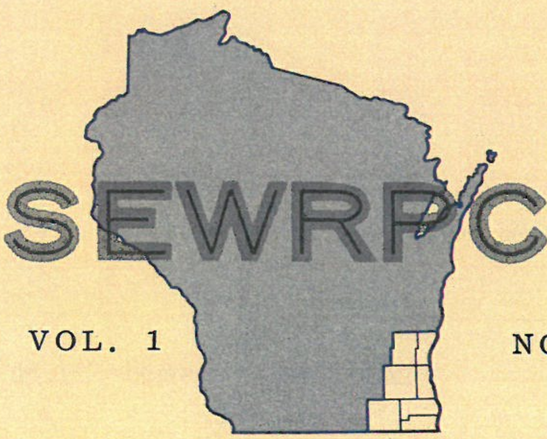
TECHNICAL RECORD



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JUNE - JULY

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RECONCILIATION OF SAMPLE COVERAGE IN THE INTERNAL O-D SURVEYS * * * THE CONTINGENCY CHECK PROGRAM * INVENTORY OF THE ARTERIAL STREET NETWORK

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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THE TECHNICAL RECORD

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A BACKWARD GLANCE

by James E. Seybold, Editor

THE MILWAUKEE AND ROCK RIVER CANAL

In the early 19th century, waterways formed the main arteries of transportation in the United States, and settlers in the Territory of Wisconsin envisioned that a waterway between Lake Michigan and the Mississippi River would greatly enhance the economy of the area. Such a waterway was believed particularly important since lead, mined in the southwestern part of the territory, was then a principal export of the territory. The metal was shipped to New Orleans via the Rock and Mississippi Rivers and then through the Port of New Orleans to the east coast.

Businessmen Take a Gamble

Ambitious promoters in Milwaukee and Green Bay were anxious to capitalize on the lucrative lead trade by having the metal shipped out of Milwaukee. Bolstered by the success of the Erie Canal in New York, optimistic speculators, led by Milwaukee businessman and financier Byron Kilbourn, proposed the construction of a canal between Milwaukee and the Rock River, a distance of about 60 miles.

The Rock River from its headwaters in Fond du Lac County flows southward in a course roughly parallel to Lake Michigan as far as Beloit where it turns westward to join the Mississippi River at Rock Island, Illinois. It was thought that by constructing a canal directly west from Milwaukee to the Oconomowoc lakes (Nagawicka, Nemahbin and Oconomowoc) in what is now Waukesha County, only 30 miles of actual channel would be required. The Oconomowoc lakes discharge into the Bark River, a tributary of the Rock River.

In 1837, Dr. Increase A. Lapham, one of the pioneer government land surveyors and a noted scientist and engineer, was engaged to find and chart the most practical route for the proposed canal. The topography west of Milwaukee varied from low tamarack swamps to oak and hickory hills comprising the Kettle Moraine, a ridge of high ground running in a northeasterly-southwesterly direction just east of the Oconomowoc lakes. It was through this terrain that the survey of the proposed canal was made. (See Map 1, page 21.)

A charter was granted by the territorial legislature to the newly formed Milwaukee and Rock River Canal Company on January 5, 1838. It stipulated that construction must start within three years and that the canal must be completed within ten years of the grant of the charter. Failure to meet these construction deadlines would result in any part of the canal route not finished being forfeited to the territory. The problem then remained for the company to find adequate financial support for the enterprise.

Continued on page 21

RECONCILIATION OF SAMPLE COVERAGE IN THE INTERNAL O&D SURVEYS

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

In the SEWRPC land use-transportation study, household and travel information was obtained in the origin-destination surveys by both conventional personal interview and postal questionnaire methods.[2] In sub-regional areas encompassing the Milwaukee, Racine, and Kenosha urbanized areas, resident travel habit and household information was gathered in standard home interview surveys using a 1 in 31 sample rate in the Milwaukee area and a 1 in 10 rate in Racine-Kenosha. Truck and taxi travel information was acquired in these same areas using standard personal interview surveys at a 1 in 12 sample rate in the Milwaukee area and a 1 in 4 rate in Racine-Kenosha.

Household and travel information for the remainder of the seven-county Region outside the personal interview areas was obtained from postal questionnaires mailed to all households and truck and taxi operators. Travel information through, into and out of the Region was acquired in the external cordon roadside interview survey conducted at the regional boundary.

PURPOSE

In the home interview and household postal questionnaire surveys, utility account records were used as sample universes. As these records were organized according to meter route groups which could not be separated readily for sampling purposes, some difficulty was experienced in relating these records to the home interview and postal questionnaire universes. The problem encountered was that some of the meter routes overlapped the home interview area boundaries which had been located to follow U. S. Public Land Survey section lines.[3] As time limitations at the time of drawing the sample did not permit manual separation of the records in these overlapping groups, a decision was made to include entire routes in the home interview survey sample universe when a majority of the records in such routes fell within the home interview area and to reconcile the inherent errors upon completion of the surveys. In effect then, the boundaries used

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

[2] See all articles pertaining to the O & D surveys in the Technical Record; SEWRPC, Vol. 1 - Nos. 1, 2, and 3.

[3] U. S. Public Land Survey quarter sections were used as the basic areal data collection reference unit in all surveys.

for the field surveys followed an irregular line described by the inclusion or exclusion of entire meter routes in the home interview area.[4] Because of the lack of coincidence in the two boundaries, some home interviews were acquired in the postal survey areas and some postal questionnaires were received from addresses within the home interview areas.[5]

The primary purpose of this article is to describe the analyses and follow-up actions involved in the reconciliation of sample coverage in the home interview and household postal questionnaire surveys. A secondary purpose is to document a special follow-up survey of certain municipal trucks which were omitted in the original truck and taxi survey.[6]

HOME INTERVIEW AND POSTAL QUESTIONNAIRE RECONCILIATION

As previously noted, the need for eventual reconciliation was recognized from the start of the surveys and a decision was made at that time to complete the survey and then make the adjustments necessary to place each sample household in its proper survey area.

The initial step in this procedure occurred during the editing and coding processes. All postal questionnaires received from the home interview area were deleted from the postal survey returns and set aside for future analysis. Also set aside were all home interview schedules acquired in postal survey areas adjacent to the home interview boundary. A few other home interview schedules, obtained in error in the postal areas at other than boundary area addresses, were converted to postal questionnaire samples at that time.

In January 1964, approximately seven months after the completion of the O & D survey, data processing had progressed to the point where survey punch cards were available and the reconciliation analysis could be performed. At that time it was decided to also conduct a preliminary check of the sample coverage in the home interview areas. As the relatively small size of the Racine-Kenosha survey area permitted the use of a more detailed approach than that used in the Milwaukee survey area, the procedure followed in the Racine-Kenosha area will be discussed separately from that followed in the Milwaukee area.

RACINE-KENOSHA ANALYSIS

The first step in the analysis was to determine if a 1 in 10 sample had been obtained within each traffic analysis zone. This was accomplished by locating and totalling by quarter section, the households interviewed in the Racine-Kenosha areas and comparing the totals with independently derived estimates of housing unit counts in the same areal units.

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[4] This situation did not occur along the south boundary of Milwaukee county as the county line was also the boundary between the utility company's Milwaukee and Racine billing areas.

[5] Some other less important causes of sampling coverage errors were billing address errors in the utility records, addressing errors in the mail out processing, and cases where summer residences were not successfully screened out of the postal survey source records. (See Vol. 1 - No. 2.)

[6] This omission was found during an accuracy check made prior to calculation of the expansion factors.

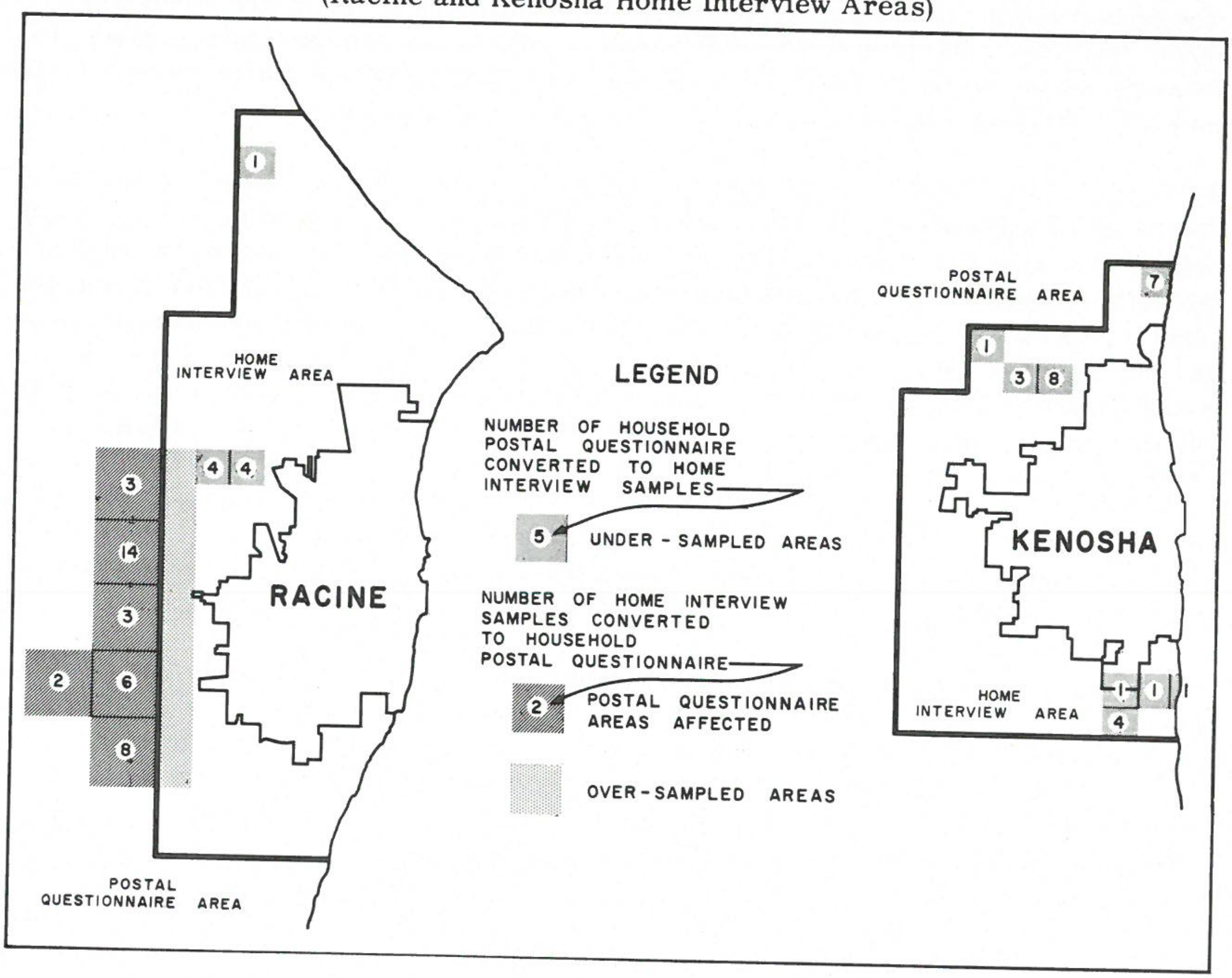
In the Racine area, the sources of these independently derived estimates of housing unit counts were: 1) 1" = 200' (1:4800) scale quarter section land use maps provided by the City of Racine Planning Department covering the corporate area of that city, and for the rest of the area, 2) a residential structure study conducted by the SEWRPC land use planning division. Although the latter provided a count of residential structures rather than of housing units, the estimates derived from this source were considered quite accurate in the areas beyond the city limits where single family residences account for nearly all residential structures.

