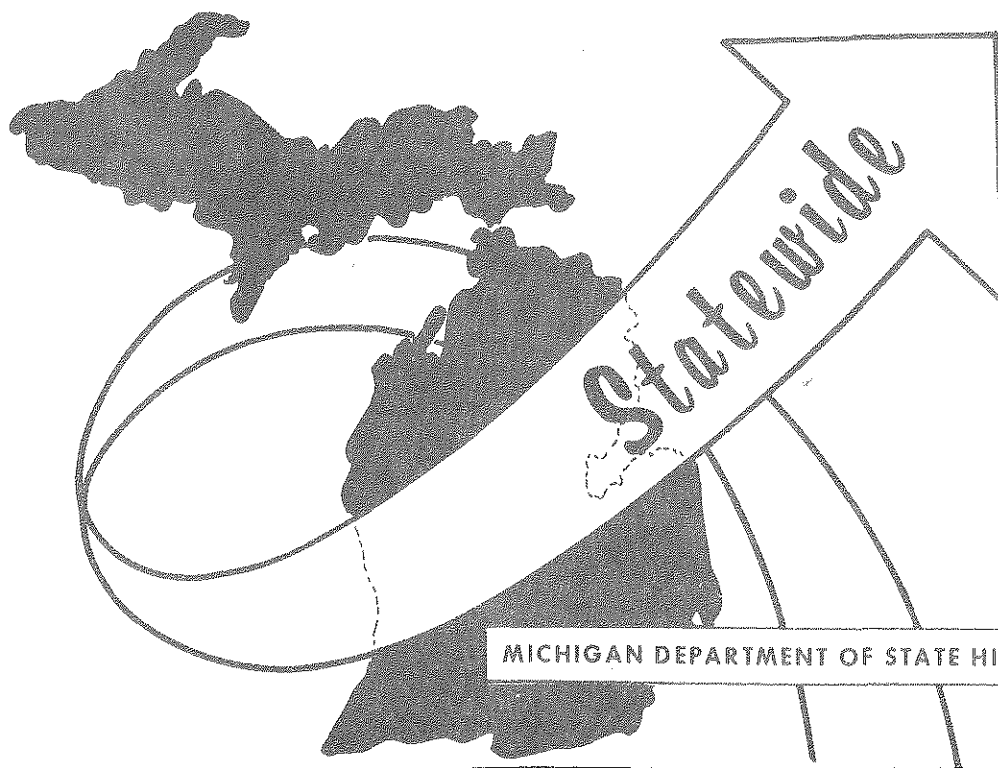# Statewide Transportation Analysis & Research

MICHIGAN'S STATEWIDE
TRANSPORTATION MODELING
SYSTEM

VOL. VII-B

MODELING MAJOR FACILITY OPENING IMPACT ON DHV PERCENT TRENDS

STATEWIDE STUDIES

NOVEMBER 1974

MICHIGAN DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

MICHIGAN DEPARTMENT

OF

STATE HIGHWAYS AND TRANSPORTATION
BUREAU OF TRANSPORTATION PLANNING

MICHIGAN'S STATEWIDE
TRANSPORTATION MODELING
SYSTEM
VOL. VII—B

**MODELING MAJOR FACILITY OPENING
IMPACT ON DHV PERCENT TRENDS**

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JOHN P. WOODFORD, DIRECTOR

November 10, 1974

Mr. Sam F. Cryderman, Deputy Director
Bureau of Transportation Planning
Department of State Highways and Transportation

Dear Mr. Cryderman:

The Highway Planning Division is pleased to present Volume VII-B in the Statewide Transportation Modeling System series. It documents an initial refinement to the Design Hour Volume forecasting model.

As explained in an earlier report, DHV as a percent of Annual Average Daily Traffic generally declines with time. The major exception seems to be when a major facility in the state opens, at which time DHV percents on nearby and otherwise related highway links sharply increase. The process described herein is an exploratory first effort to incorporate such increases into the DHV model.

This report was prepared by Mr. Lawrence G. Scott of the Statewide Interagency Procedures Research and Development Section, under the supervision of Mr. Richard E. Esch.

