee was an offset along the abscissa equivalent to a pavement width of two feet, and a straight line extension of the curves selected from Normann's work was found to cross the x-axis at two feet, as shown in Figure 5. Therefore, as can be seen in Figure 5, capacity for arterial streets could be determined by multiplying pavement width, less two feet, times a constant. This constant equals the slope of the plotted straight line approximation for curves (2) and (3) on Figure 5. In Normann's procedure for calculating intersection capacity, the value obtained from the curve must be modified by tabled constants to adjust for "type of area" (description of intersection conditions) and for "city size." The value thus obtained is then, in the SEWRPC procedure, adjusted up or down for other secondary characteristics, such as the existence of turn refuges, adverse grade, and directional imbalance.

Figure 5

INTERSECTION CAPACITIES
(headway calculation method compared with selected curves of Normann)

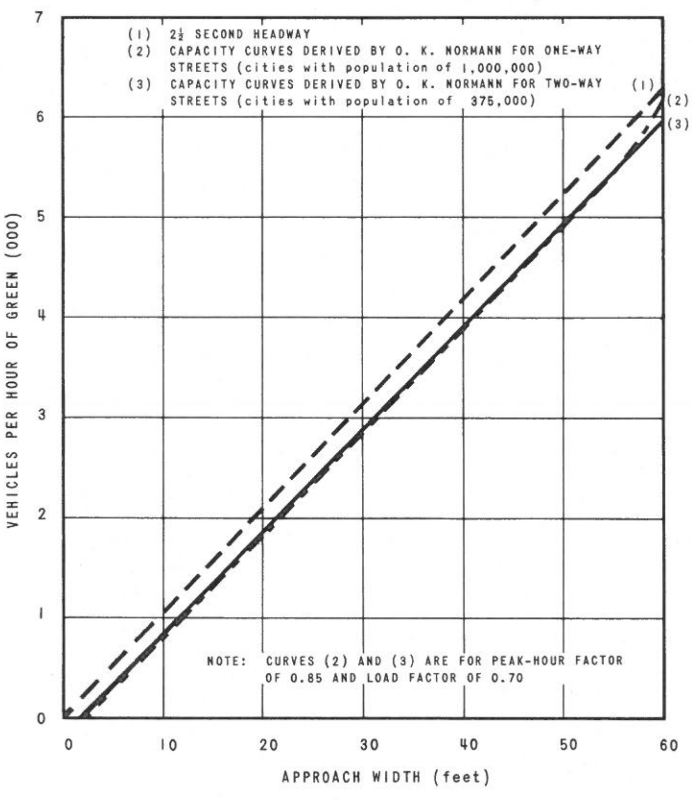
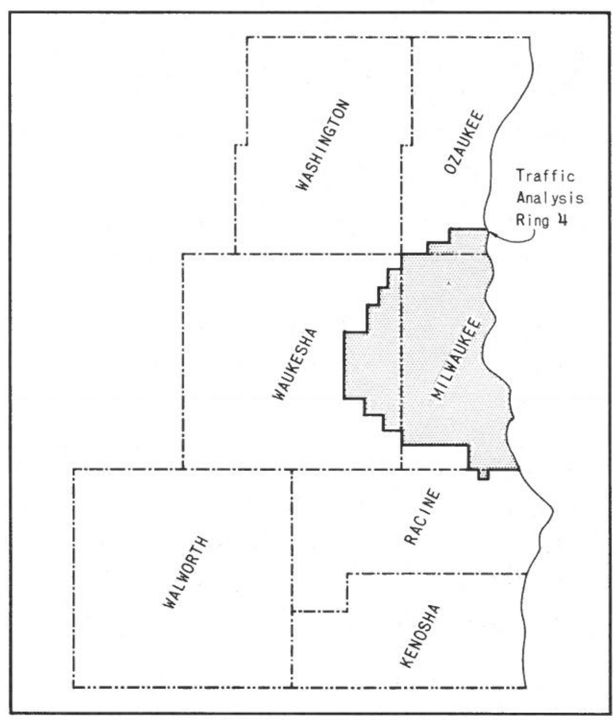


Figure 6

LOCATION OF TRAFFIC ANALYSIS RING 4 IN THE REGION



It should be noted that use of the capacity curves developed by Normann involve some new kinds of adjustment factors, which have not previously been in general use for computing intersection capacity. One such factor is the size of the metropolitan area. Different capacity adjustment factors have been developed for areas of different population size. The adjustment factor for metropolitan areas of over 1,000,000 population was used as a basis for computing arterial street capacity in the greater Milwaukee area. For convenience, these factors were applied to all links in rings zero through four in the SEWRPC network. (See Figure 6.) The city size factor for cities in group 2, population 54,000 up to 100,000, was used as a basis for computing arterial street capacity in Racine, Kenosha, and the rest of the Region. It is thereby implicitly assumed that traffic at rural intersections will behave as it does in smaller cities whenever volumes on these presently rural intersections reach capacity.

CAPACITY CALCULATIONS

The curve selected for two-way streets and reproduced as number (3), Figure 5, is applicable for a peak-hour factor of 0.85, load factor of 0.70 and "city size" of 375,000 population. It was noted that the curve obtained for one-way streets is for a different "city size" (population) than the curves for two-way streets. A table of adjustment factors for "city size" has been developed by Normann for application with each family of curves. To adjust for "city size" of over one million population, the appropriate factor is selected from the indicated table to modify the value read from the one-way curve for "city size" of one million population. A different factor is selected from a similar table which accompanies the curve for two-way streets to adjust from city size of population 375,000 to that of over one million.

From the curve shown in Figure 5 for two-way streets, a multiplier of 103 vehicles per hour of green per foot of pavement width (vphg/ft.) was obtained as equal to the slope (capacity divided by pavement width less two feet). This is for cities with a population of 375,000. Applying the assumption of 50 percent green time resulted in a value of 51.5 vph/ft.

Similarly, the slope for one-way streets was read as 102 vphg/ft., which equals 51.0 vph/ft. This is for cities with a population of over one million. Note that the two-foot zero offset must be subtracted from pavement width before applying these factors.

In each case, a level of service factor of 0.70 was selected to adjust to design capacity.[7] This level of service is judged by SEWRPC staff to be one that will provide a suitable standard for design.

The factor for directional imbalance was also uniformly applied. Division by 1.20 (or multiplication by 0.833) outside of the Milwaukee CBD accounts for the fact that if the side of a street carrying 60 percent of the traffic is operating at capacity, the side carrying 40 percent of the traffic is at only two-thirds capacity. The whole street (average of both sides) is then at five-sixths capacity.

In the SEWRPC procedure, an average of morning and evening peak-hour capacity is obtained by calculating capacity on the approach pavement at each exit from a link,

[7] See p. III - 22 Traffic Assignment Manual, USBPR, June 1964.

using a factor of 0.833, to adjust for directional split. For a two-way street where intersection approaches at both ends are symmetrical, this would not be necessary; but for cases where conditions at the link exits are not symmetrical, such an average is judged to give a better representation of the 24-hour weekday volume to be used for comparison with traffic counts and for capacity restraint in an assignment of weekday trips.

Capacity of Two-way Arterial Streets

The factor specified to adjust the capacity of two-way streets for urban areas with populations of over one million is 1.11, and this factor was used for all such streets in the Milwaukee area through ring 4 (See Figure 6). Applying these factors to the previously determined quantity of 51.5 vph/ft. yields 51.5 vph/ft. x 0.70 x 0.833 x 1.111 = 33.4 vph/ft. of width where the adjustment factors are for design level of service, directional imbalance, and city size, respectively.

A further adjustment factor for type of area is given in the adjustment tables which accompanied each curve. For "downtown" areas this is 0.82 and for all other area types it is 1.02.

The SEWRPC capacity multiplier for Milwaukee area two-way streets at type 1 intersections = 33.4 x 0.82 = 27.4 or 27 vph/ft. of width.

The SEWRPC multiplier for type 2 intersections = 33.4 x 1.02 = 34.1 or 34 vph/ft.

In the rest of the Region outside ring four, the given adjustment factor of 0.889 for a city of 75,000 was used. (This is the smallest city size given in the tables of adjustment factors.) The downtown area factor of 0.82 was also applied.

Capacity multiplier for type 1 intersection = 51.5 x 0.70 x 0.833 x 0.889 x 0.82 = 22.0 vph/ft. of width. For type 2 intersections, a factor of 1.02 in place of 0.82 yields 27.4 or 27 vph/ft. of width.

Capacity of One-way Arterial Streets

The given factor to adjust the capacity of one-way streets for urban areas with populations of over one million is 1.026 and this factor was used for all such streets in the Milwaukee area through ring 4. Under conditions of prohibited parking, no adjustment is made for type area in Normann's tables. The same factors as before apply for design level of service (0.70) and directional imbalance (0.833) for a pair of opposite one-way streets outside of the Milwaukee CBD.

Capacity multiplier = 51.0 vph/ft. x 0.70 x 0.833 x 1.026 = 30.51 vph/ft. of width. This gives a capacity multiplier of 31 vph/ft. for type 1 intersection.

Outside ring four, the given factor to adjust for a city with population of 75,000 is 0.821. This gives a capacity multiplier of 24 vph/ft. for type 1 intersection.

The values, thus calculated, are plotted in Figures 7 and 8.

Figure 7

HOURLY DESIGN CAPACITIES
INSIDE RING 4, OUTSIDE CBD

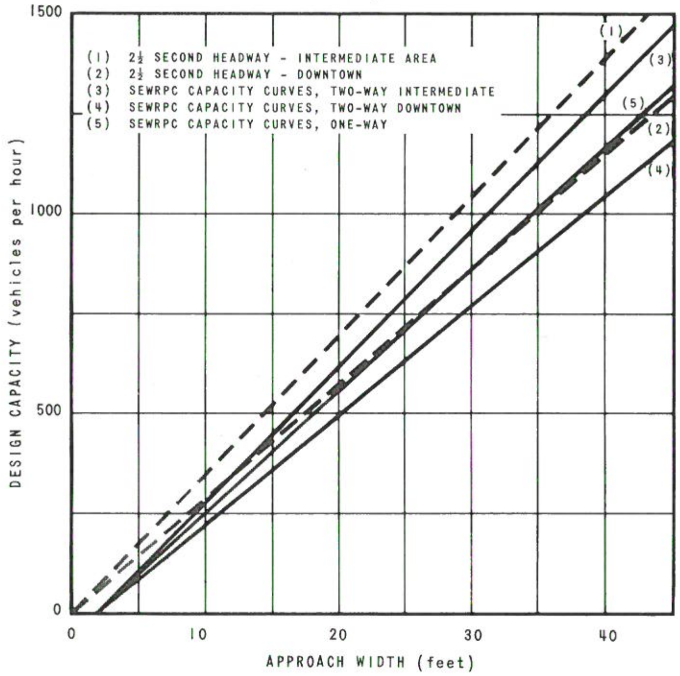
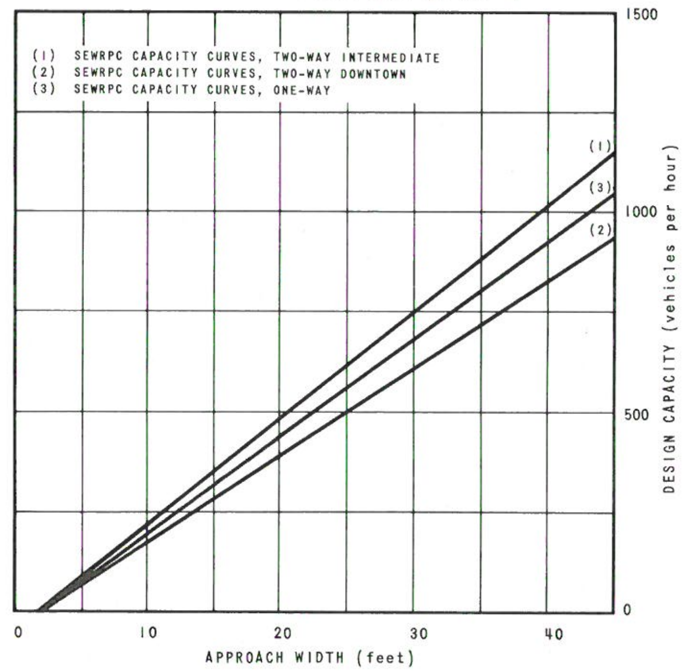


Figure 8

HOURLY DESIGN
CAPACITIES OUTSIDE RING 4



Design Capacity Values Obtained for Freeways and Expressways

Freeways: It is generally accepted that the possible (maximum) capacity of a freeway is 2000 passenger vph/lane. This value must be modified to obtain design capacities representing actual urban and rural operating conditions. For the Region, the design capacity of three freeway lanes under peak-hour conditions has been selected by SEWRPC staff as 4500 vph in the Greater Milwaukee area and 3400 in the remainder of the Region.