In the Kenosha area, the sources of such estimates were: 1) existing land use maps prepared by the City of Kenosha Planning Department and, as in the Racine area, 2) the SEWRPC residential structure study.

As a result of these checks, several quarter sections along the western boundary of the Racine home interview area were found to have been oversampled. In addition, two areas in Racine and three in Kenosha appeared to have been undersampled. These areas are shown in Figure 1.

Figure 1

AREAS INVOLVED IN THE RECONCILIATION OF SAMPLE COVERAGE
(Racine and Kenosha Home Interview Areas)



Analysis of Oversampled Areas

In the oversampled area in Racine, a further check of the location of each home interview sample address revealed that 36 households were located in the postal survey area. This condition was caused by the inclusion in the home interview survey universe of a meter route which generally followed the western boundary of the Racine area. These 36 samples were deleted from the home interview file and the data converted to postal survey samples from the areas as shown in Figure 1 by transcribing the information to postal questionnaire forms. This transcription was possible since the home interview survey provided more comprehensive information than that collected in the postal areas.

Analysis of the Undersampled Areas

The undersampled areas also appeared to be the result of sample universe delineation where overlapping meter routes were located. In order to determine if this indeed were the case, an investigation was made of those postal questionnaire returns from within the home interview area which were set aside in the coding and editing process. A total of 44 postal questionnaires were identified as return from addresses in the Racine home interview area and 52 from the Kenosha area. In Racine, 31 of the 44 returns were located in the undersampled areas thus corroborating the indication that these were areas where meter routes had been included in the postal questionnaire survey. The same conclusion was drawn in Kenosha where seven returns were received from one of the undersampled areas, 13 returns from another and 12 from the third. Each of the five areas was then analyzed in the following manner in order to determine the adjustments necessary to reconciliation.

In each of the areas, the addresses of both postal questionnaire returns and home interview schedules were specifically located on 1" = 400' aerial photographs. Utility meter routes were reconstructed and identification made of the dwelling units which properly belonged within the home interview sample universe. The sufficient number and distribution of the postal questionnaire returns from each of these areas made it possible to draw a random 1 in 10 sample of these housing units and thus provide full sample representation. A total of 35 such units were selected in the four areas, 9 in the Racine areas and 26 in Kenosha as shown on Maps 1 and 2. Selection of these postal survey return addresses was desirable as it was possible to convert these postal survey samples to home interviews for the original data of interview. This was done by transferring the trip data and other time related information from the postal questionnaire to a home interview form and then conducting a follow-up home interview to acquire the additional household data and household history information.

The 35 follow-up interviews were accomplished in about four man-days in late January and early February 1964. Although no pre-interview notification procedures were used, good cooperation was realized with only one refusal encountered. Personal Opinion Survey questionnaires were left at each interview address for all persons 21 years of age or older.

MILWAUKEE ANALYSIS

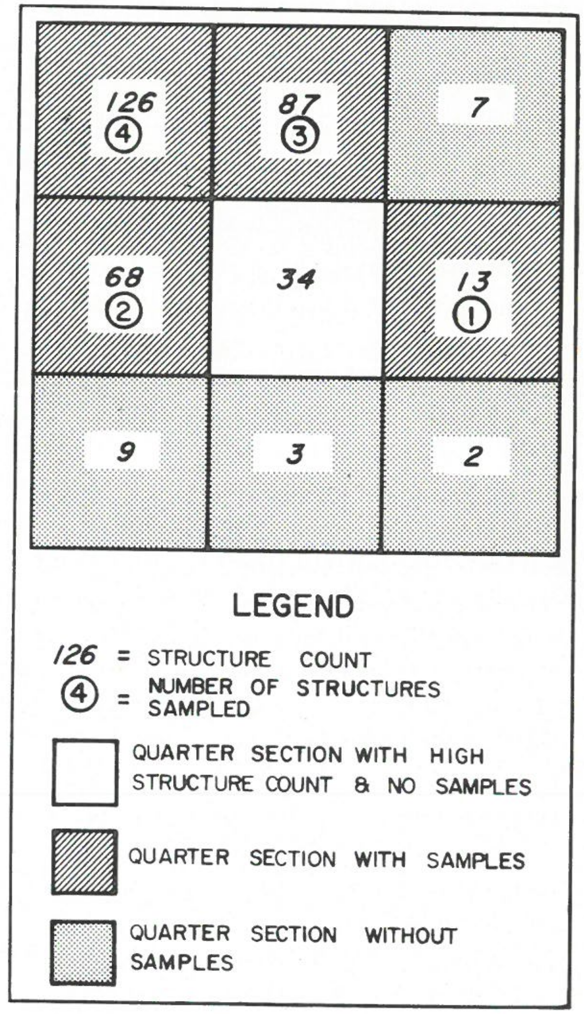
In the Milwaukee home interview survey area, the large size of the area, time and data limitations necessitated a different approach. As housing unit information was not yet available on a quarter section or other small areal unit basis, no comprehensive sample rate check could be made as in the Racine and Kenosha area. It was possible, however, to identify all quarter sections which did not contain household samples and to examine these areas to determine if they should have been sampled. It was possible, also, to investigate the boundary areas from which postal questionnaires were received. The procedure used, therefore, was to identify and examine: 1) the areas lacking home interview samples and 2) the boundary areas from which postal questionnaires were received. The detailed procedure and resultant adjustments are described below.

<u>Investigation of Areas Lacking Samples</u>

The identification of quarter sections lacking home interview survey samples was accomplished by comparing the interview address summary (#1) card deck with a special geographical reference deck which contained one card for each quarter section in the Milwaukee home interview area. A listing was prepared of all quarter sections which had no matching #1 card. The "unsampled" quarter sections were plotted on a base map of the Milwaukee home interview area. Several sources, including USGS quadrangle maps and SEWRPC aerial photographs, were then utilized to ascertain which quarter sections had sufficient residential development to indicate that they might be part of an undersampled area. While it was found that nearly all unsampled quarter sections were open land or otherwise unpopulated areas, four quarter sections were found in Milwaukee county, seven in Waukesha county and one each in Ozaukee and Washington counties for a total of 13 quarter sections, which did contain residential development and undersampling appeared possible. Each of these potentially undersampled areas was investigated further to determine if sufficient samples had been acquired in the surrounding area to compensate for the suspected deficiency. This was accomplished by comparing the number of dwelling units found with the number of samples obtained in these quarter sections and the surrounding area of contiguous quarter sections. The analysis of one of the areas in Waukesha county is shown in Figure 2.

Figure 2

EXAMPLE OF PROCEDURES USED TO IDENTIFY UNDERSAMPLED AREAS



TOTAL STRUCTURE COUNT = 349

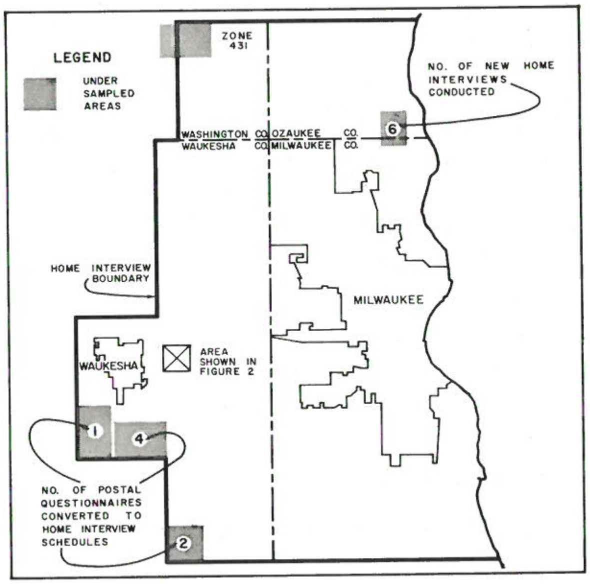
TOTAL NUMBER OF SAMPLES 10 X 31 = 310

<u>Conclusion:</u> Deficiency not great enough to warrant any corrective action.

As a result of this analysis, only five of the 13 areas were found to have deficiencies serious enough to warrant further investigation. These areas are shown on Figure 3. As four of the areas were located along the home interview area boundary, it was suspected that in these areas overlapping meter routes had been included in the postal survey universe.

Figure 3

AREAS INVOLVED IN THE RECONCILIATION OF SAMPLE COVERAGE
(Milwaukee Home Interview Area)



<u>Analysis of the Five Undersampled Areas</u>

In each case, a check was made first to determine if postal questionnaires were received from the undersampled area. In the three areas south of the City of Waukesha (see Figure 3), a total of 36 postal questionnaires were returned. As in the Racine-Kenosha analysis, the addresses were located on aerial photos along with those of the home interviews acquired. A random sample was then drawn from the postal questionnaire addresses to increase the sample rates to the desired 1 in 31 ratio. The information was transferred to home interview forms and the follow-up interviews conducted in about 1 1/2 man-days. The interview schedules were coded and edited; and the survey cards punched and placed in their appropriate decks.

In the fourth deficient area, located in Washington County in the northwestern corner of the home interview area, the undersampling apparently resulted from causes other than sample delineation, as no postal questionnaires were received from that area. While further investigation did not reveal the cause of this deficiency, the area was found to be part of a zone (431) which extended into the postal survey area. Since the zone was primarily rural and the postal questionnaires received from the postal survey portion were judged to adequately represent the entire zone, no remedial action was considered necessary.

As the fifth area was located at the Milwaukee-Ozaukee county line rather than near the survey boundary, a sampling error was suspected. Upon checking the original listings of sample selections, it was found that six samples had somehow been omitted during the preparation of the address listings used for the home interview survey. Since it was positively determined that this omission represented a "hole" (about 186 housing units) in the survey data, it was decided to conduct home interviews in February 1964 at the original sample addresses. The seasonal differences were not considered to be serious and were disregarded.

These interviews were considerably more time-consuming than postal questionnaire conversion follow-ups. Normal home interview survey procedures were followed, starting with a pre-interview personal contact made to explain the study and the survey forms. Some difficulty was experienced in two cases which required three call-backs each before the interviews were completed. Approximately 1 1/2 man-days were required to complete these six interviews. The sample information was then coded and transferred to punch cards which were placed in the appropriate survey decks.