Sincerely,

R. J. Lilly, Administrator
Highway Planning Division

MODELING MAJOR FACILITY OPENING
IMPACT ON DHV PERCENT TRENDS

By
Lawrence G. Scott

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PREFACE
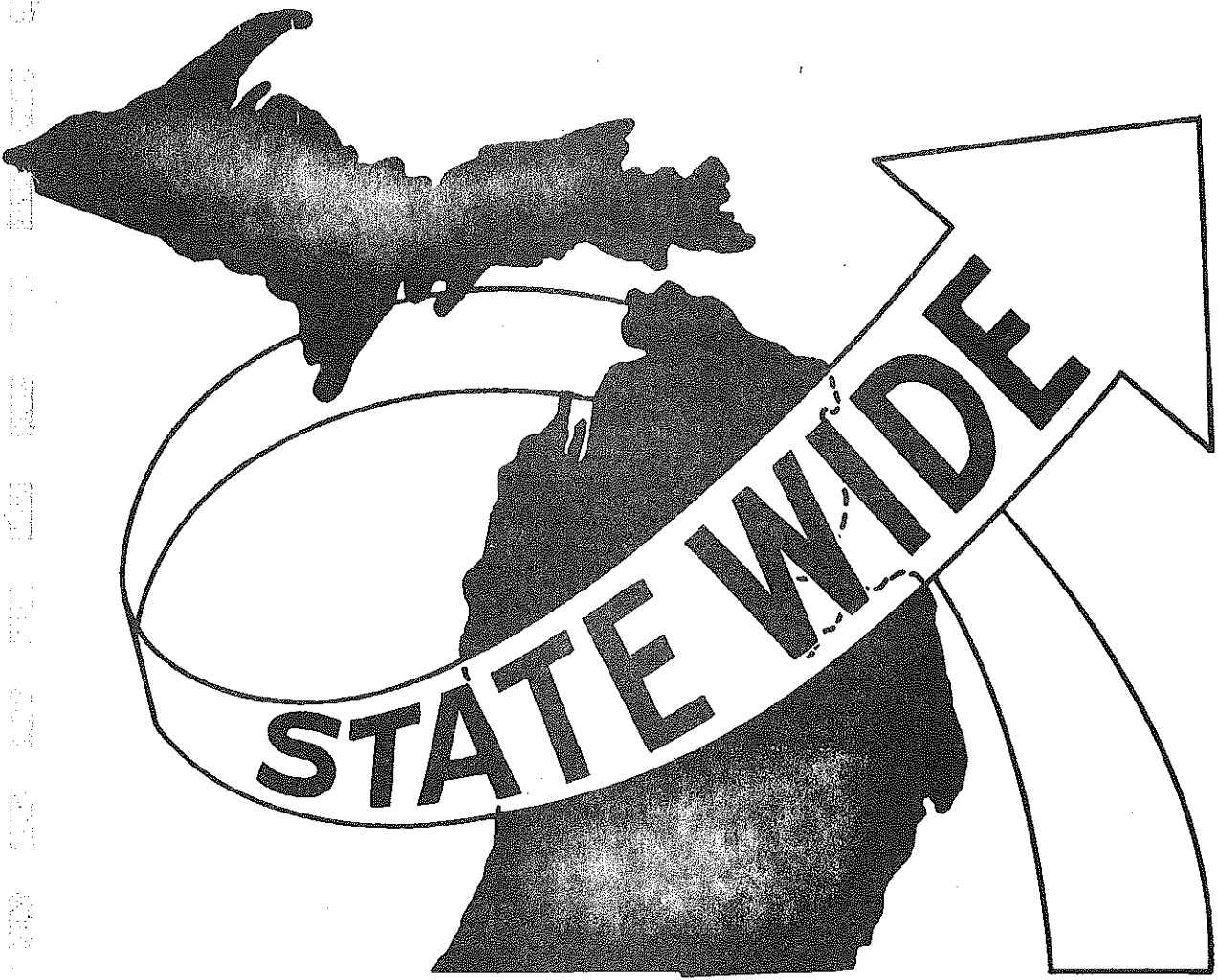
STATE WIDE

PREFACE

This report details an initial refinement to the Design Hour Volume (DHV) model of the Michigan Statewide Transportation Modeling System. The existing DHV model predicts DHV percentage trends for future years based on a DHV percentage for the base year and a statistically determined curve of typical behavior of DHV over time. The refinement described in this report disrupts that smooth curve to sharply increase the DHV percent to parallel events observed in the real world.