The Milwaukee area capacity multiplier was calculated as follows:

Correction for 10 percent commercial vehicles (assuming 1 truck = 2 cars)

$$\text{Capacity (3 lanes urban)} = \frac{4500}{1.10} = 4090 \text{ vph}$$

For use with a weekday 24-hour non-directional assignment, it is necessary to account for the 60/40 directional split by using a factor of 0.833.

$$\text{Milwaukee area freeway capacity multiplier} = \frac{4090 \times 0.833}{36-2} = 100 \text{ vph/ft.}$$

$$\text{Capacity multiplier for remaining freeway} = \frac{3400 \times 0.833}{1.10 \times (36-2)} = 75.8 \text{ vph/ft.}$$

For purposes of machine calculation, all multipliers were developed for approach widths minus two feet (W-2) because the intersection capacity curves intercepted zero capacity at two feet (as shown in Figures 5, 7, and 8). This distortion understates the two lane capacity and overstates the four lane capacity very slightly.

Expressways: In the Greater Milwaukee area, design capacity for two lanes of expressway (24 ft. approach width) was chosen as 2800 vph. For remaining expressways, 1800 vph was used. These values were derived from applying the factors 0.70 and 0.45 to the theoretical maximum of 4000 vph to adjust for design level of service.

The capacity multipliers were calculated as follows:

$$\text{Correction for 10 percent commercial vehicles} = \frac{2800}{1.10} = 2544 \text{ vph/lane}$$

Greater Milwaukee area expressway capacity multiplier =

$$\frac{2544 \times .833}{24-2} = 96.2 \text{ vph/ft.}$$

$$\text{Remaining expressways capacity multiplier} = \frac{1800 \times .833}{1.10 \times (24-2)} = 61.8 \text{ vph/ft.}$$

These multipliers were assumed to apply for type 3 intersections.

SEWRPC Capacity Multipliers

The hourly capacity multipliers calculated from the above procedure, or extrapolated from these, were prepared in tabular form, classified by type of route and type of area at the intersection. (See Table 1.)

Table 1

HOURLY CAPACITY MULTIPLIERS IN THE REGION BY TYPE OF AREA AT INTERSECTION

(in vehicles per hour per foot pavement width)

Type Route	Type of Area - Inside Ring Four				Type of Area - Outside Ring Four			
	Down-town (1)	Inter-mediate (2)	Out-lying (3)	Rural (4)	Down-town (1)	Inter-mediate (2)	Out-lying (3)	Rural (4)
Freeways	100	100	100	100	76	76	76	76
Expressway	90	93	96	96	57	60	62	65
Two-way Arterial	27	34	36	39	22	27	30	33
One-way Arterial	31	36	39	42	24	28	32	35

Ramp capacity was calculated as follows: those requiring a stop at the exit, e.g., off ramps, are considered as having capacity equivalent to that of one-way streets.

Those having a merge condition without a stop at the exit, e.g., on ramps and interchange ramps between freeways, are considered as having capacity equivalent to that of expressways.

Steps in Computing Link Capacity from Link Inventory Card

A procedure was programmed for the IBM 1401 computer to compute link capacity and produce a link data card from each link inventory card. First, the inventory card is read. On the basis of the indicated type of route and type of area at exit end (node a), a basic capacity multiplier is selected from Table 1, above. If the link is in district 00, Milwaukee CBD, the reduction for directional imbalance (0.833 previously applied to all multipliers) is removed by multiplying by 1.2. If adverse approach grade of 3 to 6 percent is indicated, a factor of 0.95 is applied; if grade is greater than 6 percent, the factor is 0.90. If a left turn refuge lane is coded, a factor of 1.10 is applied; right turn refuge lane, 1.05; both right and left turn refuge lanes, 1.15.

The approach width of pavement is read, two feet subtracted, and the resulting value multiplied times the adjusted multiplier. If the link is two-way, the computation is repeated for approach width at the other end, and the capacity of both link exits are added. This value, hourly capacity, is divided by 10 percent, except for freeway links which are divided by 8 percent.

The following example will indicate how this method applied to specific links in the network. Link 2007 to 2003 is North Capitol Drive from Atkinson Avenue to Green Bay Avenue. This was inventoried as a two-way arterial street with "intermediate" area type intersections at both ends. Since the link is inside ring four, the left half of Table 1 is used to derive the hourly capacity multiplier. The specified multiplier from Table 1 is 34. There is no adverse grade at either end. At Green Bay Avenue, there is both a right turn lane and a left turn lane. This increases the multiplier by 15 percent, giving an adjusted multiplier of 39.1 for that intersection. Eastbound pavement approach width at Green Bay Avenue is 37 feet. Therefore W-2 = 35 feet and 35 feet x 39.1 vph/ft. = 1369 vph. Since this is a two-way street, the multiplier for the Atkinson Avenue intersection, which has no turn lanes, is 34 vph multiplied by the westbound approach width of 34 feet minus two feet, or 32 feet, to get 1088. The resulting link capacity is the sum of the two intersection capacities, or 2457 vph as design capacity. Dividing this capacity by 10 percent or multiplying it by ten yields an average weekday capacity of 24,570 vehicles.

SUMMARY

Link capacity was calculated for each link in the highway assignment network, and the results posted on network maps. These maps were reviewed by members of the Technical Coordinating and Advisory Committee for any apparent discrepancies that may have resulted. All locations thus identified were field checked, and the necessary corrections made in the inventory data cards. Corrected link capacities will be used in a restrained assignment of vehicle trips determined from the O & D surveys. Comparison of this assignment with known traffic volumes will be used as a further test of the entire assignment procedure.

Cost Estimate

Data processing and computer costs for the network capacity determinations are estimated at $1,045. This cost includes: keypunching, verifying, sorting, and collating of the data cards; writing, adjusting, and assembling the program several times; and several production runs using the approximately 4,000 data cards. Engineering time, including that of the Division Chiefs and Study Director, expended in development of techniques, staff conference, calculations and review, is estimated at about $1,500. Total cost of the capacity determination, therefore, is estimated at about $2,500.

* * * * * * *

(Backward Glance continued from page ii)
1851, the 20-mile railroad between Milwaukee and Waukesha was opened.

The locomotive of the first train had been built in 1849 by the Norris Works of Philadelphia. It was called "Bob Ellis, Number 1," weighed some 20 tons, and had a "4-4-0" wheel arrangement.[3] Like the others of its times, the engine was a woodburner similar to that pictured in the photograph on page 14.

The train left Wisconsin's first depot, which was located on Second Street in Milwaukee, on its historic route at 25 miles per hour over six foot gauge iron H-rails (commonly called T-rails). The 250 passengers had paid $1.50 for a round trip, complete with band music and a dinner at the Waukesha car house.

In the cab of the first train was Byron Kilbourn, under whose direction the railroad had been completed. Kilbourn had conceived the Rock River Canal project, and when interest in the canal project had waned, he and the canal project's board of directors had moved behind the railroad.[4] The resourceful Kilbourn had been elected president and chief engineer of the railroad.

The railroad itself was a result of the vision and initiative of southeastern Wisconsin business and political leaders and the people themselves. The grading for the railroad was paid for by orders on merchants, artisans, farmers -- all receiving stock subscriptions in payment of the supplies furnished. Farmers mortgaged their farms to buy shares so that the rails could be bought and their wheat given swift and economical passage to market. The City of Milwaukee bonded itself for $234,000 to buy stock in the railroad company.

First Railroad Reaches Goal

The building of the first railroad in Wisconsin westward from Milwaukee was the beginning of a new era in the state; and also the beginning of the great transcontinental rail system, which eventually became the Chicago, Milwaukee, St. Paul and Pacific Railroad Company -- the Milwaukee Road.

The first railroad was continued from Waukesha through Eagle, Whitewater, and reached Milton, 62 miles from Milwaukee in 1852, then to Stoughton in 1853, and Madison in 1854. It reached Prairie du Chien, at the confluence of the Wisconsin and Mississippi rivers, 181 miles from Milwaukee, in 1857. The first railroad line is still in operation within the Region, providing, however, freight service only west of Brookfield.

Equipment of the Milwaukee & Mississippi, by the end of 1854, was listed as:

[3] The first locomotive constructed in the state was completed in 1853 by James Waters at the Milwaukee Shop of the Milwaukee & Mississippi Rail Road Company. In 1876, the Milwaukee Road abandoned the practice of naming locomotives.

[4] See "A Backward Glance -- Milwaukee and Rock River Canal," Technical Record; SEWRPC, Vol. 1 - No. 5.

Continued on page 14

(Backward Glance continued from page 13)
seven passenger cars, four baggage cars, 201 covered freight cars, 50 uncovered freight cars, 40 gravel cars, 14 hand cars, and 22 locomotives.

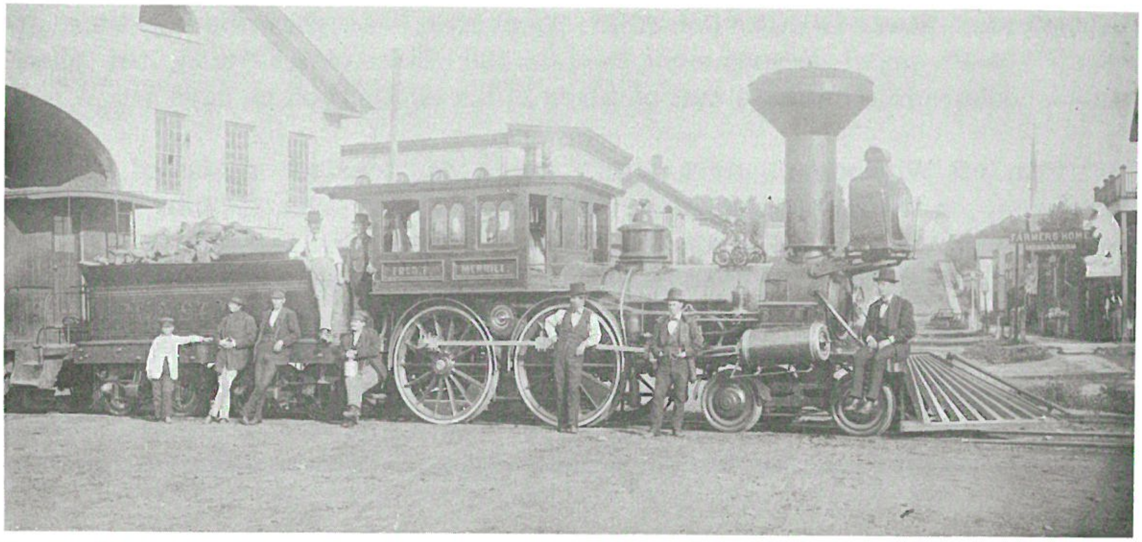


Photo courtesy of the Waukesha County Historical Society

TYPICAL LOCOMOTIVE OF THE 1850's -- Pictured above is the "Fred T. Merrill" and Caboose at the Old Freight Depot of the Milwaukee & St. Paul Railway (the Milwaukee Road), Madison Street, Waukesha, Wisconsin.

North-South Lines Begin

A north-south line -- the Madison & Beloit Railroad Company -- which was eventually to become a part of the Chicago and North Western system was begun in 1851. By the late fifties, tracks had been built from Janesville north to Fond du Lac and Oshkosh, and southward to meet a line from Chicago. It was renamed the Chicago, St. Paul, and Fond du Lac Railroad, popularly called "The Fond du Lac Road"; and subsequently became part of the Chicago and North Western.

The early north-south main line extended from Chicago through Sharon in Walworth County, thence through Janesville and Watertown to Green Bay, which was reached in 1862. Its "Kenosha Division" extended from the city of Kenosha through Genoa in Walworth County to Rockford, Illinois.