SUMMARY OF HOME INTERVIEW AND POSTAL SURVEYS RECONCILIATION
In the sample selection preparations for the home interview and postal questionnaire survey, a problem was encountered when in the time allotted, the sample source records could not be separated to conform to the home interview boundaries. This resulted in the use of a survey boundary which did not precisely conform to the prescribed home interview boundary which follows U. S. Public Land Survey section line boundaries. A sample coverage reconciliation was planned, therefore, to be conducted upon completion of the field surveys. This reconciliation was incorporated with a sample coverage check of the home interview survey and was accomplished in January-February 1964. In the Racine-Kenosha area a detailed analysis was made utilizing the SEWRPC residential structure study and City of Racine and Kenosha information, to check sample rates of the entire area. The large size of the Milwaukee area necessitated a less detailed approach whereby areas lacking sample coverage were identified and investigated separately. The results of this analysis are given in Table 1 below.

Table 1

RESULTS OF DELINEATION ANALYSIS
IN THE MILWAUKEE AND RACINE-KENOSHA AREAS

County	Area and Sample Rate			Totals
	Milwaukee (1 in 31)	Racine (1 in 10)	Kenosha (1 in 10)	
No. Postal Questionnaires Received from Home Interview Area	52*	44	52	148
No. Postal Questionnaires Converted to Home Interviews	7	9	26	42
Additional Home Interviews Conducted	6	--	--	6
No. Home Interviews Converted to Postal Questionnaires	--	--	--	36

* All in Waukesha County

CONCLUSION

The problems encountered in separating the survey sample universes were the result of time limitations imposed during the study planning stages. While these problems were more annoying than serious, their adjustment required additional work which could have been avoided if it had been possible to allot sufficient time to precisely separate the sample universe in the study planning stages. It also would have been helpful if the SEWRPC 1" = 400' scale aerial photos had been available during the sample delineation.

For transportation studies considering the use of a combination of varying sample rate surveys, as was done in the land use-transportation study; it is recommended that special consideration be given to the problems described herein and more lead time be allowed for the collection of basic land use inventory data, mapping, and for the production of aerial photos which would be useful during survey preparations.

TRUCK FOLLOW UP SURVEY

In conjunction with the development of expansion factors for the truck and taxi survey,[7] a comparison was made of civil division sample coverage with vehicle registration information obtained from the Wisconsin Motor Vehicle Department. During this investigation it was discovered that in the Milwaukee survey area trucks from the cities of West Allis, Wauwatosa, Brookfield and New Berlin appeared to be undersampled. Upon checking the interview returns from these areas, it was determined that no interviews had been obtained for municipally owned trucks in these four communities and not all other trucks had been sampled.[8] As the municipal trucks could be treated as a sample subgroup, it was decided to conduct a special survey of them and to factor the original returns to account for the others.

Sample Selection

On June 22, 1964, appropriate officials in each of the four communities were contacted to obtain information on their municipally owned trucks. Each community provided a list of municipal vehicles from which a random sample of trucks was drawn at the 1 in 12 Milwaukee area sample rate. By successively carrying over residuals from one list to the next, a sample of 30 trucks was drawn from the four municipalities at the 1 in 12 rate as shown below:

City	Total Trucks	No. of Samples
West Allis	219	18
Wauwatosa	114	9
Brookfield	18	2
New Berlin	15	1
	366	30

The Interviews

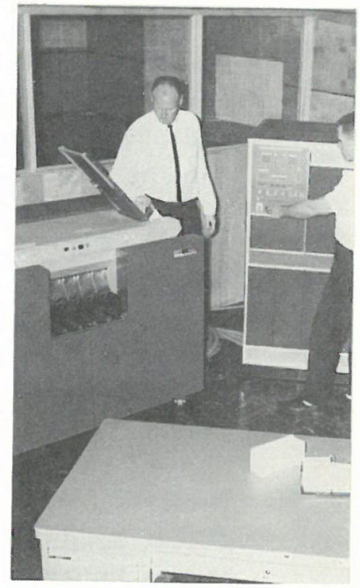
During the June 22 visits the survey and overall study was explained, and trip logs left to be completed for each of the sample vehicles' travel on June 23. Follow up interviews were conducted on June 24 during which the interview forms were completed. The information was then edited, coded and the truck trip report (#4) cards punched and placed in the truck survey deck.

7 See article in this issue.

8 "Truck and Taxi Sample Selection", Technical Record; SEWRPC, Vol. 1 - No. 1.

THE CONTINGENCY CHECK PROGRAM

by Wade G. Fox, Cartography and Design Supervisor



Previous Technical Record[1] articles have described the various origin and destination (O & D) surveys required to obtain trip and household information essential to sound long-range land use-transportation planning in the SEWRPC seven-county Region. Each phase of the O & D surveys has been described in detail, including: the sample selection, the survey procedures, and the coding and preparation of punch cards. The end result of this process was approximately 412,000 punch cards recording the data collected in the surveys (including about 2,000 personal opinion cards not described in this article). Before the great wealth of information contained in these punch cards could be used in planning analyses and in plan preparation, test and evaluation, it was imperative that every effort be made to assure the accuracy and reliability of the data as recorded in the punch cards. Although a number of checks and edits were performed as an integral part of each survey phase, errors and inconsistencies within the survey cards were found to exist as the result of the many operations necessary to collect the raw data and transcribe it into punch cards. The location and extent of these errors and inconsistencies in the survey cards, however, were not known--thus, the need for a contingency check[2] program. This contingency check program was begun immediately after all the punch cards for a survey had been keypunched and verified.

This article describes the contingency check program as conducted in the SEWRPC land use-transportation study. Included is an explanation of the basic contingency checks, a description of the operational procedures, the type of errors found by each check, an evaluation of these errors, recommendations to assist in reducing the number of errors in future surveys, and the costs of conducting the SEWRPC contingency check program.

MAJOR CATEGORIES OF CONTINGENCY CHECKS

In addition to checking that the O & D surveys information was accurately transferred into punch cards, the contingency checks were designed to identify any logical inconsistencies within the data. A total

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[1] See all articles pertaining to the O & D surveys in the Technical Record; SEWRPC, Vol. 1 - Nos. 1, 2, 3, and 4. Throughout this article, references will be made to these articles and the survey schedules (forms) illustrated.

[2] For the purposes of this article "contingency checks" are defined as checks designed to reveal errors in the numeric codes punched into cards by comparing the codes punched to permissible values established by logical relationships to other code values on the same or on related cards. Such checks are intended to reveal illogical or inconsistent code values which can then be corrected.

of 23 comprehensive contingency checks were conducted using electronic data processing (EDP) machines. Basically, the contingency checks made may be grouped under three major categories and a brief description of each category is presented in the following paragraphs.

Check of legitimate codes within a field on a survey card. This check was designed to assure that each field (a column or a group of columns) in a single punch card contained a legitimate numeric code. There were two types of checks in this category. First, each field was checked as a whole to determine that the combination of numbers punched in each column in the field comprised a legitimate code. For example, the code "19" was a legitimate code for the land use field and therefore it would be verified as being a legitimate code. Conversely, if a code "12" (an illegitimate land use code) was punched in the land use field of a survey card it would be identified as an error. Checks of complete fields were accomplished by using specially prepared "master card" decks which were compared to the survey cards using the IBM 088 Collator. Geographic location codes were particularly amenable to this type of check. The second type of check involved searching each column in a field and verifying that it contained a legitimate numeric value. This was accomplished by storing the numeric limitation of the column in the IBM 1401 Computer. For example, only the digits "1" through "7" were legitimate codes for the truck trip purpose field, this limitation was stored in the computer and any illegitimate codes identified by check of actual numbers punched against those stored. This type of check was used wherever it was impractical to use a master deck and check the complete field on the IBM 088 Collator. Codes in trip purpose, truck commodity, time and other such fields were verified by this type of numeric limitation check. Fields having no prescribed numeric limitation, such as numbers of trips made, miles traveled, and other variable types of codes were assigned numeric limitations on the basis of probable maximum values and checked in a similar manner. Apparent errors so found were investigated for validity on an individual basis by referral to the data source documents.

Check between fields in a survey card. This type of check involved logically relating one field in a survey card to one or more other fields in the same survey card. Relationships between fields, as determined by the study staff, were programmed for verification by the computer. One such contingency check, for example, verified the relationship between the mode of travel field, the sex-race-driving status field, and the age field in the internal trip card. The program logic was that if the mode of travel for a person was coded "1" (auto driver) then the sex-race-driving status field must contain a code 1, 2, 3, or 4 (persons licensed to drive) and the age code for that person could not be a code 0 or 1 (age 5 to 14). Simply explained, the logic was if a person is driving an auto he must have a driver's license and he must be of the legal driving age. All contingency checks in this category were programmed for the computer using similar "common sense" type of reasoning.

A comparison of one or more fields in a survey card with one or more fields in the same or different survey cards within the same sample number. This type of check was accomplished by programming the computer to store the code(s) contained in one or more fields of a survey card and compare these fields to related fields in another survey card from the same sample number. One such contingency check for the internal trip card of the home interview survey, for example, related data pertaining to the home location between each person's trip card from the same sample household. The program logic was that the first time a code "0" (home) was found in the trip purpose field (origin or destination trip purpose) then the home geographic code and the land use code for the home location was stored in the computer and compared to similar fields in all cards from the same household. Codes for the home location and land use fields had to be exactly the same in each card or an error message was printed out. This type of check insured consistency of data between all trips reported from the same household. Other checks of this type verified the consistency of data for each person in the household. Because of the number of interrelationships between survey cards, these contingency checks were the most complicated to program. This type of contingency check insured consistency of data between survey cards and insured accurate reporting of the trip summary information in the household summary cards.

CONTINGENCY CHECK PROCEDURES

Basically, the contingency checks were the responsibility of the coding section and the data processing center. Other staff personnel, however, were involved in the compilation of the original check lists used as a guide to prepare the computer programs for the contingency checks. In the following paragraphs the general procedures followed during the contingency check program are described. Due to the number of different checks conducted it is impossible to relate all of the particulars involved during the actual operation: however, sufficient detail is provided to permit a fundamental understanding of the methods employed.

Preparation of Original Check List

The first step in the contingency check process was to prepare a list of every possible check that could be derived from an analysis of the logical relationships existing in the data contained in each survey card.[3] No limitation was placed on the number or the feasibility of the checks, the goal was to list every conceivable possibility. This program was started about mid-way in the coding phase of the study to permit ample time to prepare a complete check list. As the check list for each survey card was completed, copies were typed and distributed to staff personnel for review, comments and additions, and a revised check list prepared. The next step was to edit the check list and prepare a final list that could be used to prepare the computer programs.