Volume VII in the Statewide Series, <u>Design Hour Volume Model Development</u>, describes the original DHV modeling effort. This report is an appendix to that volume. The entire series is presented below.
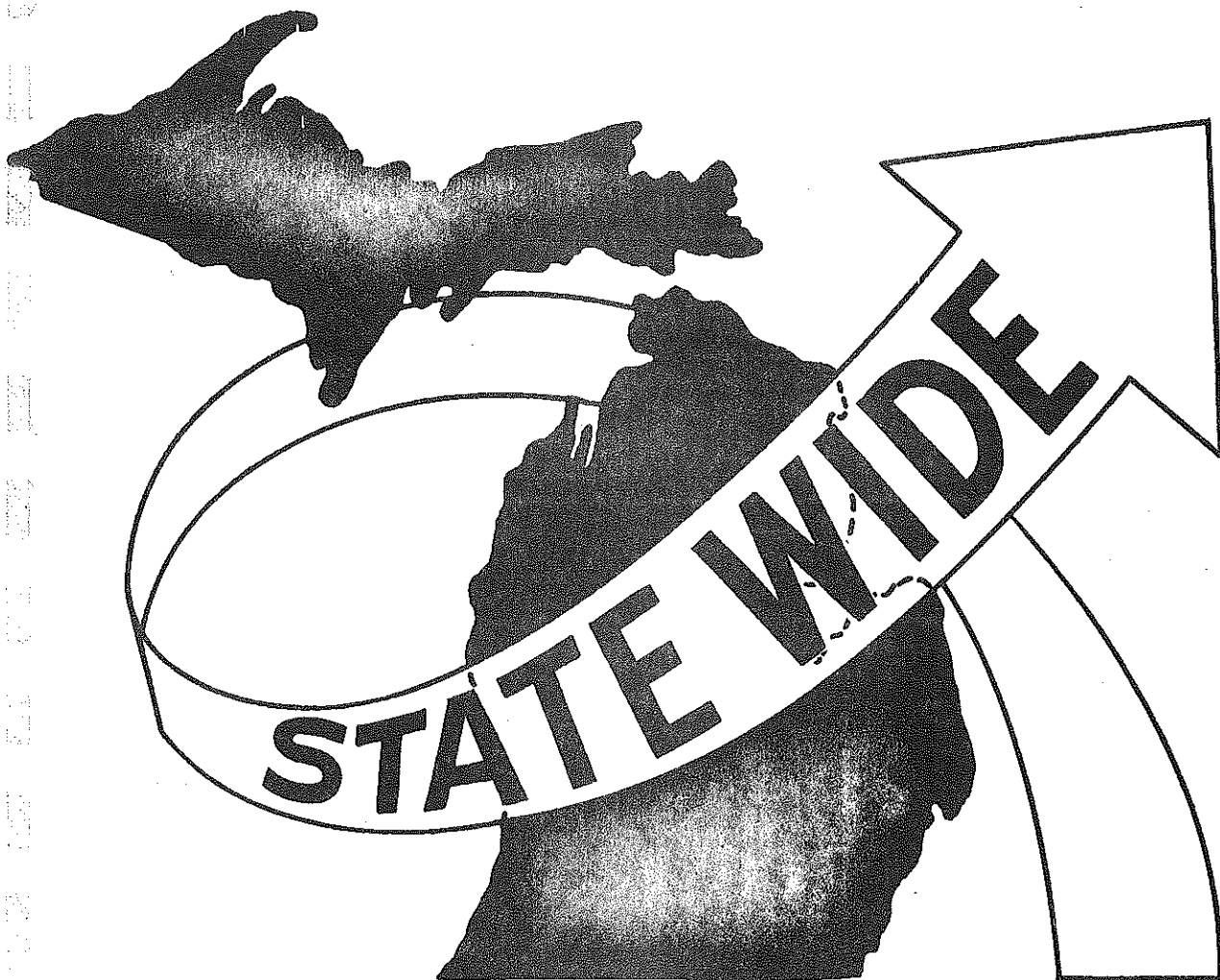
<u>STATEWIDE TRAVEL MODELING SERIES</u>

STATEWIDE TRAVEL MODELING SERIES CONTINUED

INTRODUCTION

INTRODUCTION

Design Hour Volume, or DHV, defined as the thirtieth highest hour of traffic volume in a year, is an important measure in the design of new highways. Typically a highway link is built to accommodate safely the design hour volume of traffic. Thus it is necessary to be able to predict DHV for future years when doing long range modeling and planning of highways.