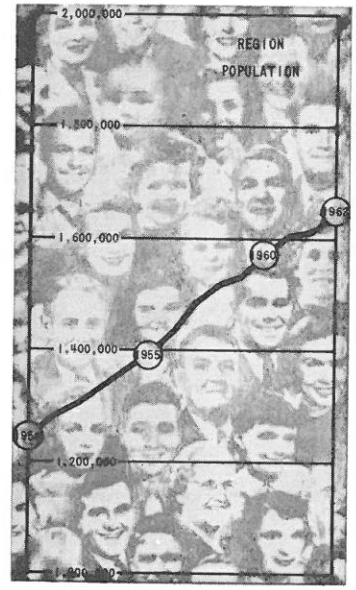
The Green Bay, Milwaukee and Chicago Railroad was chartered by the state of Wisconsin in 1851 and in 1855 was built from Milwaukee south through Oak Creek, Racine, and Kenosha to the Wisconsin state line. In 1857, the name was changed to the Milwaukee and Chicago Railroad Company. Thus, rail transportation was established between Chicago and Milwaukee, but until 1863 when the two roads consolidated as the Chicago and Milwaukee Railway, freight and passengers alike changed cars at the state line. By 1869, this line had been extended north through Hartford and Horicon, around the westerly edge of the Horicon Marsh to Fond du Lac, Oshkosh, Appleton, and Green Bay. The North Western acquired the Chicago and Milwaukee through consolidation in 1883.

Continued on page 20

THE ABC METHOD OF CURRENT POPULATION ESTIMATION

by Donald L. Gehrke, Economics and Population Analyst, and
Orlando E. Delogu, Financial Resources and Legal Analyst

INTRODUCTION



Current population estimates are an important part of the basic data necessary for sound long-range planning. Planning studies such as the Southeastern Wisconsin Regional Planning Commission land use-transportation study are often initiated in other than a census year, and current population estimates are therefore essential to a proper description and understanding of the existing state of the planning area, to the preparation of certain analyses and forecasts, and to the development of standards. Even if such studies are scheduled around a decennial census year, postcensal population estimates are an essential part of the continuing planning work centered on plan implementation and, inevitably, plan modification and adaptation.

A number of methods of estimating current, postcensal, or intercensal populations have been developed. These include: 1) mathematical methods such as arithmetic and geometric projections and extrapolations of historic trends; 2) component methods based upon analysis of births, deaths, and net migration;[1] 3) ratio and/or apportionment methods; 4) methods based on symptomatic data such as utility meter counts and school census reports; 5) graphical methods; and 6) statistical methods of correlation and regression analysis. Experimental tests have been made to determine the relative accuracy of these methods, but considerable difference of opinion still exists as to which method is best. It should, however, be noted that the selection of any population estimation method depends upon the specific uses to be made of the estimate and the time and staff experience available as well as upon the probable accuracy of the method.

Several variations of the first four of these method types have been used by the SEWRPC staff members to prepare estimates of the current population levels in the Region and the seven component counties since the census count of 1960. In addition, the origin and destination surveys, conducted as a part of the SEWRPC land use-transportation study, have provided estimates of the current population in the various traffic analysis zones throughout the Region.[2] These surveys

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[1] The U. S. Department of Commerce, Bureau of the Census, employs several variants of this method.

[2] "Arterial Network and Traffic Analysis Zones," Technical Record; SEWRPC, Vol. 1 – No. 2. This article explains the rational for, and selection of, traffic analysis zones in southeastern Wisconsin.

provided estimates of the current population level as of the survey months of April and May, 1963. As far as can be determined, one of the several methods used by the Commission staff in the preparation of current population levels is a new variation of the symptomatic data method of current population estimation. This method, labeled the ABC method, is the subject of this article.

The ABC method was developed as a part of the land use-transportation study public financial resources survey which required intercensal population estimates for each minor civil division in the Region from 1950 to 1960, and from 1960 to 1963. Efforts were directed at developing this method of estimating intercensal population levels after experiments with various mathematical interpolation techniques proved unsatisfactory to the needs of this study program.

THE ABC METHOD

Background

The ABC method is not a new method in concept, i.e., it is a method based on symptomatic data. What is new is the type of symptomatic data utilized in the technique. Previously, symptomatic methods have depended upon such data as vital statistics; school enrollment; listings in city directories; electric meter, water meter, or telephone installations; building permits; and voter registrations. The ABC method utilizes a new data source, newspaper circulation data collected by the Audit Bureau of Circulations, which has its headquarters in Chicago, Illinois. For this reason it is called the ABC method. Actual population estimates are subsequently based on an analysis of the relationship of newspaper circulation to population.

This concept is immediately appealing. Newspaper circulation change is closely correlated with population movements. People generally subscribe to the local paper when they move into an area and they stop the service when they move out. Moreover, newspaper readership has proven to be relatively unaffected by irregular political and economic changes and business cycles scarcely affect newspaper circulation. On the other hand, the factors which do affect the relationship of newspaper circulation to population are reasonably predictable. Such short run effects as strikes are readily detectable, and such long run effects as changes in family size and changes in the market position of newspapers relative to other informational media are gradual and reasonably predictable.

This method of population estimation based on newspaper readership is almost ideal with respect to availability, adequacy, and timeliness of data. This method, thus, overcomes the problems of data limitation common to some other symptomatic data techniques. The Audit Bureau of Circulations conducts an annual audit of the newspaper circulation of all the major newspapers in the United States. The data collected is carefully compiled by geographic area and checked for accuracy. The data is readily accessible and can be obtained either directly from local newspapers or from the central ABC office in Chicago, Illinois. It should be noted that only weekday circulation data is collected for this method since Saturday or Sunday newspaper circulation varies for reasons not associated with population change.

APPLICATION OF THE ABC METHOD FOR THE REGION

Data Collection

In the SEWRPC work, circulation data was obtained directly from the central ABC office for the 15 major newspapers serving the seven counties in the Region for the years 1950 to 1963 inclusive. The data which was collected reflected the average weekday circulation for the twelve months ending March 31 of each year. The necessary data collection was accomplished in the Audit Bureau's Chicago offices in one day by two staff persons although the audit reports needed could have been purchased and the data tabulated at the planning office. The combined newspaper circulation figures collected for the 15 selected newspapers for each of the seven counties in the Region for the years 1950, 1955, 1960, and 1963 are shown in Table 1.

Table 1

NEWSPAPER CIRCULATION IN THE REGION BY COUNTY FOR SELECTED YEARS

Year	Kenosha	Milwaukee	Ozaukee	Racine	Walworth	Washington	Waukesha	Region
1950. . .	27,503	329,980	6,241	38,137	13,676	7,630	28,131	451,298
1955. . .	29,741	356,626	7,590	41,701	14,403	8,311	34,232	492,604
1960. . .	32,737	371,085	10,224	44,450	15,930	10,051	52,243	536,720
1963. . .	33,848	377,514	11,264	46,186	15,958	10,610	58,457	553,837

Source: Audit Bureau of Circulation records.

Determining Newspaper Circulation to Population Ratios

The basic analytical task in the ABC method of estimating total population was to determine the ratio of newspaper circulation to population in each of the estimation years. This was accomplished by an analysis of the known ratios, that is, the ratios in the years in which the U. S. census was conducted. In the public financial resources study, the ratios of combined newspaper circulation to population in each of the Region's seven counties for 1950 and 1960 were calculated and are shown in Table 2.

Table 2

RATIO OF NEWSPAPER CIRCULATION TO POPULATION IN THE REGION BY COUNTY FOR CENSUS YEARS 1950 AND 1960

Year	Kenosha	Milwaukee	Ozaukee	Racine	Walworth	Washington	Waukesha	Region
1950.	0.365	0.378	0.267	0.348	0.328	0.225	0.327	0.364
1960.	0.325	0.358	0.238	0.313	0.304	0.217	0.330	0.341

It is apparent from the table that the ratio of newspaper circulation to population in the seven counties declined slightly from 1950 to 1960 in all cases but one. Among other factors, this reflects the increase in the proportion of children in the populations of these counties over the ten year period. By assuming that the change in these ratios was relatively constant, it was possible to estimate the ratios for the years between 1950 and 1960 by simple linear interpolation. To estimate the ratios in the postcensal years, the ratios for each county were extrapolated at slightly less than their 1950 to 1960 rate of change. This assumption appeared to be sound since recent information, collected in the SEWRPC land use-transportation study, indicated that the population structure in the Region has experienced further increases in the proportion of children, but at a slower pace than during the 1950 to 1960 decade.

Estimating the Population

Once the newspaper circulation to population ratios had been determined, the actual population estimates were obtained by utilizing the formula: $P = C/R$;

where

P = population estimate,

C = newspaper circulation, and

R = the readership ratio.

The estimates for each of the seven counties in the Region for the years 1955 and 1963 are shown in Table 3.

Table 3

TOTAL POPULATION ESTIMATES FOR THE REGION BY COUNTY

Year	Kenosha	Milwaukee	Ozaukee	Racine	Wal-worth	Wash-ington	Waukesha	Region
1950[a]	75,238	871,047	23,361	109,585	41,584	33,902	85,901	1,240,618
1955[b]	86,100	967,600	28,500	125,900	45,500	37,500	104,100	1,395,200
1960[a]	100,615	1,036,047	38,441	141,781	52,368	46,119	158,249	1,573,620
1963 ABC[b]	107,500	1,072,100	42,800	151,700	55,200	49,900	183,000	1,662,200
1963 I[c]	108,800	1,073,500	43,300	150,700	55,200	49,900	189,100	1,670,500
1963 II[d]	N/A	1,075,300	42,600	N/A	N/A	49,800	177,700	N/A
1963 III[e]	106,700	1,086,300	41,600	150,600	55,500	49,500	184,200	1,674,400
Average 1963 I, II, III	107,800	1,077,300	42,500	150,700	55,300	49,700	183,500	1,666,800
Percent Difference ABC/Average	-0.3%	-0.5%	+0.7%	+0.7%	-0.2%	+0.4%	-0.3%	-0.3%

[a] *U.S. Census counts.*

[b] *Estimates as calculated from ABC data.*

[c] *Estimates as obtained from Wisconsin State Board of Health, Bureau of Vital Statistics.*

[d] *Estimates as obtained from The Milwaukee Journal Company.*

[e] *Estimates as obtained from the SEWRPC 1963 origin and destination surveys.*

The 1963 population estimate prepared by the ABC method was checked against 1963 estimates prepared independently by the other methods. These comparative estimates are also shown in Table 3. In the table, the estimates obtained from the method labeled "1963 I" were developed by the Wisconsin State Board of Health, Bureau of Vital Statistics utilizing vital rates and events as symptomatic data; "1963 II" estimates were developed by The Milwaukee Journal Company utilizing building and demolition permits as symptomatic data; and "1963 III" estimates were obtained by expanding the sample data collected as a part of the SEWRPC land use-transportation study origin and destination surveys. It can be seen from the table that the ABC estimates compare very closely with those made by the other techniques.

SUMMARY

This article has described what is believed to be a new technique for making intercensal and postcensal population estimates. It is a technique based on a variation of the symptomatic data method, i. e., a method utilizing data which is closely correlated with population change. The method is called the ABC method because the symptomatic data used is newspaper circulation data readily available from the Audit Bureau of Circulations.

The method appears to be particularly adaptable to preparing current population estimates for counties and metropolitan areas. In addition, this technique is adaptable for estimating the current population of larger municipalities; although changes in the corporate limits lines over time, if not taken into account, may decrease the accuracy of the estimate.

The method described is quite practical for a number of reasons: 1) the symptomatic data used is readily accessible and accurate; 2) the method does not involve a multiplicity of complicated assumptions and calculations; 3) the estimates appear, on the basis of very limited experience, to be as accurate as those obtained by more complex techniques now in use; and 4) it is extremely cheap.[3]

The method does, however, have certain limitations. The most important such limitation is the fact that the relationship of newspaper circulation to population does not remain constant over time, and the changes in the relationship must be estimated by linear interpolation and/or extrapolation. Further study of this relationship may facilitate more refined estimates. In any case, the method appears to be a worthwhile contribution to the broad field of demography and a useful, relatively simple, and very economical tool for the planner.