Programming the Contingency Checks

A total of 23 programs were prepared for the IBM 1401 computer to perform the contingency checks on the eight O & D survey cards edited. All of the programs written can be classified under one of the major contingency checks listed.

1. Check legitimacy of the control number of each survey card.

2. Check that the geographic codes (quarter section, civil division and census tract) for the household's address or truck's garaging address were compatible.

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[3] In addition to the resident staff, Mr. James Walsh, an engineer assigned to the SEWRPC land use-transportation study from the U. S. Bureau of Public Roads, was instrumental in preparing the initial list of possible contingency checks.

3. Check columns and fields and the relationship between fields in each survey card.

4. Check the relationship between fields in different survey cards from the same sample number.

Prior to processing the survey cards using the computer programs, however, additional contingency checks were performed using the IBM 088 Collator. These checks, as previously described, involved verifying codes by use of "master decks" containing every possible legitimate code for a particular field on a survey card. During these checks any code in a survey card field not recognized as a legitimate code was denoted by a special punch in the card in error. This special punch was recognized during the computer contingency check as a particular type of error and printed out as such.

Due to the complicated nature of the contingency check about 15 man-weeks were required to write and "de-bug" the computer programs. The 23 contingency check programs, in addition to verifying the accuracy of about 4.6 million fields coded in the survey cards, also checked out the logic of about 3.9 million relationships in the 410,000 survey cards.

Identifying Survey Card Errors

The method used to identify errors found in the survey cards by the computer program was very satisfactory and expedited the contingency check program to a great extent. The content of the survey card containing the error was printed out in its entirety, and the letters "ER" were printed above each field in error: where computer storage permitted, the type of error was also printed above the card. In some cases, due to varying circumstances other means of identifying errors were incorporated into the program. When fields in different survey cards were compared and an error found, the contents of both cards were printed out and the "ER" identification printed over the appropriate fields.

As the error was recorded by the IBM 1403 printer an additional card was punched out containing the control number identifying the survey card found in error. A unique control number was used for each survey card processed. The additional cards punched were used to prepare a listing of survey cards in error. (This listing was used by coding personnel to pull out of the files the survey schedule in error.)

Each contingency check for a survey card was completed independent of the other contingency checks for the same card. This was necessary because it was imperative that the data in each survey card be as accurate as possible before the next contingency check was performed. As the contingency check for one survey card was completed the error list was forwarded to the coding section for corrections. While the corrections were being made another survey card was processed and its contingency check performed on the computer. This procedure permitted a continuous flow of survey cards through the data processing center and the coding section.

Although a set sequence of the type of contingency check for each survey card was maintained, no particular survey card was processed first. As a contingency check program for a survey card was completed and proven, it was immediately used to check out the survey card for which it was prepared. Since all the survey cards had to be "clean" of errors and inconsistencies before any of the accuracy checks could be conducted, the order in which the contingency checks were performed was irrelevant.

In order to assure that the proper survey card was corrected it was necessary to assign a unique control number to each survey card. The survey card sample number was used for the basic control of all survey cards. The control used for the internal trip cards included the person number and trip number in addition to the sample number. The truck and taxi trip cards used sample number and trip number. The external survey trip report used a serial number in conjunction with station, direction, and hour period codes. This unique identification of each survey card was necessary to permit corrections by EDP machine methods.

Correction Procedures

The actual correction procedures followed by the coding personnel were about the same for all surveys. The data processing center, after printing out the survey cards in error, listed the control number of each survey card having an error. These two print-outs were forwarded to the coding section for processing. While the list of errors was reviewed for completeness, clerical help (using the print-out of the control numbers as a guide) began "pulling" out the survey schedules corresponding to the survey card in error.

The coder reviewed the content of the survey card in error as printed on the listing and compared the fields identified as having an incorrect code with the proper survey schedule. The coder then reviewed the information contained on the schedule to identify the reason for the error. When the correct code for the field in error was determined the schedule was corrected. The coder also recorded the correct code in the appropriate field on a check coding form. In addition to the correct code, the control number for the survey card containing the error was also written on the form (this was necessary so that the proper survey card would be "pulled" for correction by the collator). The coder also noted on the form the type of error by source, that is, if it was a coding error, an interviewing error, or a keypunching error. An analysis of the source of the errors was made in order to determine where efforts might be concentrated to increase the efficiency of future O & D studies. The results of this analysis are discussed in another portion of this article.

When all errors in the survey schedule were corrected the check coding forms, containing the control number and correct code for the field in error, were forwarded to the data processing center. The control number and correct code written on each check coding form was punched into a "puller card". All survey cards and the "puller cards" were then processed through the collator to sort out the survey cards in error. Next, the error cards and the puller cards were merged and run through a correction program on the computer to create a new card containing all the information that was correct in the original survey card and the corrected fields in the puller card.

This corrective program was designed to accept any field containing a code in the puller card as being correct and any field not punched in the puller card as being correct in the original survey card. The exception to this was the control number which was assumed to be correct in the original survey card. The end result of this process was a new survey card with all fields, columns and relationships between the columns corrected.

When the corrections were all made by the computer the new survey cards created were again processed through the same contingency check. This was to insure that all survey cards in error were corrected properly and that no erroneous punches were introduced into the survey cards. Merging of the newly created survey cards with the survey cards not in error was necessary only when the contingency check was between cards. That is, if the corrections could affect only one survey card then only the new survey cards were run through the contingency checks a second time, however, if relationship between cards were involved then all cards were processed through the contingency check the second time. Errors found during the re-edit of the cards were forwarded to the coding section and the corrections made as before and returned to the data processing center. If only a few cards were involved, they were corrected by hand. If a great number of corrections were necessary, the mechanical method of correcting the cards was used. When the re-edit corrections were completed all survey cards were considered "clean" for that particular contingency check and the survey cards were ready for the next contingency check.

Throughout the contingency check and correction procedure many controls were incorporated to guard against duplications and omissions. About 39 man-weeks were required in the coding section and about 32 man-weeks in the data processing center to correct errors found during the 23 contingency checks.

ERRORS AND THEIR EVALUATION

To permit the study staff to evaluate the source and reason for errors found during the contingency checks a complete record of the number of corrections necessary for each survey card was maintained as part of the contingency check program. These could then be related to the data collection, coding, and keypunching operations. For example, in the personal interview surveys (home, truck and taxi, and external) the interviewer recorded the codes for such items as trip purpose, mode of travel, vehicle type, person and trip number, and other direct-coding information. For these same surveys, the coders were responsible for the coding of all written information such as the household or vehicle geographic locations, land use, trip start and end times, occupation, business-industry and other related information. The transition of the coded information on the survey schedules to punch cards was the responsibility of the data processing center.

A detailed evaluation of every contingency check performed on the survey cards is not possible in this article. However, a technical report presenting the contingency check program and its evaluation in greater detail is being prepared and will be available soon. Table 1 shows the distribution of errors found and corrections made during the contingency checks, by survey card, in addition to the approximate percent of cards requiring corrections. In examining these percentages it should be noted that in some instances, more than one error was found in the same survey card. The percentage distribution of the 13,319 errors made by the originator shown in Table 1 was derived using the work responsibility criteria described above for interviewing, coding and data processing personnel.

Table 1

SUMMARY OF CORRECTIONS BY SURVEY CARD

Survey Card	Prelim. Card Count	Total Errors	Approx. Percent of Cards in Error	Percent of Errors by Originator		
				Coder	Inter-viewer	Key-punch
Address Summary	17,757	1,409	8	41	55	3
Internal Trip Report	120,790	3,209	3	47	49	4
External Trip Report	43,369	2,115	5	70	24	6
Truck & Taxi Trip Report	22,930	609	3	71	26	3
Household History	114,807	1,650	1[a]	48	47	5
Postal Address Summary	11, 117	1,136	10	96	--	4
Postal Trip Report	68,400	2,942	4	98	--	2
Postal Truck & Taxi Trip Report	10,500	249	2	96	--	4
Total & Average	409,670	13,319	3[b]	--	--	--

a The 1 percent rate shown is low because the method of processing the household history survey cards permitted more than one 5 card from a household to contain the same information, however, when an error was found in a card that was duplicated, the error was only counted once. A more realistic error rate would be about 3 percent.

b Considering the higher rate of error (3 percent) for the household history the overall rate should be about 4 percent.

In the following paragraphs the types of coding errors found prevalent, an evaluation of the reasons for the errors, and the corrective measures that could be taken to reduce the number of errors will be discussed.

Interview Error Concentrations

In each of the three personal contact O & D surveys there were concentrations of interviewer errors. The most noteworthy of these errors are listed below for each of the personal interview surveys.

Home Interview Survey

The number of persons making trips plus the persons not making trips did not equal the number of persons 5 years of age or over plus visitors (address summary schedule). Information common to both the address summary and household history schedules did not agree.

Information recorded for the destination of one trip was not recorded properly for the origin of the next sequential trip made by a person in a household (internal trip report schedule).

The question "Was a car available?", which identifies choice and captive transit riders, was not fully understood by all the interviewers (internal trip report schedule).

Truck and Taxi Survey

Some of the interviewers had a misconception of the trip purpose category "base of operation".

External (Roadside) Survey

Confusion between truck and passenger car information on the external survey schedule. Most of the errors were caused by a misuse of passenger car trip purpose for truck trip purpose.

Confusion also was noted between passenger car trip purpose and stop purpose.

Coding Error Concentrations

There were two major concentrations of errors noted in the geographic coding. One was of the general type and affected all geographic coding, the second was limited to the household address summaries from the home interview and the postal questionnaire surveys. The circumstances causing these concentrations of errors were:

Two different basic geographic control units were used to record household and trip-end locations: the U. S. Public Land Survey sections and the quarter sections.[4] The quarter section base was used as the basic geographic control unit in all the personal interview areas and in the intensely developed areas of the postal questionnaire survey area. In the remainder of the Region the section was used as the basic geographic control unit. This change of basic geographic control created some problems for the coders.

The home location for the home interview survey and the postal questionnaire survey was geographically located by more than one type of code. In the home

[4] See "Backward Glance", Technical Record; SEWRPC, Vol. 1 - No. 2.

interview survey, in addition to the quarter section identification, the census tract and civil division geographic code for the home location was recorded. Similarly, the civil division code and the quarter section (or section) code for home location in the postal questionnaire survey was recorded. When an error in the quarter section (or section) of the geographic codes was found on a survey schedule or questionnaire, all codes used to locate the home geographically were to be checked by the coder and changed accordingly. In some cases, however, this was not done and only the quarter section (or section) correction was made.

Another error found quite often in the household postal questionnaire survey was caused by coding the minor civil division given by the respondent. It appears that many citizens do not know in what civil divisions they reside!

The basic cause of other coding errors in many instances was very similar to the cause of the interview errors. This was especially true in the home interview and external surveys. Following are the major sources of errors in general coding of the survey schedules.