As noted in Statewide Report Volume VII, Design Hour Volume Model Development, the DHV percent, defined as the percentage value of the ratio of DHV to Average Daily Traffic (ADT), generally decreases over time. The general trend developed for the DHV model is plotted in Figure 1; this general trend correlated highly with observed data, except for certain noticeable fluctuations. Such fluctuations, which appear as sharp increases in DHV percent, were attributed to two factors:

(1) major highway construction which greatly improves accessibility; or

(2) opening of major statewide or regional recreational attractors.

An example is provided by the opening of the Mackinac Bridge in June 1958. Traffic counts taken at Permanent Traffic Recorders permit yearly calculation of DHV and ADT for selected locations. Figure 2 shows eight PTR stations, whose graphs of DHV as a percent of ADT are shown in Figure 3. The group of stations in Figure 3-A are close and directly lead to the bridge; the DHV percents increased from 3.6% to 6.4% for the station on I-75 at St. Ignace. The group of stations in Figure 3-B were further away from the bridge, yet still exhibted increases
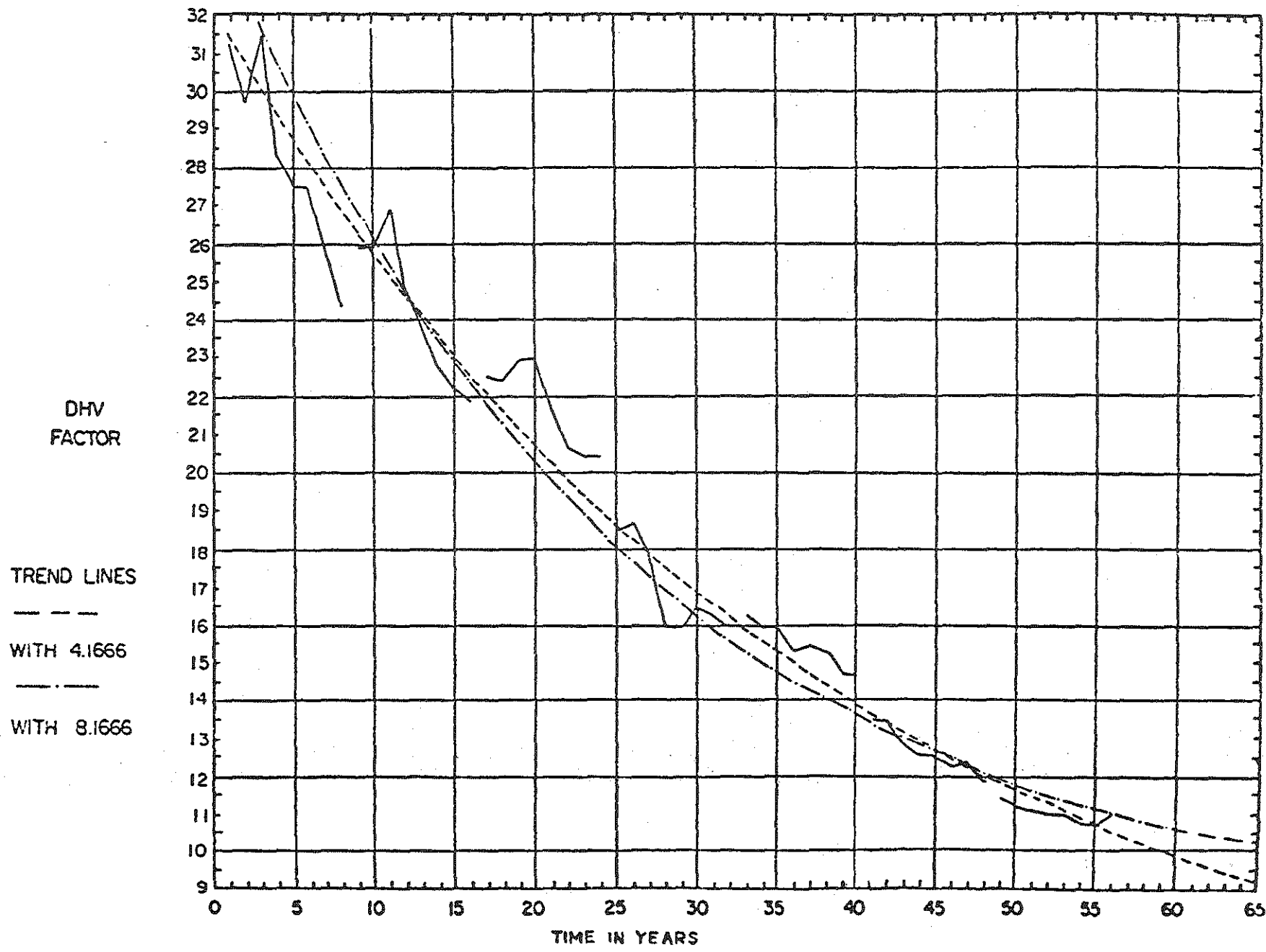
FIGURE 1:   GENERAL TREND IN DHV FACTOR AT CONSTANT DECREASING RATE