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[3] The preparation of current population levels for the years 1950 through 1963 inclusive for the Region and for each of the seven counties comprising the Region was completed at a total cost of approximately $150.

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(Backward Glance continued from page 14)

Consolidation Follows Panic

Every railroad in the state went bankrupt after the Panic in 1857 which was engendered by speculation. In a series of consolidation moves, larger companies absorbed a line here and a line there and then built suitable connecting links. Some poorly conceived and located little railroads were wiped out completely.

By the end of 1860, there were 891 miles of railroad in Wisconsin (30,000 miles in the nation), mainly in the state's two east-west railroads across the state -- the Milwaukee & Mississippi and the LaCrosse & Milwaukee[5] -- and the north-south line -- Chicago and North Western -- and shorter ones west from Racine and Kenosha. A line connected Racine to Burlington, Elkhorn, Delavan, and Beloit by 1869. Railroads had taken the place of river shipping so effectively that the Mississippi traffic never regained its relative importance.

Civil War Intervenes

Increased traffic and the closing of the Mississippi-Gulf route by the Confederacy during the Civil War -- a route which had formerly been a major outlet for Wisconsin lumber, lead, and farm produce -- intensified the need for railroad transportation; so it was fortunate that a basic railroad network had already been built in the state before that time.

Immediate further development of peacetime enterprises were halted by the war. Troops were rushed to preserve the Union by all available trains; and the railroads' stamina was proved during the war period. Scarcity of material and labor and inflation in building costs halted major railroad building until after the war's end in 1865.

SYSTEM EXPANSION

Complex consolidations continued as the two great railroad systems -- the Milwaukee Road and the Chicago and North Western -- took form and expanded in the state of Wisconsin.

Milwaukee Road

The Milwaukee & Mississippi, the LaCrosse and Milwaukee, as well as certain other smaller lines were absorbed by the Milwaukee and St. Paul Railway Company which was chartered at the close of the Civil War. It was formally organized in Milwaukee in 1865 with Alexander Mitchell as its first president.

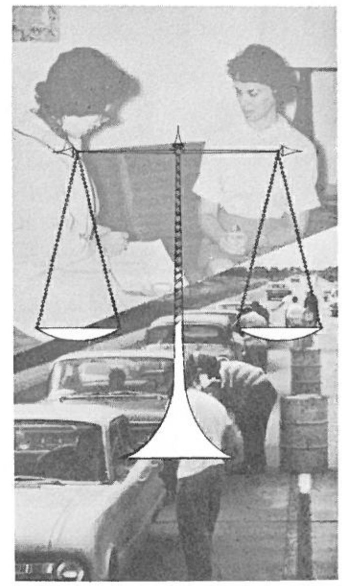
The management of the Milwaukee and St. Paul purchased two railroads then being constructed and also secured a ferry connection across the Mississippi.

[5] Kilbourn's new project, the LaCrosse & Milwaukee railroad, reached the Mississippi River at LaCrosse in 1858. It was constructed west from Milwaukee through Oconomowoc, Watertown, Portage, and Tomah to LaCrosse. It is still in service within the Region providing both passenger and freight service, including the twice daily commuter train serving Watertown, Oconomowoc, Brookfield, Wauwatosa, and Milwaukee.

Continued on page 34

O & D SURVEYS ACCURACY CHECKS

by Eugene G. Muhich, P. E., Transportation Planning Engineer[1]



In the SEWRPC land use-transportation study, five separate origin and destination (O & D) surveys were required in order to obtain complete information on the amount, type, and distribution of person and vehicle travel taking place within and through the Region on an average weekday in 1963, and to provide other related information necessary to land use-transportation planning. These were the home interview, the truck and taxi interview, the household postal questionnaire, the truck and taxi postal questionnaire, and the external roadside interview surveys, all of which have been described in previous Technical Record articles.[2]

The home interview and the truck and taxi personal interview surveys accounted for the person and vehicle trips by residents and vehicles with home bases in the urbanizing areas of the Region. The household and truck and taxi postal questionnaire surveys accounted for person and vehicle trips by residents and vehicles with home bases in the remainder of the Region. The external survey reported the person and vehicle trips by both residents and non-residents entering, leaving, or passing through the Region.

Since it was financially impractical to personally interview each family in the Region, sampling procedures were developed to provide reliable estimates of the average daily travel and household characteristics throughout the Region. Accordingly, nearly 18,000 dwelling places and approximately 4,500 trucks and taxis were sampled for personal interview in the urbanizing areas of the Region; and postal questionnaires were mailed to all other residents and to all other truck and taxi owners within the Region. (See Map 1.) Approximately one-third of all autos and trucks crossing the external boundary of the Region were intercepted and their drivers interviewed to obtain information on the balance of daily travel within and through the Region.

Throughout these surveys, various controls and checks were employed to ensure that the various data were accurately collected and

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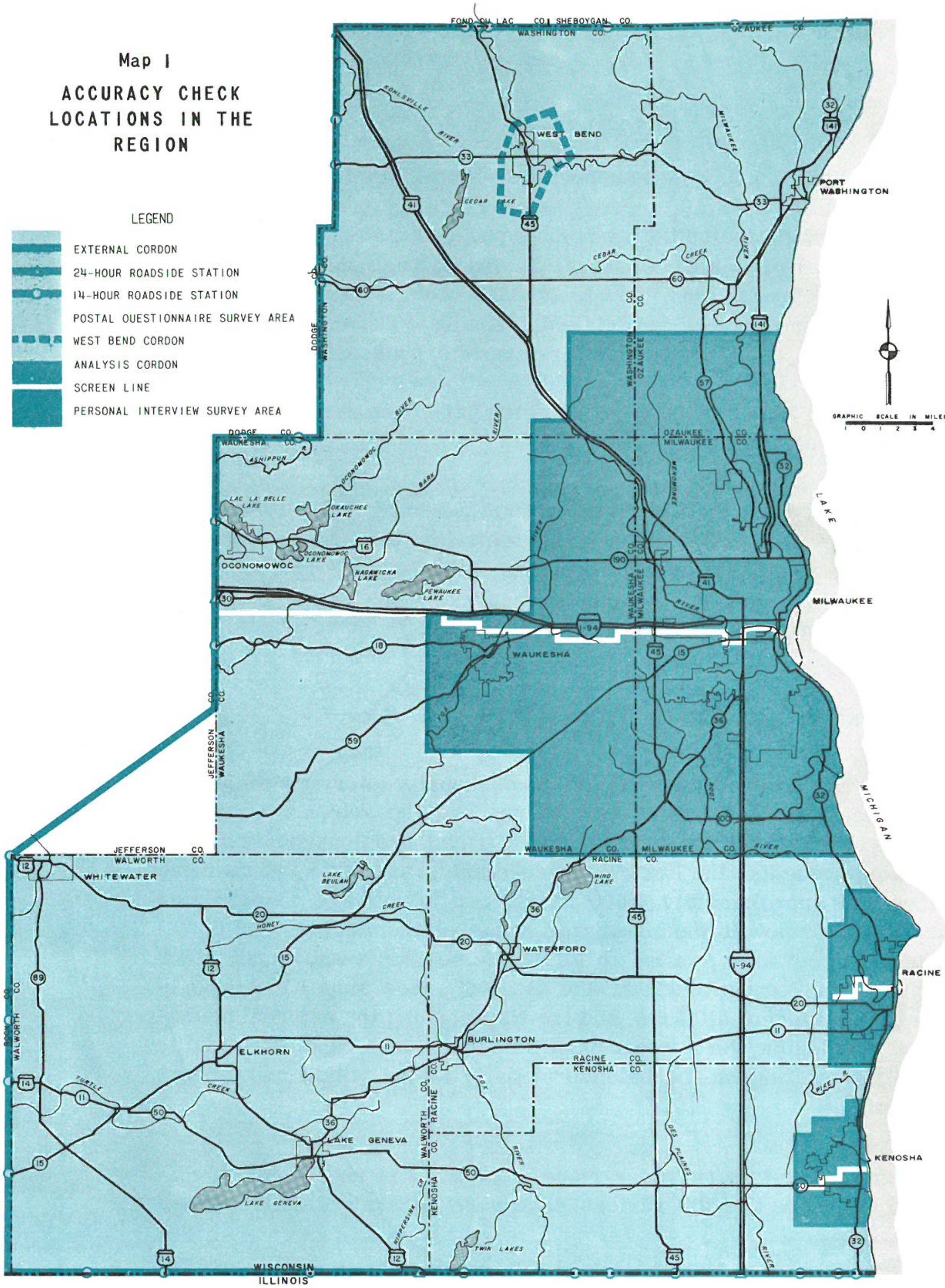
[1] On assignment to SEWRPC from the U. S. Department of Commerce, Bureau of Public Roads.

[2] See articles in all previous issues of the Technical Record; SEWRPC, Vol. 1 – Nos. 1 - 6.

Map I

ACCURACY CHECK LOCATIONS IN THE REGION



processed.[3] These included various comparisons with information from the U. S. Bureau of Census, Wisconsin Motor Vehicle Department, and other independent sources. In addition, several formal checks were planned to measure the accuracy and completeness of survey trip information. These included the traditional external cordon and screen line comparisons and a special comparison with the results of an independent O & D survey conducted in the West Bend area by the State Highway Commission of Wisconsin. The purpose of this article is to present: first, in Part I, a brief description of the preliminary checks of household data with independent source information then; in Part II, the results of the trip accuracy checks conducted by the SEWRPC.

PART I: PRELIMINARY HOUSEHOLD CHARACTERISTICS CHECKS

During the processing of the household postal questionnaire and home interview surveys data, several preliminary checks were made against census data. These included comparisons, on a civil division basis, of various significant characteristics; i.e., households by family size, housing units by structure type, and automobile ownership groups. The purpose of these checks was to determine, as early as possible, if any significant errors or biases existed in the survey data. No serious discrepancies were found during any of these checks.

A check was also made to verify complete sample coverage in the boundary area demarking the home interview from the postal questionnaire surveys. Due to the method of sample selection, it was necessary to make some adjustments in these areas.[4]

Finally, population, as derived from the surveys, was checked on a civil division basis using independent estimates of population for July 1963. Similarly, comparisons were made with automobile registration information from the Wisconsin Motor Vehicle Department. Table 1 shows a summary of the results of the automobile registrations and population comparisons by county.

As a result of these preliminary checks, the surveys' sample coverage and expansion procedures were judged to be accurate and that, therefore, the data processing and analysis should proceed.

PART II: TRIP ACCURACY CHECKS

The next step in the O & D Surveys accuracy checking procedure was to check the accuracy of the trip data. In O & D surveys, it has been found that individuals tend to under-report certain trips, especially incidental short trips. While careful interviewing, postal questionnaire handling, editing, and other precautions can minimize this under-reporting, it is necessary to compare the expanded survey trip data with information from other sources to determine if additional factoring is necessary to realize a proper representation of the actual situation. In the SEWRPC study, this

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[3] Ibid. footnote 2.