Confusion between trips made in sequence as reported on the internal trip report schedule. Processing comparatively new survey schedules such as the household history and postal questionnaires also created some unforeseeable coding problems.

Coding errors made on the external survey schedules were caused, in part, by the confusion arising from the mixture of truck and passenger car trips reported on the same schedule.

Data Processing Error Concentrations

During the preparation of the survey cards the data processing center had a very low rate-of-error. One of the dominant concentrations of errors occurred in the preparation of the punch cards for the external survey schedules. These errors were caused, in part, by a change in the basic make-up of the trip-end geographic field. Nine coding columns were provided for the normal eight column field. The ninth column was added to be compatible with the standard form used by the Wisconsin Highway Commission. Due to this extra column, codes following the trip origin or destination would sometimes be offset one column from their proper field in the survey card.

In addition to the external survey cards, there was a concentration of errors in the household history cards. The data processing errors in these punch cards were due, in part, to special processing of the schedules necessary to provide a basis for further, more detailed analyses. This special processing was in the form of "X overpunches" in selected columns in pertinent fields in the survey card. In some instances, however, the special punch was not introduced into the survey cards by the keypunch operator. This type of error became evident during the contingency check and was corrected.

Recommendations

Although the overall error rate in the survey cards was low, the correction process was, nevertheless, very expensive and time-consuming. In addition, regardless of the completeness of the contingency check program some errors are not identifiable. For these reasons, and others, it is imperative that the data on the schedule that is punched into the survey cards be as accurate and complete as possible. Improvements in O & D survey operations and processing could expedite the handling of the survey schedule and reduce the number of errors in the survey cards. Following are some recommendations that could improve the O & D survey procedures:

Creation of a personal characteristics survey card that would contain the sex-race-driving status, age, occupation and industry codes for each person 5 years of age or over in a sample household.

A change in the method used to record trip data during the home interview survey which would introduce a schedule designed to be an individual trip report. Each person's trips would be recorded on a separate trip schedule.

Develop a method of entering codes pertaining to the home location directly into survey trip cards by EDP machines.

Code directly into survey cards by EDP machines items from trips made in an orderly sequence from a tripmaker.

Develop a method through redesign of the schedule to separate truck and passenger car data obtained during the external survey.

Improve the design of the household postal questionnaire to clarify the identification of the person making a trip.

Change data collection procedures for obtaining the household history information by retaining only that portion of the schedule pertaining to the home and work location during a pre-interview contact. Later when the trip information is obtained, the interviewer would pick up the practically completed household history and ask the questions pertaining to income, rent or market value, educational attainment and the like.

In place of the single truck and taxi survey card, prepare a summary card and a trip card (when applicable) for each truck or taxi schedule provided. (This would parallel the present address summary and internal trip cards used in the home interview survey.)

Emphasis should be placed on the development of, and utilizing an adequate editing program with well-trained personnel in the district field offices during the home interview and truck and taxi surveys. A minimum of one editor for every four interviewers for the home interview survey and one editor for every six to eight interviewers for the truck and taxi survey should be maintained. If, however, the home interview survey is comparable to the SEWRPC survey it may be necessary to have a higher ratio of editors.

ESTIMATED COSTS

The total estimated cost of the contingency check program was approximately $15,350. This cost included: salaries, EDP rental cost, punch card stock, paper stock and miscellaneous supplies and equipment. An itemized list of the costs is provided below. These costs do not include rent, administrative and other overhead items.

Estimated Coding Cost		
A. Salaries (coders and supervisor)	$ 3,050	
B. Other costs (printing - supplies)	100	
Total	$ 3,150	$ 3,150
Estimated EDP Cost		
A. Salaries - Programming (includes supervision). . . .	$ 4,500	
B. Salaries - Processing (includes supervision)	2,240	
C. Machine Rental	4,310	
D. Card and Paper Stock	150	
Total	$11,200	$11,200
Other Cost		
A. Preparation of Initial Check List	$ 1,000	$ 1,000
Grand Total		$15,350

Unit Cost

The cost incurred up to, but not including, the contingency check correction program ($10,760) related to the total number of survey cards processed (409,670) resulted in a unit cost of $2.63 per hundred survey cards processed. Considering the cost of the coding section and data processing center ($4,590) to correct the survey cards in error (13,319) the unit cost per hundred survey cards corrected was $34.46. As can be seen the unit cost of conducting the contingency check program was much lower than the unit cost to correct the errors. The importance of reducing the number of errors to a reduction of the total cost and the time involved in the checking processes is apparent. For example, the average time required to write, "de-bug" and assemble a contingency check program required about five man-days (including preparation of the initial check list). Processing the cards through the IBM 1401 computer to do the check required takes about a half hour for 20,000 card deck. The correction of 800 errors (using a 4 percent error factor) required about an eight-ten man-day (including data processing time). By reducing the number of errors the overall program can be expedited greatly.

SUMMARY

Before the great wealth of information derived from the five origin and destination (O & D) surveys conducted by the SEWRPC and transcribed to punch cards could be used in planning analyses and in plan preparation, test and evaluation it was imperative that every effort be made to assure the accuracy and reliability of the data as recorded in the punch cards. A comprehensive contingency check program was, therefore, developed to verify the accuracy and completeness of the data in the survey cards. The checks were designed to identify any errors in the survey cards through established logical relationships in the coded data; and to designate the exact location of any errors on a print-out of the content of the survey card found in error.

The 23 contingency checks applied verified the coding accuracy of about 4.6 million items (fields) and checked the logic of about 3.9 million different relationships between items (fields) in the approximately 410,000 O & D survey cards. During the contingency check program about 13,300 errors were found in the survey cards. This indicates that about 3 percent of the survey cards required corrections.

Of the corrections required for survey cards from the home interview survey (address summary, internal trip report, and household history) the greater proportions of the errors were evenly distributed between the survey interviewers and the coders. Alterations in the design of the internal trip card schedule would probably reduce these errors to a great extent, and also expedite the processing of the schedules. Other changes in the design of the address summary and household history schedule could further improve the operation of the survey by minimizing liabilities to make errors.

Although the error rate for the external survey card was low, there are some alterations to the survey schedule that could be made to expedite the processing of the schedules and eliminate unnecessary confusion during interviewing.

The corrections necessary to eliminate the errors in the truck and taxi survey card were proportionally smaller than the home interview schedules. Approximately the same proportion of geographic coding errors were made in both surveys, however, other coding errors and interviewer errors were lower on the external survey schedules than on the home interview survey schedules. This lower proportion of error was due, in part, to the ability to follow one vehicle's trip movement in lieu of an entire family's trip movement. Also, because of a smaller work load in the truck and taxi survey more time could be spent editing the schedules in the field offices.

The household summary and trip report survey cards from the postal questionnaire survey had a comparably high rate-of-error content. This was especially true of the household summary portion of the survey cards where a number of errors were made in coding the home location of the respondent. Unreliable addressing by the respondents of the survey affected many of these geographic coding errors. There are, however, some alterations to the questionnaire's design and some changes in the survey procedure that might improve the operation and processing of the questionnaires.

The truck postal questionnaire survey cards had the lowest error rate of any of the surveys. Special processing required to obtain an adequate sample rate permitted a

detailed evaluation of each questionnaire during coding. The single vehicle movement also aided in simplifying the processing of the questionnaires and therefore reduced the possibility of coding errors to a great extent.

Cost

The total cost of conducting the contingency check was about $15,350. Of this amount, $12,200 was incurred in the data processing center (including preparation of the initial contingency check listings) and $3,150 was incurred in the coding section. Relating the $15,350 total cost to the 13,319 errors corrected the cost per hundred errors corrected was about $115.24. The contingency checks outlined in this article probably comprise one of the most comprehensive programs of this type ever undertaken to search out and correct errors in O & D survey data. The comparably low rate-of-error found in most of the survey cards processed indicates that the interviewing, coding, and data processing operations were adequately carried out. Nevertheless, many changes or alterations could be made in future surveys to improve the collection and processing of the survey data and reduce the possibilities of errors to a great extent.

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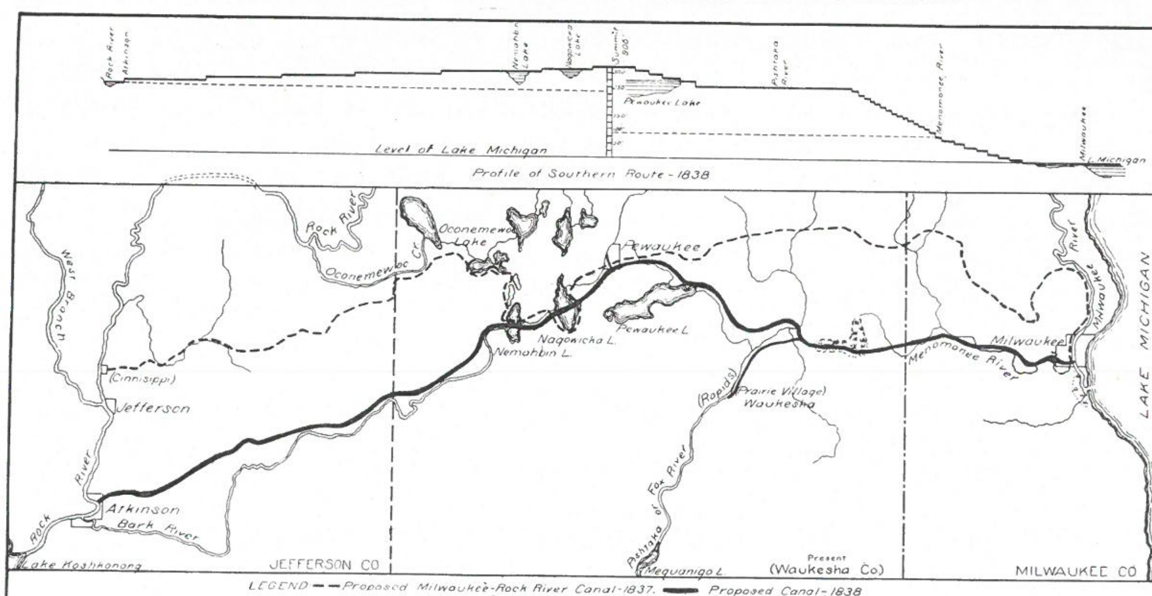
(Backward Glance continued from page ii)

Map 1

MAP SHOWING PROFILE AND PROPOSED ROUTES
OF THE MILWAUKEE AND ROCK RIVER CANAL



Taken from Dr. I. A. Lapham's original 1837 map.