CONTINUOUS AUTOMATIC TRAFFIC RECORDER STATIONS
STATEWIDE TRAFFIC SURVEY

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
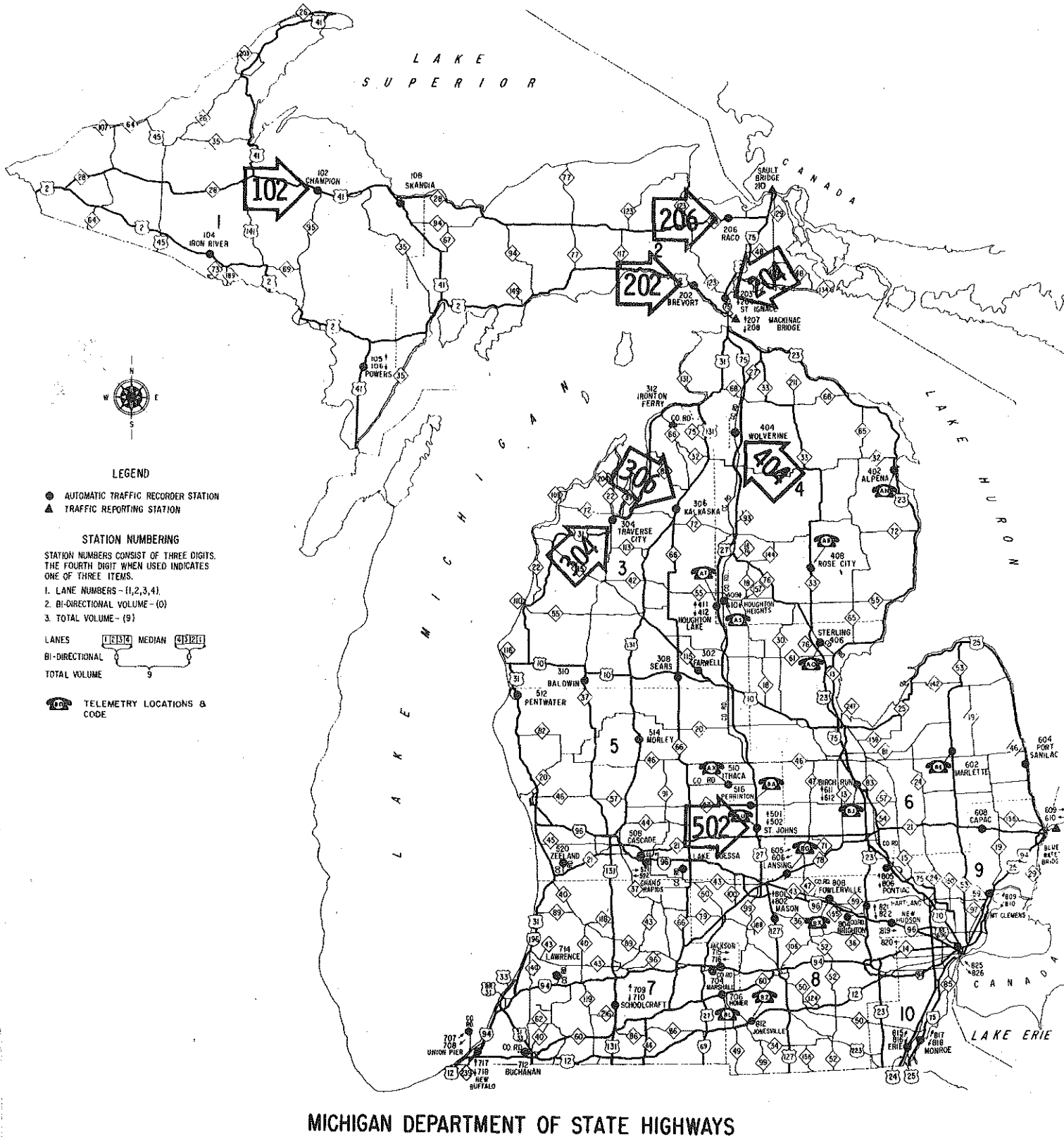
FIGURE 2:   PERMANENT TRAFFIC RECORDING STATIONS