[4] "Reconciliation of Sample Coverage in the O & D Surveys," Technical Record; SEWRPC, Vol. 1 – No. 5.

was accomplished by the following comparisons which will be discussed in the order shown:

1. External cordon comparison.

2. Personal interview area "analysis cordon" comparisons.

3. Comparison of SEWRPC vs State Highway Commission of Wisconsin (SHCW) O & D Surveys--City of West Bend.

4. Screen line comparisons.

5. Selected work place check.

6. Vehicle-miles of travel check.

Table I

COMPARISON OF CURRENT POPULATION AND AUTOMOBILE REGISTRATIONS

County	1963 Population			1963 Automobile Registrations		
	Average of Independent Estimates[a]	O & D Surveys (expanded)	Percent O & D Ind. Est.	Wisconsin Motor Vehicle Department[b]	O & D Surveys[c] (expanded)	Percent O & D MVD
Kenosha.	107,400	106,665	99.3	38,852	36,445	93.8
Milwaukee. . . .	1,072,200	1,086,291	101.3	335,744	317,818	94.7
Ozaukee.	42,700	41,591	97.4	15,771	15,903	100.8
Racine	151,100	150,562	99.6	52,600	50,721	96.4
Walworth	54,700	55,506	101.5	21,398	20,941	97.9
Washington . . .	49,700	49,508	99.6	17,879	16,941	94.8
Waukesha	182,400	184,166	101.1	68,435	68,524	100.1
Total Region	1,660,200	1,674,289	100.8	550,679	527,293	95.8

[a] *The Milwaukee Journal Company's 1963 Consumer Analysis Report, Building Permits, State Health Department, and Audit Bureau of Circulations estimates, July 1963*,

[b] *Includes company-owned autos and rental cars but excludes taxis, federal- and municipal-owned autos (except unmarked municipal or federal autos). Also includes autos registered by persons who have moved from the Region during the 1962-1963 fiscal year and any auto that has been junked and no replacement auto purchased.*

[c] *Includes private, company, federal, and municipal autos garaged at residences.*

EXTERNAL CORDON ACCURACY CHECK

The external cordon check consisted of comparing certain trips crossing the external cordon which are reported in both the external and internal surveys. Two types of trips fall into this category; 1) auto trips made by residents of the Region; and 2) trips by trucks garaged in the Region. Since the information gathered in the external survey was obtained from a larger sampling percentage and was acquired by roadside interview while the trip was actually in progress, it is considered to be more accurate than corresponding travel data obtained in the internal surveys.[5] The accuracy and completeness of the internal survey information, therefore, is measured by comparing the internal trip information with the corresponding external surveys' information obtained during the roadside interviews at the external stations. A brief description of the external survey is given below so that the reader may better understand the external cordon accuracy check.

SEWRPC External Survey

In the SEWRPC land use-transportation study, an external cordon roadside interview survey was conducted at the boundaries of the seven-county Region as shown on Map 1. Interview stations were operated along the cordon line at the 32 most important highways[6] to obtain data on travel into, out of, and through the Region. Roadside interviews were conducted at all 32 stations from 6 a.m. to 8 p.m. (14-hours), and night interviews (8 p.m. to 6 a.m.) were obtained at the five stations having the highest nighttime traffic volumes. Based upon classification counts, the external interview data were expanded to represent the day time (14-hour period) traffic by vehicle type on an hourly basis, by direction at all 32 stations. For the night period, interview data were expanded similarly, but only at the five stations where night interviews were conducted. At each of the remaining 27 stations, the 14-hour day time information obtained was expanded to represent the full 24-hour period. Since hourly external interview information was not obtained during the nighttime hours at these stations, comparisons with internal survey data, on an hourly basis were made only for the 14-hour period.

Vehicle Trip Comparisons

The comparison of regional residents' auto trips crossing the external cordon revealed that the internal survey data equalled 96 percent of the external survey data during the 14-hour day period and 87 percent for the factored 24-hour day. These results indicate that very complete information for such trips was obtained in the internal survey.

In the comparison of external cordon crossings by trucks garaged in the Region, the internal survey data equalled 112 percent of the external survey trips during the 14-hour hour day period and 97 percent for the 24-hour period. These close comparisons also indicated that internal survey reporting was very good for these trips. An examination of the trip data indicates that one of the reasons the internal survey truck trips exceed the external survey counts is that many of the trucks from the postal questionnaire survey area were light trucks, probably in agricultural service, and likely to cross the external cordon on the local service roads not included in the roadside survey.

A comparison of total vehicle trips (auto and truck) produced very satisfactory checks of 98 percent for the 14-hour day period and 89 percent for the full 24-hour period.

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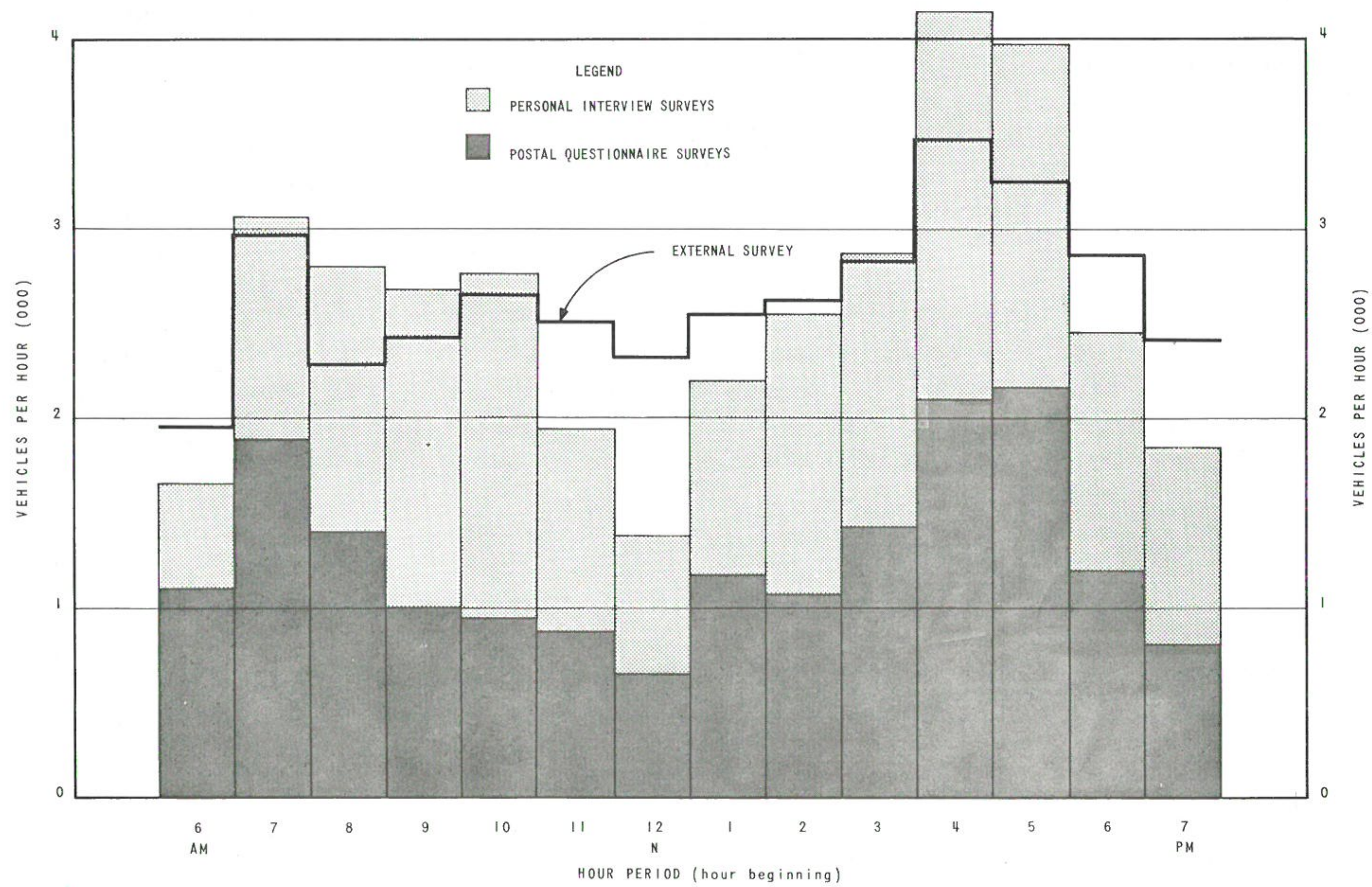
[5] All person and vehicle trips reported in the internal survey as crossing the cordon were deleted from the internal surveys after the cordon line accuracy check was completed. This insured that there was no duplication of resident trips entering or leaving the Region.

[6] Those highways which, in combination, carried in excess of 85 percent of the total average daily traffic crossing the external cordon on all highways. The amount of travel on the remaining roads crossing this border was not considered significant for regional planning purposes.

Hourly comparisons of these trips are shown in Figure 1. The results of this external cordon comparison indicated that trip reporting in the internal surveys was quite complete.

Figure 1

COMPARISON OF EXTERNAL AND INTERNAL SURVEYS DATA AT THE EXTERNAL CORDON
(all vehicles, except buses)



PERSONAL INTERVIEW AREA CORDON ANALYSIS CHECK

In most O & D surveys employing only the personal interview technique, the external cordon is located at the boundary of the personal interview survey area. In the SEWRPC study, the personal interview areas are separated from the external cordon line by an intervening area in which the postal questionnaire survey was conducted. Because of this, a check of vehicle travel into and out of the internal personal interview survey areas was made by comparing traffic assignment volumes derived from the O & D data with actual traffic counts at all links intercepted by "analysis cordons" as shown on Map 1. These analysis cordons were drawn to coincide with the boundaries of the Milwaukee, Racine, and Kenosha personal interview areas. The results of these analyses, which are given in Table 2, indicated that trip reporting in the personal interview and postal questionnaire survey areas was quite complete.

Table 2

COMPARISON OF TRAFFIC COUNTS AND TRAFFIC ASSIGNMENT VOLUMES AT SPECIAL ANALYSIS CORDONS

Personal Interview Area	*24-Hour Assigned Volumes (A)	24-Hour Traffic Counts (B)	Percent (A/B)
Milwaukee.	145,748	142,663	102
Racine	42,008	47,310	89
Kenosha.	52,992	59,450	89

* *First free assignment - all vehicles to 1963 network.*

WEST BEND ACCURACY CHECK

In order to adequately measure the accuracy of data reported in the postal questionnaire surveys, additional checks were necessary. Fortunately, a unique opportunity for such a check was afforded when, as part of the normal operations of the State Highway Commission of Wisconsin (SHCW), a roadside interview survey of travel in the West Bend area was to be conducted in July 1963.[7] Close cooperation between the two agencies (SEWRPC and SHCW) resulted in the use of a cordon line around the City of West Bend which virtually coincided with the outer boundary of seven SEWRPC traffic analysis zones in the postal questionnaire survey area (see Map 1). The O & D data collected by the SHCW, therefore, was readily comparable to the information obtained from the SEWRPC surveys.

The cordon line around West Bend encompassed an area of about 23 square miles and intercepted seven major highways at which roadside interview stations were operated. Auto and truck drivers of vehicles passing through these stations were interviewed to obtain origin, destination, and other information concerning their trips. Traffic and classification counts of vehicles crossing the cordon were also made.

Expanded data from the SHCW survey and the SEWRPC surveys were compared by vehicle type, by time, by trip purpose, and by geographic distribution of trip ends. The results of the comparisons of auto and truck trips crossing the West Bend cordon are given in Table 3 and the hourly comparison graph is shown in Figure 2.

[7] This survey was conducted to provide traffic data to determine the need for a bypass to carry STH 45 around the City of West Bend.