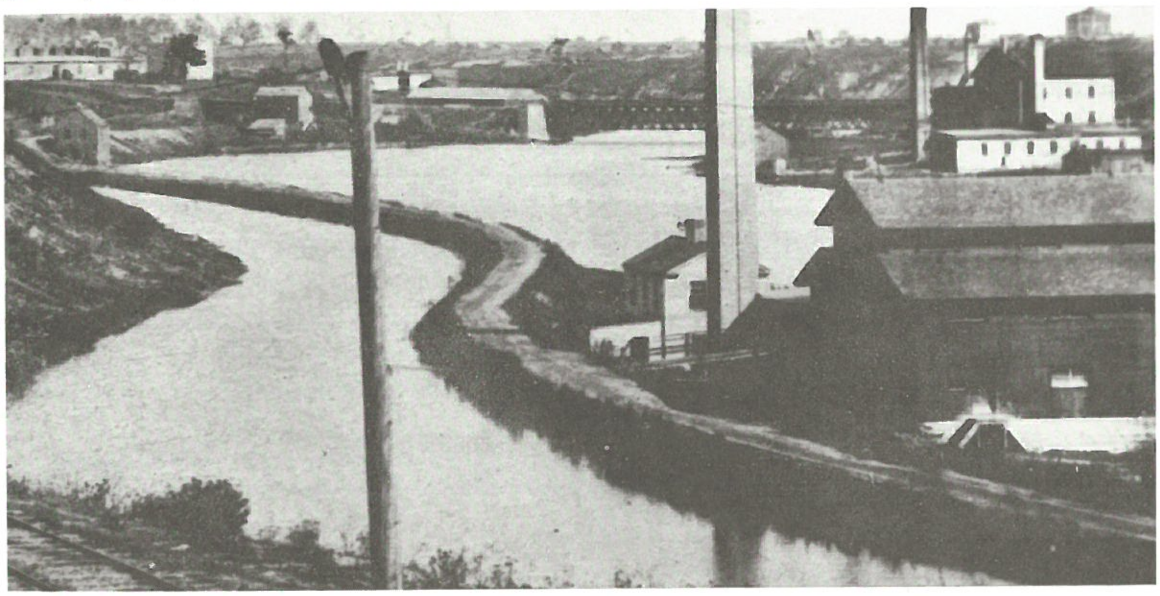
Continued on page 22

(Backward Glance continued from page 21)

Finance A Big Problem

After the necessary charter had been granted, it was found that the preliminary construction cost estimate of $798,715 was too low to complete the project. In order to save the project, Kilbourn went to Washington late in 1838 and obtained a congressional grant of public land in support of the project. Approximately 166,400 acres of public lands lying along the proposed canal right-of-way was to be sold at a minimum of $2.50 an acre and the return used to construct the canal. It was anticipated that eager settlers would purchase this land and thereby provide the necessary funds to carry out the operation.

On the Fourth of July, 1839, actual construction was begun in Milwaukee, but it soon lagged to a standstill when the anticipated revenues from the sale of the public land grant failed to materialize. In three years, only a one-mile stretch of canal along the Milwaukee River was actually completed. Water was dammed in the river and diverted into the canal where a mill race was constructed. (See photograph.)



The Milwaukee and Rock River Canal as it looked about 1850 shortly before it was filled in. The building with the tall smoke stack in the right foreground was the old Ludington and Garland Paper Mill, one of many industries that utilized the canal as a source of water power. (Courtesy Milwaukee County Historical Society)

The only useful service that the canal provided was to supply water power that benefited the early manufacturing industries of Milwaukee. By 1842, five flour mills, an edge tool factory, wood turning shops, a foundry, a pail company, a tannery and a woolen mill were in operation along the canal. Soon, a total of 24 mills and factories were humming busily on its banks. The completed one-mile section of canal cost $56,745 of which the sale of granted lands paid more than half.

Continued on page 34

INVENTORY OF THE ARTERIAL STREET NETWORK

by Wm. T. Wambach, Jr., P. E. [1]

INTRODUCTION

A "Transportation Study" requires an evaluation of both the demand and supply sides of the transportation "equation." Evaluation of the demand side is achieved through the travel inventories and the relation of travel to land use. Evaluation of the supply side is achieved through an inventory of the capacity and level of service of the transportation system. Such a capacity and level of service inventory may be used to determine what deficiencies, if any, exist in the transportation system under present loadings and conversely what excess capacity may be available in the system for future loadings. In the conduct of an arterial street inventory, it is necessary to measure the physical dimensions of each link in the existing arterial street and highway network and to determine certain other pertinent information affecting system capacity, such as operating speeds and traffic volumes. In a previous article,[2] it was stated that "the network of links and nodes thus obtained" (which comprise the highway transportation system) "can be described to a digital computer by preparing a punched data card for each link, identified by its two node numbers (eight digits) and containing link length, travel time and traffic capacity." The collection and coding of the data required to delimit these elements for each link in the arterial street and highway system of the Region are the subject of this article.

Scope of the Inventory

In order to arrive at an evaluation of the capacity of the existing street and highway system, the entire arterial network serving the Region, an area containing over 2600 square miles, had to be inventoried. This network consisted of 4350 links, intercepted at 2650 nodes, and included over 3300 miles of arterial streets and highways ranging from urban freeways to rural county trunk highways. The bulk of the network was centered in the cities of Milwaukee, Racine, Kenosha, and Waukesha which, with their surrounding urbanizing areas, occupy approximately 20 percent of the total area of the Region, but contain 69 percent of the network links, 67 percent of the network nodes and 44 percent of the network mileage.

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[1] Assigned to SEWRPC by District 2, State Highway Commission of Wisconsin.

[2] "Arterial Network and Traffic Analysis Zones," Technical Record; SEWRPC, Vol. 1 - No. 2.

In the design of the network inventory and the inventory forms, four factors required careful consideration:

1. A link identification system.

2. Factors affecting link capacity.

3. Factors affecting minimum time paths through the network.

4. Information necessary for arterial system analysis.

Link Identification System

In order to correlate inventory data from such varied sources as the State Highway Needs Determination Study, local street and highway inventory records, and SEWRPC field measurements, it was necessary to devise a link identification system which would permit positive identification of each link in the network in each data source. In order to accomplish this objective, it was determined to identify each link in the network on the inventory forms in three ways.

First: The name of the street or highway along which the link lay and the name of the intersecting street or highway forming the node at each end of the link was recorded on the inventory forms.

Second: The node numbers at each end of the link as shown on the SEWRPC network maps[3] were recorded on the inventory form.

Third: The geographic location of each link in the Region was identified by recording the traffic analysis district (ring and sector) and zone number on the inventory form.

In addition, each inventory form was assigned a "sheet number" to permit ready retrieval of any original data for links recorded on the form in the event that any apparent errors were discovered during later processing and analysis of the data. The map source, from which link length and grade information was determined, was also recorded on the inventory form.

Factors Affecting Link Capacity

The term "capacity" may be defined as the ability of a link in an arterial street and highway network to accommodate traffic. The capacity of any link in a network depends upon conditions determined by the physical features of the roadway itself, by the characteristics of the traffic using the roadway, and by characteristics of abutting land uses.

Since the capacity determinations were being made for long range planning purposes, it was decided that only those characteristics of a link which would have major significance in limiting link capacity would need to be inventoried.

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[3] Ibid., footnote 2.

After careful consideration by the SEWRPC staff and the Origin and Destination Subcommittee of the Technical Coordinating and Advisory Committee, composed of highway and traffic engineers, it was determined that the prevailing conditions on which data would be collected would be:

1. Pavement width.
2. Type of route.
3. Type of area.
4. Grade at intersection approach.
5. Separate, permanent turning lanes.

The pavement width was taken as the basic measure of capacity, and all other factors were applied as modifiers to this capacity as determined in the Highway Capacity Manual[4] and current supplementary data obtained from the U. S. Bureau of Public Roads.

Collection of data on the type of route recognizes the effect on capacity of the operating characteristics of the major functional types: freeways, expressways, and standard arterials; while collection of data on the type of area recognizes the effect on capacity of side friction created by parking and pedestrian interference.

With respect to the effects of these two factors on capacity, the procedures and capacity reduction values outlined in the Highway Capacity Manual and the U. S. Bureau of Public Roads supplementary data were followed.

For the effect of grades at intersection approaches on capacity, the following criteria were adopted: for favorable grades and adverse grades less than 3 percent, no reduction in capacity; for adverse grades between 3 and 6 percent, a 5 percent reduction in capacity; for adverse grades greater than 6 percent, a 10 percent reduction in capacity.

With respect to the effect of turning lanes at intersections on capacity, the following criteria were adopted; If separate, permanent-turn lanes at least six feet wide and 100 feet long were provided, a 5 percent increase was made in capacity for such a right-turn lane; a 10 percent increase was made in capacity for such a left-turn lane or a 15 percent increase was made if both were provided.

These procedures appear sound in light of findings published in the Highway Capacity Manual and should result in a determination of link capacity as accurate as can be determined for long-range planning purposes.

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[4] Committee on Highway Capacity, Department of Traffic and Operations, Highway Research Board, U. S. Department of Commerce, Bureau of Public Roads. U. S. Government Printing Office, Washington, D. C., 1950.

Factors Affecting the Network Minimum Time Path

Since application of the mathematical model to be used to assign both existing and future traffic loads to the links of the network requires knowledge of the least travel time paths connecting traffic analysis zones within the Region, it was necessary to determine overall travel time, including the effects of usual delays such as traffic signals for each link in the network. Time and budgetary limitations precluded the determination of actual travel times of all links by speed and delay studies. Therefore, it was determined to compute link travel times from measured link lengths and average running speeds, as estimated by SEWRPC staff and checked by local traffic and highway engineers, and supplemented by special speed and delay study runs for check purposes.

Information Necessary for Arterial System Analysis

One method of checking the validity of the mathematical models used to assign traffic to the existing and proposed street and highway network is to compare the traffic volumes derived from an assignment of survey trips with the actual volumes using the links during the time when the travel inventories were made.

Such a check required that existing traffic counts be collected for the existing network. The traffic count program of the State Highway Commission of Wisconsin, the County of Milwaukee, and the City of Milwaukee covers such a large area that every street and highway could not be scheduled each year. Therefore, for some streets and highways, it was necessary to use older counts and factor them to May 1963. Further investigation revealed that some areas did not have an adequate coverage and a number of links did not contain a counting station, so special counts were made by SEWRPC personnel. Consequently, in addition to recording the traffic count information, the type of count, e.g., 24-hour machine count, 16-hour manual count and/or older counts factored to 1963, was also recorded as a measure of the degree of accuracy of the count as a standard of comparison.

Analysis will also be made of the total capacity of all parallel routes within a certain corridor of travel demand. For this reason, the direction was recorded for each link. Further, since one of the basic remedies for correcting deficiencies in capacity is widening the pavement, and this can only be done within the limitations of available right-of-way, it was decided that wherever local records carried the information, right-of-way width would be collected.