Mackinac Bridge opened to public
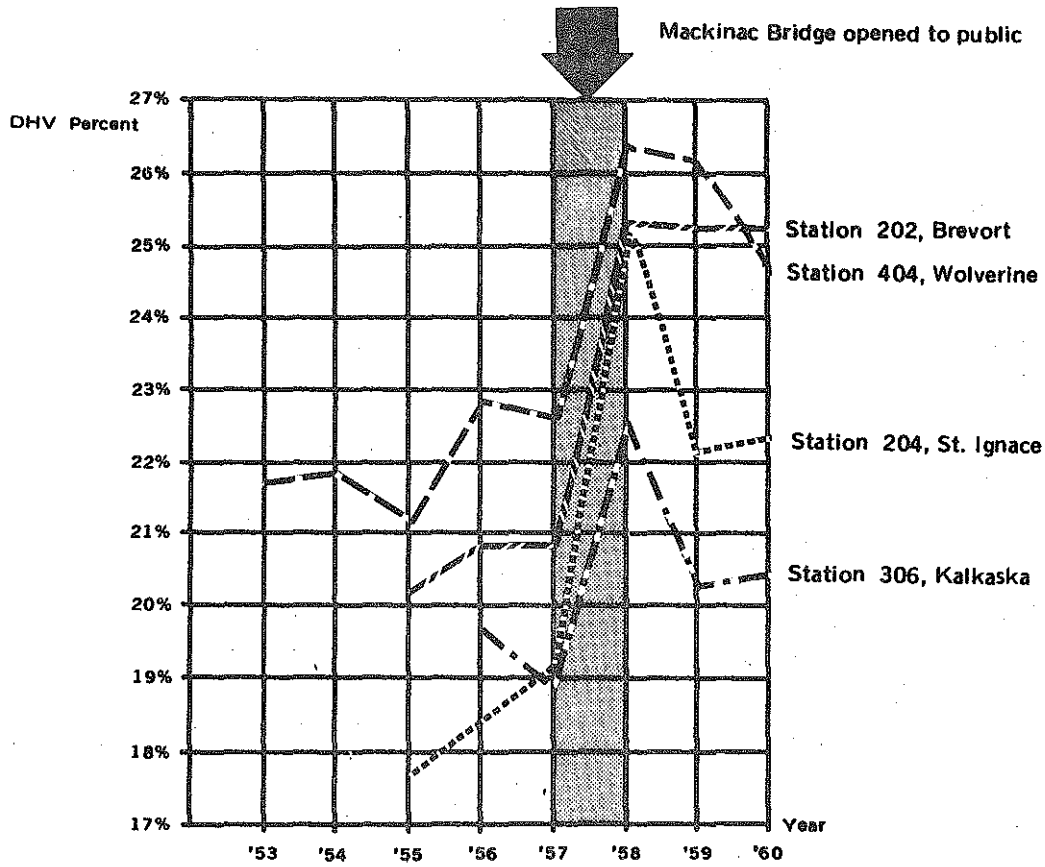
Figure 3-A: Large increases