Table 3

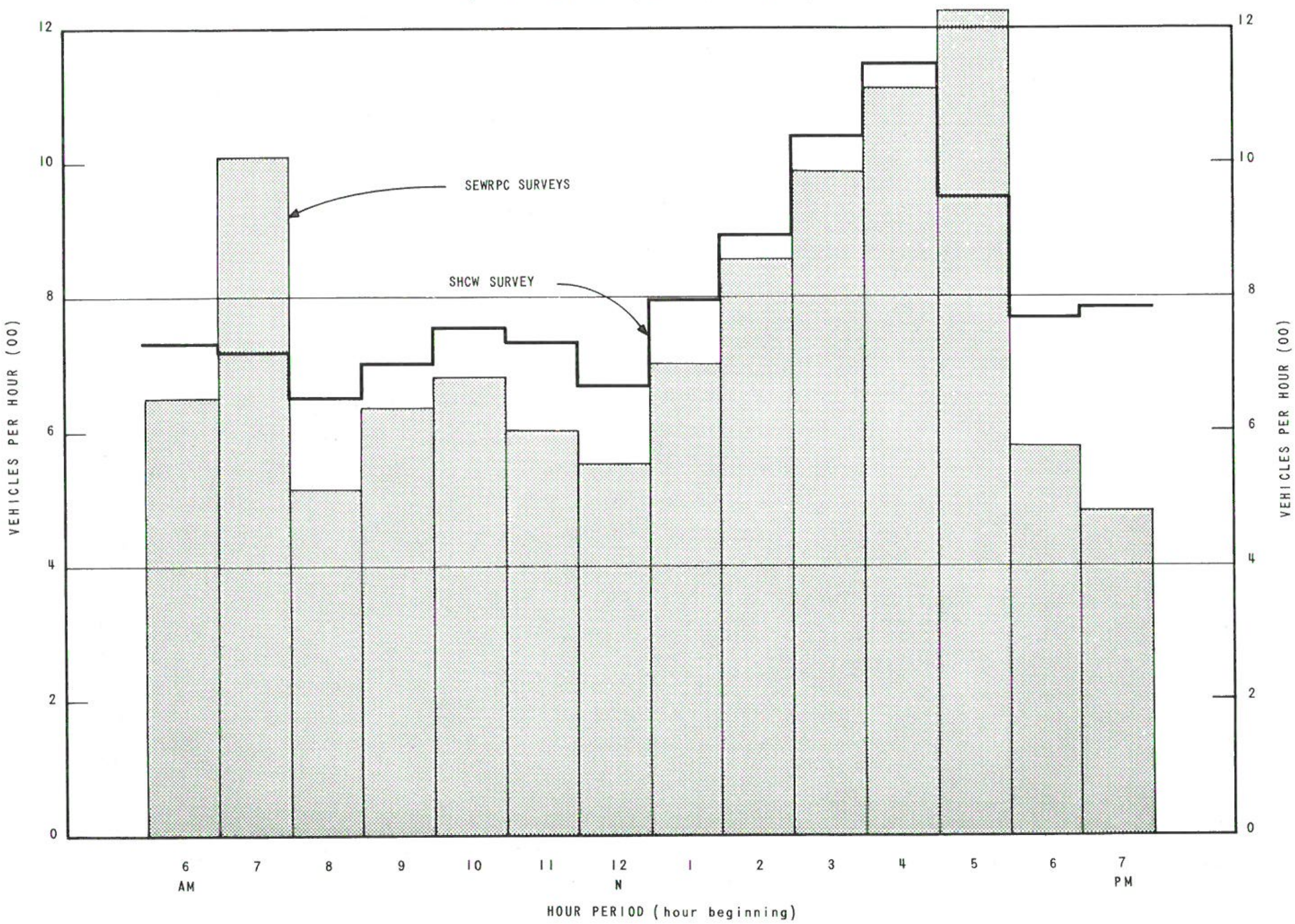
COMPARISON OF SHCW AND SEWRPC SURVEYS DATA IN THE WEST BEND AREA*

Vehicle Type	SHCW	SEWRPC	Percent SEWRPC/SHCW
Autos.	9,643	8,528	88
Trucks and Taxis	1,660	2,042	123
All vehicles (except buses).	11,303	10,570	94

* *14-hour day period (6 a.m.-8 p.m.) — expanded trip data excluding through trips.*

Figure 2

COMPARISON OF SHCW AND SEWRPC O & D SURVEYS DATA AT THE WEST BEND CORDON
(all vehicles, except buses)



This check indicated a high degree of correspondence between the results of the two independent surveys. Most of the hourly differences shown in Figure 2 can be attributed to seasonal variations since the SHCW roadside survey was conducted during the month of July 1963 and the SEWRPC surveys during earlier periods of the same year. The SEWRPC household postal questionnaire survey was conducted in May, the truck postal questionnaire survey in June, the home interview and the truck and taxi interview surveys in May and June, and the external (roadside) interview survey in June and July. An analysis of the trip purpose comparison revealed that work trips were more dominant in the SEWRPC survey during the morning and evening peak-hours, whereas, social and recreational trips tended to predominate the late morning and evening hours in the SHCW data.

SCREEN LINE ACCURACY CHECKS

A screen line comparison check consists of separating a survey area into two parts by means of a "screen" line so that the number of vehicles crossing that line, as determined by ground counts, can be compared with trip crossings recorded in the

O & D surveys. The screen line must intercept large volumes of traffic to provide a meaningful check on travel in the internal area. Natural or man-made barriers, such as rivers and railroads, usually make the most suitable screen lines. The barriers should be pierced by relatively few highway crossings which preferably should be far enough apart so as to discourage multiple crossings by vehicles circulating locally. In areas where no such barriers exist, it may not be possible to establish a suitable screen line. In such cases it may be advisable to adopt an alternate type of accuracy check; i.e., the control point comparison method.[8]

In the SEWRPC study, an excellent screen line was established through the Milwaukee urbanized area across the entire Region providing the primary check of travel in the Region. Two secondary screen lines were established, one in Racine and the other in Kenosha, in an attempt to provide additional checks of the travel survey data in those separate internal interview survey areas. The decision to utilize these last two screen lines was made on the basis that they represented the best available means of checking the travel data even though difficulty was encountered in selecting good locations. The three screen lines and the results of the comparisons are discussed below.

Milwaukee Screen Line

Almost ideal conditions existed for the establishment of an east-west screen line across the entire Region, approximately through the center of the Milwaukee urbanized area. Starting in the east at Lake Michigan, the screen line follows a natural topographic barrier formed by the Menomonee River Valley to 27th Street in the City of Milwaukee; the Interstate Highway (I-94 which was under construction) to the City of Waukesha and then south of, and parallel to, I-94 through the more rural areas to the western boundary of the Region (see Map 1). Because very little opportunity existed for multiple crossings and for incidental travel which might not be recorded in the survey, the location was excellent for screen line purposes.

Traffic and classification counts were obtained at 42 stations along the Milwaukee screen line. This information was compared with trips crossing the screen line as recorded in the O & D surveys. The day period hourly comparison was restricted to 12 hours (7 a.m. - 7 p.m.) because only 12 hours of complete screen line crossing information could be derived from the 14-hour external survey trips due to the travel time (approximately one hour) required to travel between the screen line and most points on the external cordon. The comparison of auto crossings for the 12-hour day period revealed that survey trips were approximately 88 percent of the classification counts and approximately 86 percent of the 24-hour period. The truck and taxi crossings were 90 percent of the classification counts for the 12-hour period and 87 percent for the 24-hour period. The total vehicle comparisons, excluding buses, for these same periods were 88 percent and 87 percent, respectively. The hourly comparisons for all vehicles are shown in Figure 3.

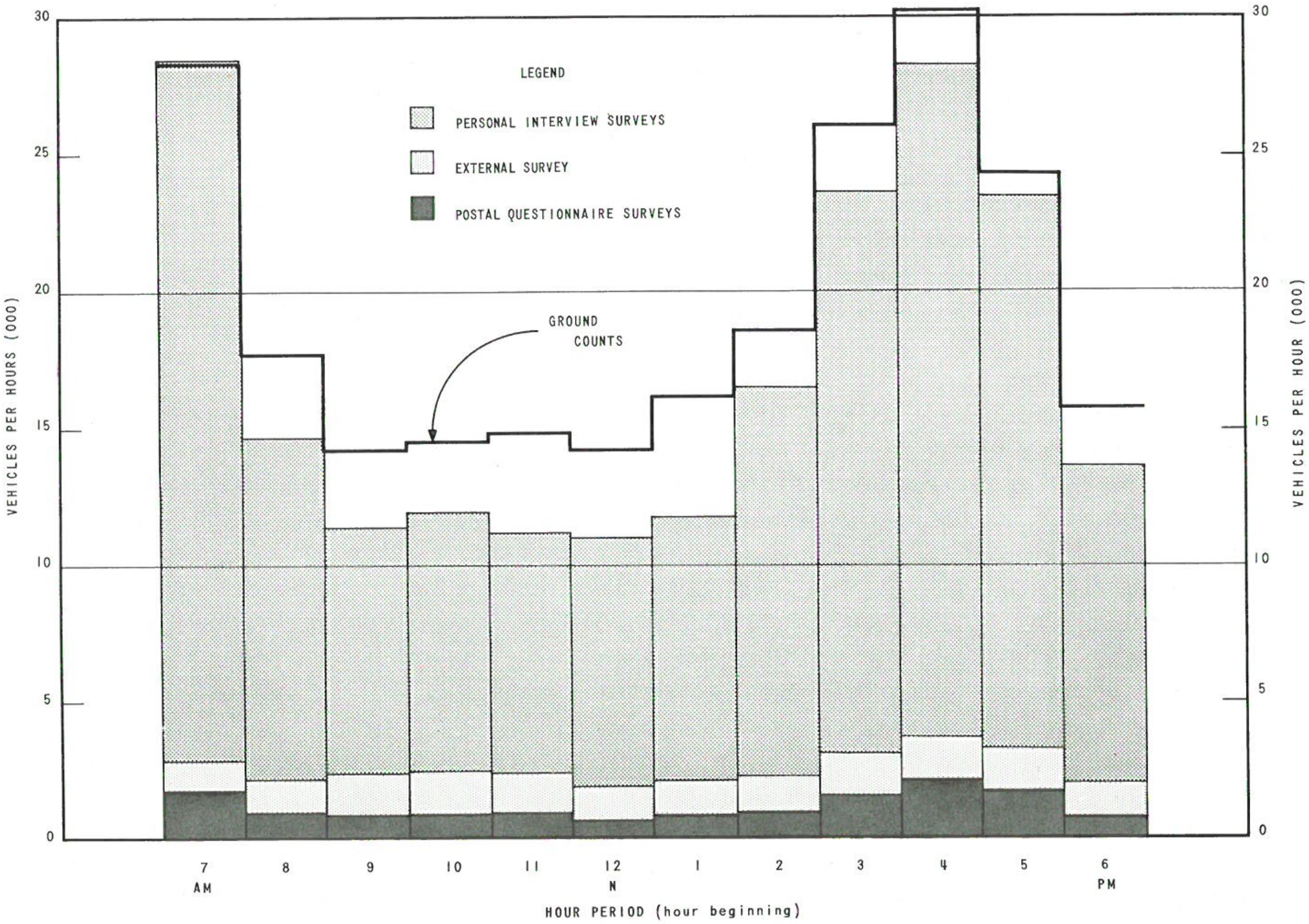
In addition, a check made of the assigned O & D volumes against ground counts on the

[8] In this method, two or three well-known points such as viaducts, bridges, or underpasses, are selected before the survey is started. Specific questions are then asked in the O & D surveys to determine which trips cross these points. This data is then compared with classification counts obtained at the control points.

arterial streets intercepted by the Milwaukee screen line revealed that assigned volumes were approximately 92 percent of the ground counts.

Figure 3

COMPARISON OF GROUND COUNTS AND O & D SURVEYS DATA
AT THE MILWAUKEE SCREEN LINE
(all vehicles, except buses)



Racine and Kenosha Screen Lines

In the Racine and Kenosha areas, no really suitable natural or man-made barriers existed along which screen lines could readily be established for checking north-south movements. Consequently, a line was selected in each city running from Lake Michigan, at the edge of each central business district (CBD), westward through the best available points of interception. Each line was terminated beyond the western limits of development where little additional north-south circulation, pertinent to a check of internal travel in the Racine and Kenosha areas, appeared to exist (see Map 1).

While some multiple crossings and incidental local circulation appeared possible, they did not, at the time of screen line location, appear serious enough to consider abandoning the screen lines in favor of control point comparisons.

Machine and classification counts were obtained at 18 stations in Racine and 21 stations in Kenosha. The results of the 14-hour day period (6 a.m. to 8 p.m.) comparisons with survey data are shown in Table 4.

Table 4

RACINE AND KENOSHA SCREEN LINE COMPARISON OF GROUND COUNTS AND O & D SURVEYS DATA

Vehicle Types	Racine			Kenosha		
	Survey Data (A)	Traffic Counts (B)	Percent (A/B)	Survey Data (A)	Traffic Counts (B)	Percent (A/B)
Auto.	36,930	61,601	60	43,090	65,473	66
Trucks and taxis.	4,383	7,724	57	4,343	7,898	55
All vehicles (except buses) . .	41,313	69,325	60	47,433	73,371	65

In view of these poor results, exhaustive investigations were made to determine if errors existed in the O & D survey data, if the analyses were in error, or if the screen lines were unsuitable. An extremely thorough check of all data used in the analyses proved, to the satisfaction of the staff, that no significant errors existed in the data or in the analyses.

The results of the comparisons were further verified by comparing the assigned volumes (first free assignment) with the average weekday "ground" counts on links intercepted by the screen lines. In Racine, the assigned volumes produced a 67 percent match of the ground counts. In Kenosha, the comparison was 59 percent.