PRE-INVENTORY PROCEDURES

Design of the Form

The basic consideration in the design of the arterial link inventory form was that the form should be self-coding; that is, all information which would be keypunched could be entered in numeric form so that keypunching could be done directly from the inventory form. The number of spaces assigned to each piece of inventory data, their size and shape, were laid out to be compatible with the necessary degree of accuracy of the measurements, ease of understanding by the personnel who would do the collecting, and legibility and clarity for the keypunch operators. The sheet size chosen was 8 1/2" by 14", standard legal size, since it was not possible to get all the necessary data onto an 8 1/2" by 11" letter-size sheet. The spaces for recording data on the inventory form were numbered to correspond with the columns allocated for this information in code form on the punch card. (See Figure 1.)

Scheduling and Personnel

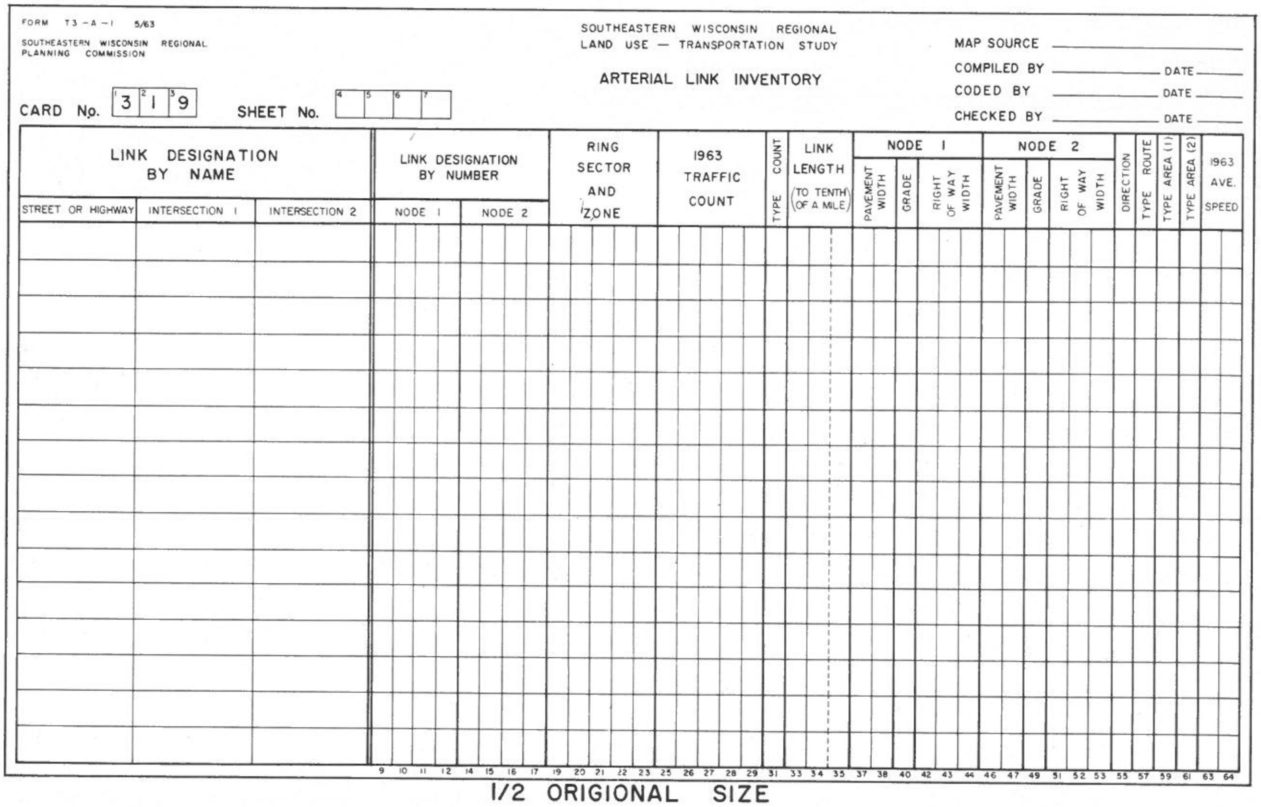
It was not necessary to conduct the facility inventory concurrently with the travel inventories because it was possible to reconstruct the network, and determine the link characteristics for the May 1963 base period. Therefore, in order to utilize personnel more effectively, it was decided to perform the inventory immediately following the completion of the travel inventories. Six of the temporary employees retained for the travel inventories were selected to collect the network inventory data under the direction of one of the traffic planning engineers.

Sources of Data

For purposes of identifying the names of the arterial links, county highway maps were collected from the State Highway Commission, tourist maps from oil companies, and urban street maps from the local communities.

Figure 1

ARTERIAL LINK INVENTORY FORM



FORM T3-A-1 5/63
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

SOUTHEASTERN WISCONSIN REGIONAL LAND USE — TRANSPORTATION STUDY

ARTERIAL LINK INVENTORY

MAP SOURCE ______
COMPILED BY ______ DATE ______
CODED BY ______ DATE ______
CHECKED BY ______ DATE ______

CARD No. 3 1 9 SHEET No.

LINK DESIGNATION BY NAME			LINK DESIGNATION BY NUMBER		RING SECTOR AND ZONE	1963 TRAFFIC COUNT	TYPE COUNT	LINK LENGTH (TO TENTH OF A MILE)	NODE 1			NODE 2			DIRECTION	TYPE ROUTE	TYPE AREA (1)	TYPE AREA (2)	1963 AVE. SPEED
STREET OR HIGHWAY	INTERSECTION 1	INTERSECTION 2	NODE 1	NODE 2					PAVEMENT WIDTH	GRADE	RIGHT OF WAY WIDTH	PAVEMENT WIDTH	GRADE	RIGHT OF WAY WIDTH					

9 10 11 12 14 15 16 17 19 20 21 22 23 25 26 27 28 29 31 33 34 35 37 38 40 42 43 44 46 47 49 51 52 53 55 57 59 61 63 64

1/2 ORIGIONAL SIZE

Data on pavement and right-of-way width, and on type route were gathered from the 1958 State Highway Needs Determination Study, from Federal aid primary and secondary route logs, and from the data files of local municipal engineering departments; and supplemented, where necessary, by field measurements made by the SEWRPC staff.

Information on turning lanes and link running speeds was gathered from local records, and supplemented by checking with local traffic engineers; and, where necessary, through supplementary speed and delay runs. Link length, grade, and direction were measured on SEWRPC 1:62500 base maps and on 1:24000 scale USGS quadrangle maps having contours with a vertical interval of 10 feet.

As already noted, traffic counts were collected from the records of the State Highway Commission and local communities wherever available and supplemented with manual and machine counts by SEWRPC staff personnel.

DATA COLLECTION PROCEDURES

Link Identification and Direction

The first step in completing the arterial link inventory form (Figure 1) was to assign a consecutive sheet number. The next step required recording the numeric code designating the map source used to measure link lengths and approach gradients. Five source maps were used in the study for this purpose:

Code 1 - City of Milwaukee central area, scale 1:7200.

Code 2 - Milwaukee County, scale 1:24000.

Code 3 - Region, scale 1:62500.

Code 4 - Racine and Kenosha, scale 1:24000.

Code 5 - City of Waukesha, scale 1:24000.

A mylar overlay containing a diagram of the arterial link network with node numbers was prepared for each base map, and the node numbers at each end of the link were transcribed to the columns on the form headed "Link Designation by Number." In the case of a two-way link either node could be designated as "Node 1." In the case of a one-way link, e.g., freeway, one-way ramp, or one-way street, however, the node designated as "Node 1" had to be the node at the entrance to the link. No pair of node numbers could be used more than once to identify a link or links, in either forward or reverse direction. To avoid errors in omitting links, it was necessary to use a print of the network and color the coded link as it was listed on the inventory form.

A second mylar overlay of the base maps showing the ring, sector and zone boundaries was used to record the geographic location of each link. One and two-digit zone numbers required the use of lead zeros, e.g., Zone 6 was coded 006, and Zone 83 was coded 083. A link was assigned to the lowest numbered zone in which, or along the boundary of which, a half or more of its length lay.

Next, the direction of the link was coded as follows:

Code 1 - East-West.

Code 2 - Northeast-Southwest.

Code 3 - North-South.

Code 4 - Northwest-Southeast.

Type of Link and Name

If it were readily apparent, the type of route was also coded at this time. The type of route designated was always checked with local municipal, highway, or traffic engineers. This was particularly important in the identification of one-way streets not otherwise readily apparent from the base maps. The following codes for the type of route were recorded on the inventory form:

Code 1 - Freeway: an expressway with full control of access and fully grade-separated intersections.

Code 2 - Expressway: a divided arterial street or highway with full or partial control of access and with some grade-separated intersections.

Code 3 - Free flow ramp: an interconnecting roadway carrying traffic in one direction only between two or more highway facilities on different levels, which has a free merge or a yield sign at the exit end.

Code 4 - Two-way arterial highway: a street or highway used or intended to be used primarily for fast or heavy through traffic and which provides a reasonably continuous route through the whole or a major portion of a city or a county within the Region and generally connects with the principal highways radiating from the urban area.

Code 5 - Non-free flow ramp: an interconnecting roadway carrying traffic in one direction only between two or more highway facilities on different levels, which has a stop condition at the exit end.

Code 6 - One-way arterial highway: an arterial street or highway whose entire pavement is used in one direction only.

Code 7 - Arterial highway for which each direction of a two-way street is coded as a link: usual purpose, to identify radically different capacity characteristics at opposite ends of the link.

The link length was measured by scaling on the base map, and the data recorded on the inventory form. Clear plastic scales were specially constructed for this purpose. The link length was measured to the nearest tenth of a mile.

Next, the columns headed "Link Designation by Name" were completed. In the first column headed "Street or Highway," was recorded the official name, number or letter identifying the link as shown on applicable source maps. At "Intersection 1," the name, number or letter of the crossroad or sideroad at Node 1, and at "Intersection 2," the name, number or letter of the crossroad or sideroad at Node 2 was similarly entered. If the crossroad or sideroad had no identification on any of the various source maps, or if the node was not at an intersection, it was described by distance from some identifiable place, e.g., "1.2 mi. west of CTH F."

Intersection Approach Grade

The proper code for the column headed "Grade" on the inventory form was determined by the longitudinal slope of the pavement in the last 200 feet before the node. Using USGS 1:24000 scale quadrangle maps having 10 foot contours, the difference in elevation between the intersection at which spot elevations are usually given on the USGS quadrangle maps and the first contour more than 200 feet from the intersection was computed, and the distance between these two points of known elevation was scaled. If the grade was favorable, i.e., downhill toward the node, Code 0 was entered. If the grade was adverse, i.e., uphill toward the node, the proper code was determined by using an approach capacity reduction chart, which had been prepared to avoid the necessity for the computation of the actual percent grade. Relating the distance and the difference in elevation between two points on the chart, the proper code was read and subsequently recorded on the inventory form.