Station 202, Brevort
Station 404, Wolverine
Station 204, St. Ignace
Station 306, Kalkaska
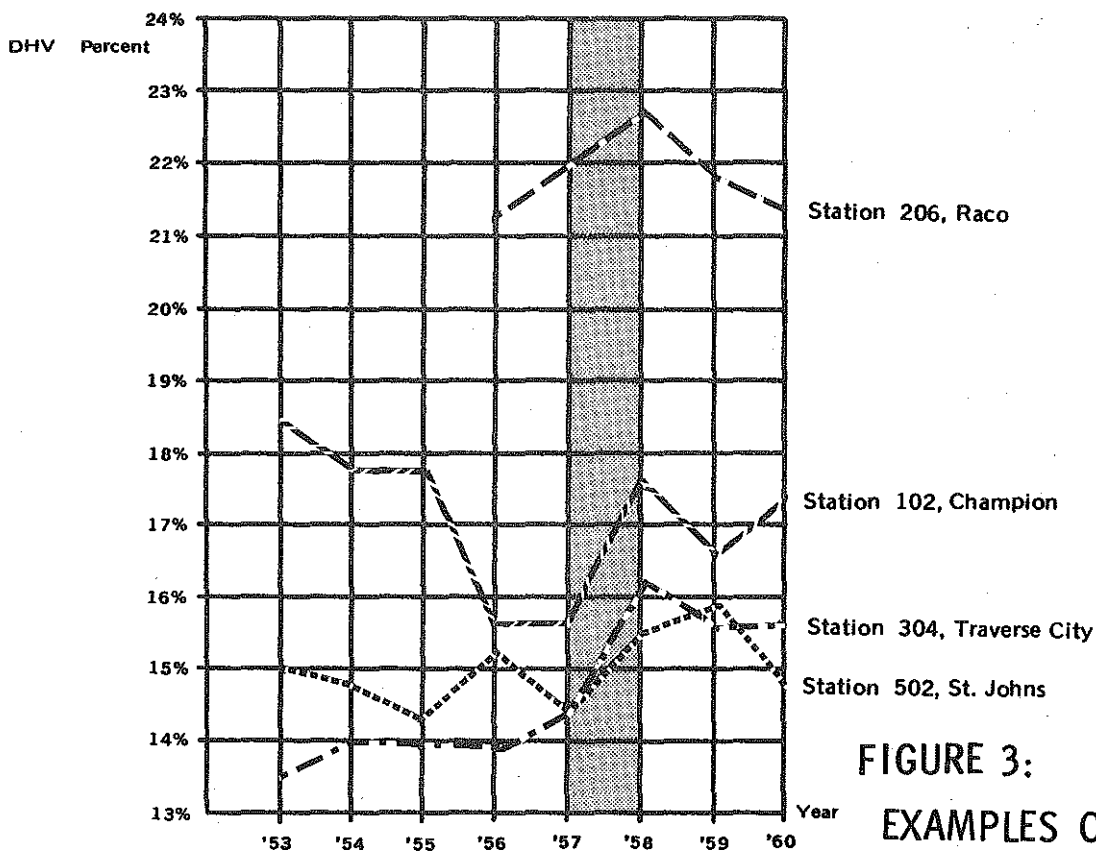
Figure 3-B: Moderate increases

Station 206, Raco
Station 102, Champion
Station 304, Traverse City
Station 502, St. Johns

FIGURE 3:

EXAMPLES OF INCREASES

IN DHV PERCENT

in DHV percent of 1% to 2%. Other stations in the state exhibited declines or small increases not obviously attributable to the bridge opening.

The following sections detail the development, operation, and application of the current effort to model sharp increases in DHV percent when significant construction or recreational projects are opened for public use.