The hourly patterns in both cities showed good peak-hour relationships in essentially the same pattern as the ground counts indicating good peak-hour to off-peak-hour relationships in the survey data. This, and a generally high degree of confidence in the survey data, which had developed throughout the survey, indicated that the screen lines were deficient. These suspicions were fortified with the discovery, during the analysis, of some multiple crossings which could be only partially quantified at that time. These, and additional strong indications of heavy local circulation across the screen lines near the CBD's and near some large industrial plants, demonstrated that the screen line shortcomings were, in fact, more serious than anticipated; and led to the conclusion that screen line locations were not suitable for these purposes.

A re-investigation of alternative screen lines in the areas involved was made to determine if, in retrospect, the best lines had been selected. This further investigation revealed that each substitute screen line would have had similar, and in some cases more, inherent deficiencies; and, therefore, no satisfactory screen lines were possible. Similarly, it was concluded, upon re-examination, that the use of control point comparisons would have been no more effective.

In view of: 1) the 89 percent check of assigned volumes versus ground counts at the personal interview area analysis cordons; 2) the good check (89 percent) of first work trips as compared to average daily employment at selected large industries; 3) the excellent control maintained during the Racine-Kenosha personal interview survey; 4) the high trip reporting (in excess of eight trips per occupied housing unit; and 5) the good results from the housing unit check; it was concluded that the survey data accurately represents internal travel and that the Racine and Kenosha screen line comparisons, in retrospect, did not provide a reasonable basis for factoring the survey information.

SELECTED WORK PLACE ACCURACY CHECK

Another type of trip accuracy check performed was to compare employment (average weekday attendance) at certain selected large industrial plants with "first work trips" reported to those locations in the O & D surveys. Six such industries to which work trips could be isolated were identified in the Region. Four were from the Milwaukee personal interview area and one each from the Kenosha and Racine areas.

The spring 1963 average weekday attendance was obtained through telephone contact with the management of each of the industries. The "first work trips" to these industries were comprised of the initial work trip of each person reporting a work trip to the location of the industries in the internal surveys and all inbound work trips to these locations from the external survey. External auto passenger trips were assumed to have the same trip purpose as the auto driver. The results of the comparisons of this information are shown in Table 5.

Table 5

COMPARISON OF EMPLOYMENT AND FIRST WORK TRIPS AT SELECTED WORK PLACES

Work Place	Location of Employer (survey area) (A)	Estimated Average Weekday Attendance (spring 1963) (B)	Survey First Work Trips	Percent (A/B)
1.	Kenosha	12,287	10,906	88.8
2.	Racine	2,750	2,459	89.4
3.	Milwaukee	6,800	6,536	96.2
4.	Milwaukee	4,710	4,889	103.8
5.	Milwaukee	2,247	2,318	103.2
6.	Milwaukee	1,420	1,383	97.4
Total (all six employers)		30,214	28,491	94.3

As the selected industrial plants are located in widely scattered points within the three urbanized areas of the Region, represent various types of manufacturing activities, and comprise over 13 percent of the total manufacturing employment in the Region, this check is considered to be further evidence of the high order of accuracy of the O & D survey trip information.

VEHICLE-MILES OF TRAVEL CHECK

One other check pertinent to internal trip accuracy is the vehicle-miles of travel check. In the SEWRPC 1963 existing arterial street network, a total of approximately 3,400 miles of principal streets and highways are included. By multiplying the 1963 traffic volume count data obtained for each link times the link length and summing the results, a total of 13,168,000 vehicle-miles of travel was obtained as a measure of 1963 average weekday travel. A comparable figure of 12,410,000 vehicle-miles of travel, which was obtained in the first unrestrained traffic assignment of O & D surveys data, provided a 94 percent comparison with the figure determined from the 1963 traffic counts. Restrained assignments are expected to yield a slight increase in vehicle-miles of travel.

SUMMARY AND CONCLUSION

The travel information obtained in the SEWRPC origin and destination studies was checked by a series of survey sample and trip accuracy checks. These include the traditional population, cordon and screen line checks, in addition to work place and vehicle-miles of travel checks.

All of the trip accuracy checks, with the exception of the Racine and Kenosha screen line checks, where the screen lines were found lacking because of the unsuitability of their locations, proved that the O & D data was within plus or minus 13 percent of actual ground counts or other independent data. These results of the checks are within the limits suggested by the U. S. Bureau of Public Roads guides as being indicative of survey results which accurately represent actual travel behavior.

The vehicle-miles of travel check corroborated these results when a 94 percent comparison was found between the O & D assigned volumes and the measured traffic volumes on arterial streets and highways. The selected work place check provided further evidence of the accuracy of the trip information.

While any one of the accuracy checks described in this article does not individually assure the accuracy of the surveys, collectively the checks do indicate that a very high degree of reliability can be placed on the O & D survey results as accurately representing actual travel behavior in the Region. Consequently, it was decided that travel analyses could proceed without any further adjustment of the initial trip factor.

Costs

The cost of preparing the different accuracy checks will vary with the amount of data that has to be processed, the type of processing required, and the man-hours needed for analysis and report preparation. Table 6 lists the best estimate of cost for only that work directly connected to the individual accuracy check analysis. Staff costs include salaries and travel expenses but exclude rent, overhead, and administrative costs. Data processing (EDP) includes cards, keypunching, equipment usage, and EDP supervision.

Table 6

ESTIMATED COST OF ACCURACY CHECKS IN DOLLARS

Costs	External Cordon	Analysis Cordons	West Bend	Screen Lines		Selected Work Place	Veh.-Miles of Travel
				Milwaukee	Rac.-Ken.		
Staff. .	700	150	475	600	1300	175	200
EDP. . .	1900	--	1075	1500	1400	125	50
Total	2600	150	1550	2100	2700	300	250

* * * * * * *

(Backward Glance continued from page 20)

By November 1867, the completed line was opened to St. Paul, through Prairie du Chien thereby establishing the first rail connection between Minneapolis and Chicago by way of Milwaukee. In February 1874, the corporate name was changed to the Chicago, Milwaukee and St. Paul Railway. The Milwaukee Road was to have only one more corporate name change up to the present time when it was reorganized in 1927 as the Chicago, Milwaukee, St. Paul and Pacific Railroad Company. It was in 1910 that the railroad had expanded to the West Coast -- Seattle -- becoming a great transcontinental system.

Chicago and North Western

The Chicago and North Western continued to grow when it merged with the Galena and Chicago Union (retaining the former name) in 1864. It then obtained control of the Lake Shore Service between Chicago and Milwaukee -- acquisition of a railroad directly connecting the then two great supply and distribution depots of the Midwest.

For a two-year period from 1869-71, Alexander Mitchell took over the presidency of both the Milwaukee and North Western roads. However, a statute was passed forbidding the same director to control railroads with parallel competing lines, and the two roads became competitive again.

By 1874, the two railroad systems virtually controlled the entire network of Wisconsin railways, the Milwaukee Road with its terminus at Milwaukee and the Chicago and North Western with its terminus at Chicago. They have dominated the state's railroad picture from the earliest days to the present.

Wisconsin Central - Soo Line

Another railroad that figured in the early transportation history of the Region was The Wisconsin Central, which was chartered in 1871. Its original purpose was to reach into the timbered territory of far northern Wisconsin. In 1881, the railroad turned southward to Fond du Lac, Slinger, Waukesha, through the western part of Kenosha County and on to Chicago.

In 1886, the chief division headquarters and shops of the Wisconsin Central were moved from Stevens Point to Waukesha. Five miles of switching and storage tracks were laid; and a 12-stall roundhouse for locomotives built at a cost of $300,000. The railroad was reorganized in 1897 and the division headquarters moved to North Fond du Lac.

The Minneapolis & Sault Ste. Marie Railway, called the Soo Line, acquired a majority of capital stock in the Wisconsin Central in 1908; and subsequently the two railroads entered into a working agreement that the Soo was to operate

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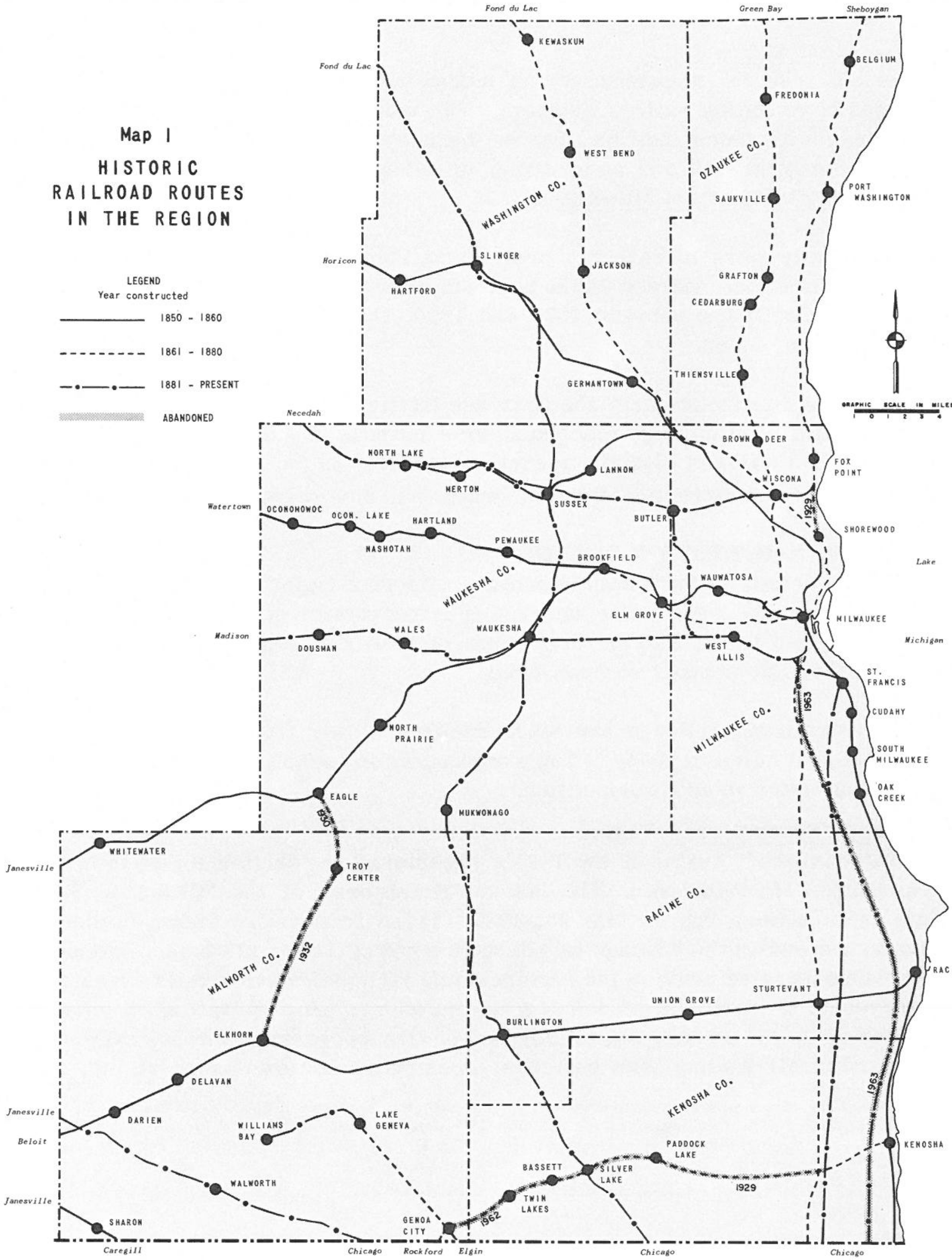

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the Wisconsin Central for 99 years. From that time on, it was a common practice to apply the name "Soo Line" to the Wisconsin Central.[6]

Mileage Reaches Peak

Milwaukee grew in importance as an industrial center as well as the central terminus of a leading railroad system. "To that pioneer railroad, more than any other thing except her location on Lake Michigan, Milwaukee is indebted for her steady growth and commercial prominence," noted Elmer Barton in The Industrial History of Milwaukee.

The 1,000 mile mark of railway tracks in the state was passed in 1867 and the trackage more than doubled in the next six years. The Panic of 1873 brought a short standstill but between 1875 and 1890, the mileage more than doubled again, reaching 5,583.

By 1916, just in time to carry the immense traffic resulting from World War I, the state's railroad mileage reached an all-time peak of 7,693 miles. There was also about 250 miles of electric interurban trackage in the Region at that time.[7] (Table 1 shows construction dates for major rail line segments in the Region.)