Type of Area

Next, the "Type Area" was determined. Research aides were provided with copies of the following codes and definitions:

Code 1 - Downtown type area: that portion of a municipality in and surrounding a business development where ordinarily there are large numbers of pedestrians and a heavy demand for parking space during periods of peak traffic, or a sustained high pedestrian volume and a continuously heavy demand for parking space during business and industrial employment hours. This definition applies to industrial and business areas outside of, as well as those within, the central part of a municipality.

Code 2 - Intermediate type area: that portion of a municipality which is outside of a downtown area, but generally within the zone of influence of a business development, characterized by moderately heavy pedestrian traffic and a somewhat lower parking turn-over than is found in a downtown area.

Code 3 - Outlying type area: a residential development, or a mixture of residential and commercial establishments, within the outer fringe of a metropolitan area, characterized by few pedestrians and a low parking demand or turnover.

Code 4 - Rural type area: any area not within a town, city, or metropolitan area.

Code 5 - All freeway nodes.

Current SEWRPC aerial photos at a scale of 1" = 400' on which existing land use had been delineated were consulted for determining the proper "Type Area" code. Figure 2 is an illustration of a small portion of one of the aerial photos. The land use codes as recorded in the existing land use inventory are shown around the intersection, and are:

Figure 2

SAMPLE OF LAND USE DELINEATION

00 - Single family residential.

03 - Multifamily low rise 1 to 4 story.

10 - Local retail and services.

58 - Off-street parking.

60 - Local institution.

63 - Regional government.

71 - Local public recreation area (open).

Examination of the aerial photo showing these existing land uses would indicate that the area is subject to moderately heavy pedestrian traffic; and, therefore, the intersection would be judged to be Code 2, intermediate type area. All "Area Type" codes were entered on a print of the arterial network diagram, and subsequently reviewed with the local municipal, highway, or traffic operations engineers.

Pavement and Right-of-Way Widths

Pavement and right-of-way widths were next recorded in two steps. The first step was to record the full pavement width on a print of the network diagram at each leg of each node. The first sources consulted for data on pavement width were the Federal aid primary and secondary route logs, dated January 1963. The second source consulted was the computer print-out of the 1958 State Highway Needs Determination Study data for rural roads and all streets in communities of under 2,500 population. Since the "Needs Study" data for larger urban communities had not been converted to punch cards as yet, the records of the local engineering departments were consulted. The local records proved to be a particularly valuable data source. The City of Kenosha Engineering Department had a large scale map on which all pavement widths and right-of-way widths were shown. The City of Racine had carbon copies of "Needs Study" field collection forms bound into books. In the City of Milwaukee, where the largest number of links was located, the engineering department had an alphabetical punch card file inventory of pavement width and right-of-way width, gathered for their continuing road life studies, with a card for each city block along each street. The data is updated as each construction season is completed. It should be noted that the City of Milwaukee system was cited by the National Committee on Urban Transportation as the example of the best method currently in use for such inventories and studies.[5] In most other communities of the Region, there were very few links for which pavement width and right-of-way width could not be gathered. After all of the previous data sources had been exhausted, the final recourse was to obtain the remaining information by actually measuring the pavement width in the field using a two-man survey crew.

Although columns were provided on the inventory form for recording the right-of-way width at both nodes, it was found that right-of-way width often varied substantially throughout the length of single links; and, in many cases, it was not recorded on local records because of this variability of the width. Where information was available, the "usual" right-of-way width throughout the link was recorded, i.e., if over half the length of a link had a 60 foot right-of-way and other short sections had more or less, 60 feet was recorded. This practice provided a fair indication to the traffic planning engineer of available existing right-of-way width for pavement widening. At this same time, the existence and location of separate, permanent right- and/or left-turn lanes was ascertained by consultation with the local engineers, and was entered on the prints of the arterial network by means of a red "R" or "L" on the proper leg of the intersection.

The second step in recording the pavement and right-of-way width was to transfer this information from the work prints of the arterial network to the arterial link inventory sheets. On two-way pavements, half the pavement width was entered at the proper node. On divided streets, the width of the through lanes, including parking lanes, in the direction toward the node was entered. For one-way streets, and full pavement width was entered at "Node 2." The usual right-of-way width was entered in the column under "Node 1," and the column under "Node 2" for right-of-way width was not used. Turn lanes were entered by use of a red "R" or "L," or both, in the columns headed "Intersection 1" or "Intersection 2" under "Link Designation by Name."

<u>Running Speed and Traffic Volume</u>

The next step in completing the inventory form was to enter running speed data for each link. Running speed data on certain links was available from the City of Milwaukee Traffic Engineering Department, which had made recent speed and delay runs on certain selected major radial routes, north-south crosstown routes, and east-west crosstown routes for the purpose of updating speeds obtained from an existing isochronal map. Some additional speed runs were made by the SEWRPC staff to obtain first-hand knowledge of local operating conditions where other sources of data were not available. Staff members, who were long-time residents of the Region and had knowledge of the posted speed limits, then assisted in assigning realistic running speeds on the remaining links. These speeds were then posted to prints of the arterial network and adjustments were made, where necessary, to accurately represent the proper relationship between adjacent or competitive routes. When these adjusted speeds had been checked with the local traffic operations engineers, they were transferred from the prints of the arterial network to the inventory form.

[5] "Inventory of the Physical Street System," <u>Procedure Manual 5A</u>, National Committee on Urban Transportation. Public Administration Service, 1313 E. 60th St., Chicago 37, Illinois.

The final step in the completion of the inventory forms was to enter 1963 traffic volume counts for each link. The collection and refinement of traffic volume data for each of the approximately 4,500 links in the network was a lengthy and complex task and for this reason a future article will be devoted to this phase of the network inventory.

SPECIAL PROBLEMS AND SOLUTIONS

The variety of secondary data sources required adaptation of methods of data collection to the available records. This necessitated frequent shifting of personnel from one phase of the inventory to another. Consequently, the blanks provided in the upper right corner of the form for person "Collected by" and "Coded by" were not particularly useful. Only the line for person "Checked by" was finally used.

The inventory forms had already been printed when it was determined that turn lanes should be recorded. Provision of a column for a turn lane code at each node was made on the punched card. Some time could have been saved if there had been columns originally provided on the inventory form for this data.

The measurement of link length to the tenth of a mile did not prove entirely satisfactory. For example, there are many streets in the Region which have link lengths of a quarter mile. If one such link is coded 0.2 mile, and a nearby parallel link is coded 0.3 mile, the computed running time with equivalent speeds favors the shorter coded route. It was necessary to hand-fit speeds to individual links affected in order to produce realistic running times in such situations. It may be desirable that all links be measured to the nearest five hundredth (0.05) of a mile in future inventories.

Also, because of the variability of existing right-of-way widths along a link, only the usual right-of-way width can be a meaningful piece of information. Therefore, the columns for right-of-way width under "Node 2" served no useful purpose and should be eliminated from the form.

COST ANALYSIS

The total cost of the arterial link inventory was about $33,500. For the 4,350 links there were 8,200 link-ends for which data was inventoried. The cost, therefore, was slightly more than 4 dollars per link-end. The total man-hours for the inventory were approximately 5,700 hours, which reduces to 0.7 man-hour per link-end. If all of the secondary data sources had not been available, the costs in time and money would have been much greater.

CONCLUSION

A capacity and level of service inventory of the existing arterial street and highway network is an important part of a transportation study. The data collected is necessary to calculate existing traffic-carrying capacity of a street or highway, to compute minimum time paths between traffic analysis zones, and to analyze the entire system capacity. All available secondary sources of data required for the inventory should be investigated, since these sources can substantially reduce the time and money necessary to collect the necessary information.

The basic arterial street inventory recorded the status of the network as of May 1963 when the origin and destination surveys were made. Assignment of the surveyed trips to this network will be checked against May 1963 traffic counts in order to check and calibrate the traffic assignment models.

Future assignments will be made after the basic inventory data has been expanded to include links constructed or reconstructed since May 1963, and links to be constructed or reconstructed in all committed construction programs. All other highway transportation plan proposals, which include additional facilities, can then be tested and evaluated by inserting the data for the proposed links and making additional traffic assignments.

Alternate land use-transportation plans can, thereby, be tested and adjustments made until a balanced system is produced. Regular updating of the inventory will result in a continuing capability for testing the effect of any differences in the actual land development pattern from the adopted land use-transportation plan.

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(Backward Glance continued from page 22)

The unpurchased land from the congressional grant eventually reverted back to the territory and was sold, the money being used for educational purposes. Thus, the dream of a trans-state waterway faded and ended like so many other canal attempts of that era, such as the proposed Fox River Canal which was to provide navigation on the river, by a series of 12 locks and dams, from Prairieville (Waukesha) to Elgin, Illinois, in failure.

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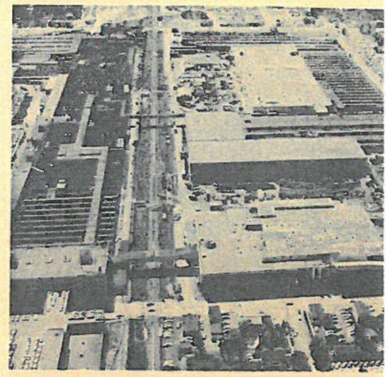
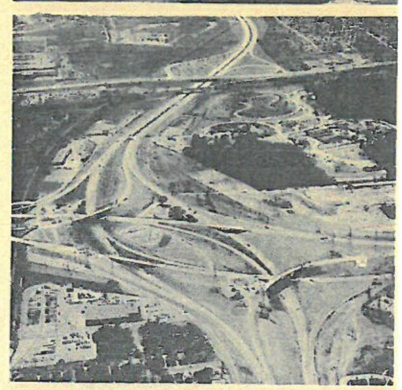
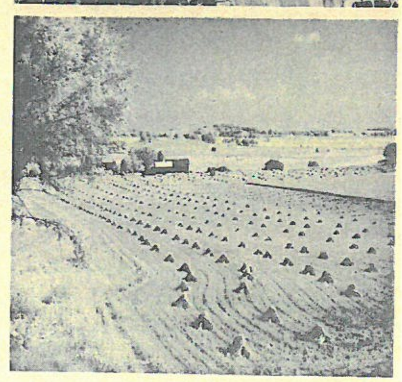
Sources: Bulletin No. 58; Wisconsin Geological and Natural History Survey, Madison, 1921.

Southeastern Wisconsin - History of Old Milwaukee County, Vol. II, by John G. Gregory, Chicago, 1932.

The Milwaukee Story, The Milwaukee Journal, 1946.



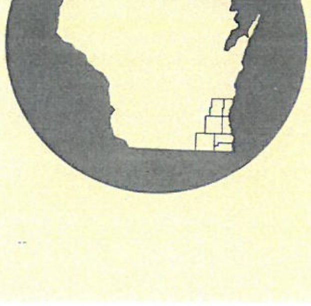




THIS IS SOUTHEASTERN WISCONSIN

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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