MAJOR TRANSPORTATION CHANGE

The second decade of the twentieth century witnessed major changes in transportation system utilization. The increasing improvement of motor vehicles and highways began to cut into the dominance of railroads as far as both passengers and freight transport was concerned.

The state railroad mileage has since declined slowly from its peak of 7,693 miles to 6,350 miles in 1964.[8] The shrinkage is in branch lines which suffered most from motor vehicle competition.

Introduce "Super Speed" Trains

The "streamlined" trains of the 1930's recaptured the excitement of the early "iron horses" in Wisconsin. The famed "Hiawathas" of the Milwaukee Road made their maiden run on May 29, 1935. These trains were known to clock a maximum speed in the Chicago to Milwaukee run of 116 to 118 mph. Extensive improvements were made in the line including laying of heavier rails, reduction of curves to a maximum of one degree, increasing superelevation on curves, lengthening spiral transitions, elimination of all unnecessary switches and cross overs and of all leading point switches, construction of grade separations, and

[6] In 1961, there was a formal merger of the old Soo, the Wisconsin Central, and the Duluth, South Shore & Atlantic railways. At the present time, the Soo Line is the third largest in the state. It passes through the Region as it comes up through Illinois and proceeds through Fond du Lac and north along what was the main line of the Wisconsin Central.

[7] See "A Backward Glance –The Electric Interurban Railway," Technical Record; SEWRPC, Vol. 1 - No. 4.

[8] Much of the state's railroad abandonments were a result of the decline of the once great lumber industry of northern Wisconsin.

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Table I

CONSTRUCTION DATES FOR MAJOR RAIL LINE SEGMENTS IN THE REGION[a]

Year Constructed	Present Owner	Line
1850	CMStP & P[b]	Milwaukee to Elm Grove
1851	CMStP & P	Elm Grove to Waukesha
1852	CMStP & P	Waukesha to Milton
1854	CMStP & P	Chestnut St. to North Milwaukee
1854	C & NW[c]	Elgin, Illinois to Genoa
1855	C & NW	Carey, Illinois to Janesville (via Sharon)
1855	C & NW	Milwaukee to Illinois State Line
1855	CMStP & P	North Milwaukee to Horicon
1855	CMStP & P	Brookfield to Watertown
1855	CMStP & P	Racine to Delavan
1856	CMStP & P	Delavan to Beloit
1862	C & NW	Kenosha to Rockford, Illinois[d]
1864	CMStP & P	Milwaukee to Brookfield (via West Allis)
1869	CMStP & P	Grand Ave. Junction to North Milwaukee
1870	CMStP & P	Elkhorn to Eagle[e]
1870	CMStP & P	North Milwaukee to Cedarburg
1871	CMStP & P	Milwaukee to Illinois State Line
1871	CMStP & P	Cedarburg to Hilbert Junction
1871	C & NW	Genoa to Lake Geneva
1872	C & NW	Shorewood to Sheboygan[f]
1873	C & NW	Milwaukee to Fond du Lac
1882	C & NW	Milwaukee to Madison
1882	Soo Line	Neenah to Slinger
1886	Soo Line	Slinger to Illinois State Line
1888	C & NW	Lake Geneva to Williams Bay
1889	CMStP & P	Granville to Sussex
1897	CMStP & P	Sussex to North Lake
1900	CMStP & P	Janesville to Illinois State Line (via Zenda)
1906	C & NW	St. Francis to Illinois State Line (freight)
1908	North Shore	Chicago to Milwaukee (via Racine)[g]
1911	C & NW	West Allis to Butler
1911	C & NW	Wiscona to Necedah
1928	C & NW	Wiscona to Fox Point

[a] *All rail line segments shown in the above table are listed under the current railroad company ownership.*

[b] *CMStP & P - Chicago, Milwaukee, St. Paul and Pacific Railroad Company (The Milwaukee Road).*

[c] *C & NW - Chicago and North Western Railway Company.*

[d] *Abandoned: Bain (in Pleasant Prairie) to Bassett, 1939; Bassett to Genoa, 1962.*

[e] *Abandoned: Eagle to Troy Center, 1930; Troy Center to Elkhorn, 1932.*

[f] *Abandoned: Shorewood to Fox Point, 1929.*

[g] *Chicago, North Shore, and Milwaukee Railroad discontinued operation in 1962.*

Source: Public Service Commission of Wisconsin.

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installation of an improved block signalling system. Through the process of polishing and perfecting, one of the fastest schedules in the country between major metropolitan centers was possible with four trains a day making the 85 mile run from Chicago to Milwaukee in 75 minutes, nine in 80 minutes, six in 85 minutes, four in 90 minutes, and only five additional trains taking longer than 90 minutes. Other equally famous express trains operating through the Region included the Chicago and North Western's "400's."

Aided World War II Victory

It is estimated that the railroads of the nation carried about 90 percent of the transport load essential to victory during World War II. Wisconsin's railroads put to maximum use existing facilities to expedite the services required, and coordinated services to achieve the movement of men, material, and supplies to the points of need. Southeastern Wisconsin as the state's most important industrial area manufacturing goods vital to the war effort saw much of this invaluable activity.

After the war, railroads were faced with problems created by the expense of maintaining and acquiring equipment coupled with decreasing revenue.

THE PRESENT PICTURE

At the present time, the North Western has the most trackage in the state -- 2,633 miles. Milwaukee Road has 1,519 miles in the state. Together they operate about 63 percent of the 6,350 miles of railroad in the state. Third largest in the state is the Soo Line with 1.331 miles, approximately 23 percent of the mileage. In recent years, diesel engine power has to a large extent replaced steam power in railroad locomotion.

Currently, the aforementioned three dominant carriers serve the Region with freight and passenger service. Now, passenger service is only a very small part of the total daily travel within the Region, the greatest frequency of passenger service being in the Milwaukee-Chicago corridor.

The Milwaukee Road operates eight passenger trains daily in each direction between Chicago and Milwaukee with no stops in the Region outside of Milwaukee. The Chicago and North Western Railway operates ten trains daily in each direction with stops at Racine and Kenosha. The Milwaukee Road operates six trains daily (four west bound and two east bound) between Chicago and Madison with a stop at Walworth. They also operate five trains daily in each direction between Milwaukee and Watertown. The Milwaukee Road also operates one train daily in each direction between Milwaukee and Green Bay (and beyond) and between Milwaukee and Beloit (and beyond). In addition to service in the Chicago-Milwaukee corridor, the Chicago and North Western Railway operates three trains daily in each direction between Milwaukee and West Bend (and beyond).

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The Soo Line operates only one passenger train daily in each direction with stops at Burlington and Waukesha. By February 12, 1965, the Soo Line will have discontinued passenger service in the state.

With the exception of the Chicago-Milwaukee rail service, the frequency of the remainder of the rail passenger service mentioned is such that it cannot be considered to be available throughout the day. Thus, with the exception of the Chicago-Milwaukee corridor, rail service was not included in the SEWRPC 1963 Transit Network.

According to Public Service Commission figures, the peak year in passenger traffic in the state was 1920 with 20,188,000 passengers carried. In 1963, the passenger traffic figure had dwindled to 2,623,000.[9]

Revenue freight traffic reached 105,745,000 tons within Wisconsin in 1920, declined through the depression years, and built up during and after the World War II period, to a high of 127,555,000 tons in 1953. In 1963, there were 89,158,000 tons of revenue freight traffic within Wisconsin.

Freight hauling is becoming more and more important to the railroads in southeastern Wisconsin, for example, the Milwaukee area is the largest single freight revenue producer for the entire Milwaukee Road system from Chicago to the West Coast. The Soo Line is proceeding with a plan to centralize freight service, and one of its centralized freight service stations will be at Burlington.

Epic Merger Eminent

A new era in railroad history in Wisconsin is approaching with the proposed merger of the state's two great railway systems -- the Milwaukee Road which has 10,450 miles of railroad and the Chicago and North Western, 10,435 miles in a total of 15 states. The two railroads serve 141 points in common. The merged lines would be the longest rail system in the nation, and would be known as the Chicago, Milwaukee & North Western Railway Company.

The proposed consolidation would be unique in American rail history in other than an operating standpoint. The North Western, from its earliest days, has run its trains along the British pattern-- on the left hand side of a double track, and locomotive engineers sit on the right inside the locomotive cab. The Milwaukee Road and most other major United States lines, operate on the right hand side of a double track. Officials of the two railroads say that left hand operation will not pose any problems.

The merger would smooth the path for a union railroad station in Milwaukee and

[9] Because the Region has always been a major rail terminal of the state with lines extending in all directions, state statistics available are especially meaningful.

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would presumably release real estate (as duplication of services are eliminated) for development in the area.

The major Wisconsin railroads have profited by the general upturn in business. Millions of dollars have been poured into new locomotives, rolling stock, right-of-way improvements, data processing, more agressive merchandising of freight and passenger service, and new types of freight trains.

As William J. Quinn, president of the Milwaukee Road, which had its beginning 113 years ago in southeastern Wisconsin, stated recently, "There is a new vitality in the railroad industry." This vitality will be felt in the Region as well as the state and nation.

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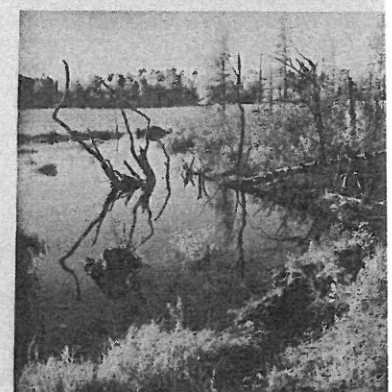
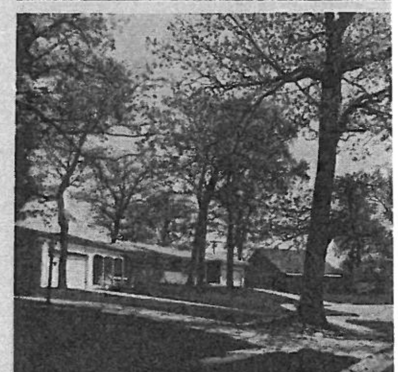
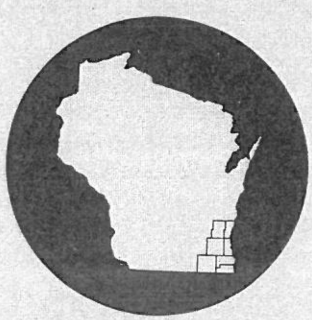
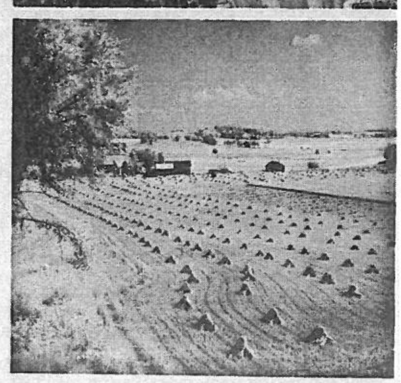
Important vital statistics on the Region and percent of totals for the State of Wisconsin.



Land and Water Area (sq. mi.)	2,688	5%
Population (1960)	1,573,620	40%
Resident Employment (1960)	612,723	42%
Resident Unemployment (1960)	24,174	41%
Resident Labor Force (1960)	636,897	42%
Resident Man'f. Employment (1960)	253,292	52%
Resident Non-Man'f. Employment (1960)	359,431	37%
Disposable Personal Income (1960)	$3,572,000,000	46%
Retail Establishments (1958)	15,780	33%
Retail Sales (1960)	$2,045,000,000	42%
Property Value (1960)	$8,726,000,000	46%
Total Shared Tax (1960)	$62,777,000	54%
Total State Aids (1960)	$35,474,000	26%
Total Property Tax Levy	$239,380,000	50%
Total Long Term Public Debt	$378,592,000	55%
Total Highway (miles) (1960)	8,740.45	8.9%
Value of Mineral & Non-Metal Production (1961)	$15,494,487	20.08%
Total Vehicle Registration (1962-1963)	633,540	36.8%
Auto Vehicle Registration (1962-1963)	551,188	40%
Truck Registration (1962-1963)	55,950	23%
State Parks & Forest Areas (acres) (1963)	12,546	3.02%







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