SYSTEM DEVELOPMENT

STATE WIDE
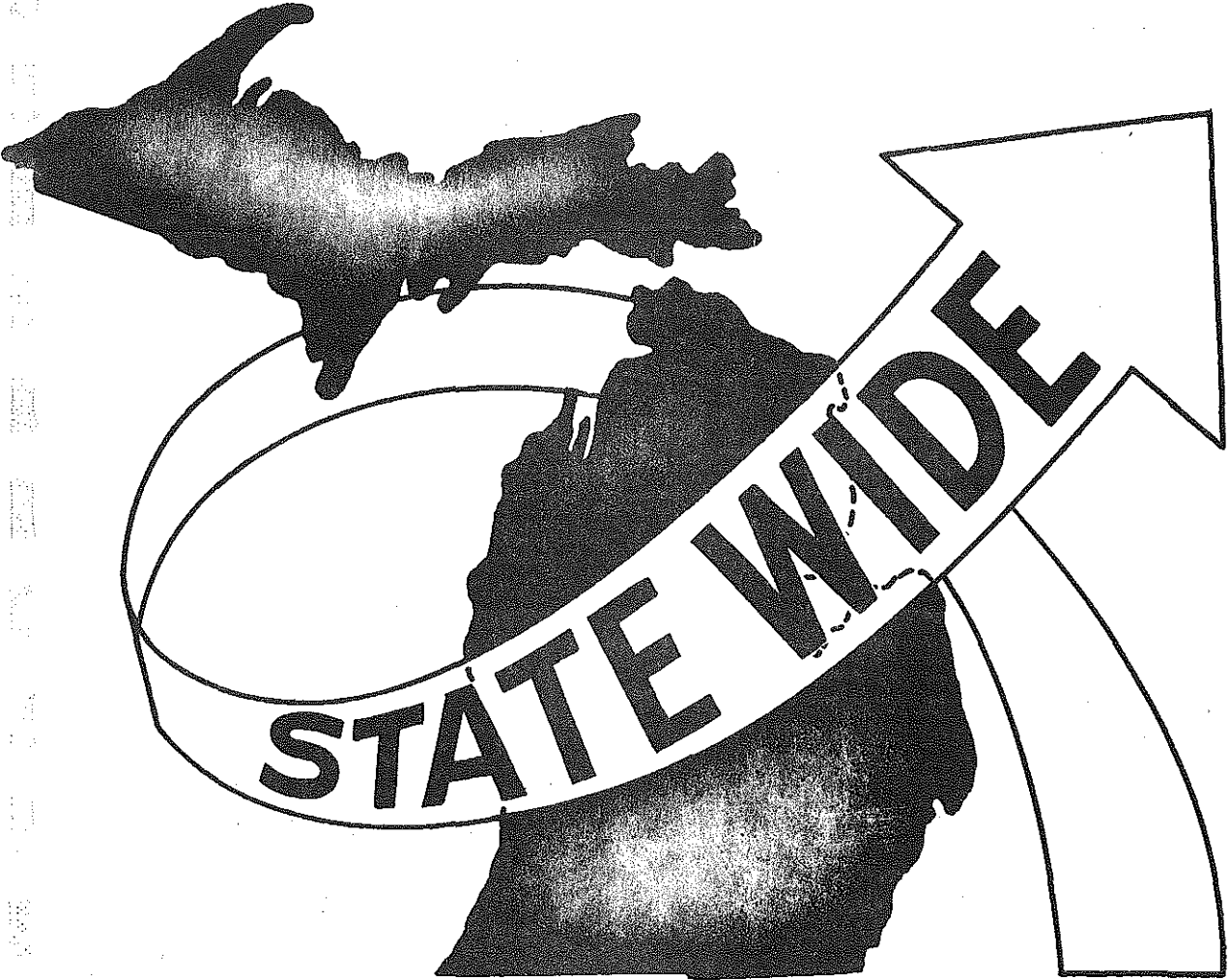
SYSTEM DEVELOPMENT

When considering how to model the inconsistent behavior described in the introduction, two questions presented themselves: (1) on the basis of what characteristics would a link's DHV be increased and (2) by what schedule or curve would increases occur?

THE LINK CHARACTERISTIC

When examining the map of the PTR stations in Figure 2, several factors appear which could have been statistically correlated with the increase in the DHV percent, e.g. distance from the bridge, directness of path to the bridge, or absence of other factors which may have diluted the influence of the bridge opening. In an intuitive sense however, one single factor, already a part of the model, implicitly considers those other factors, viz. the trip assignments that are made by the model's trip generation and distribution component.

Given a selected zone or a selected link, it is possible with existing programs to determine, for every link in the network, the number of trips which end or begin in the selected zone or which pass through the selected link. The ratio, for each link, of the number of such selected trips to the total number of trips on the link provides a good relative measure of the influence of the selected zone or link. Figure 4 graphically illustrates this procedure for a selected link.
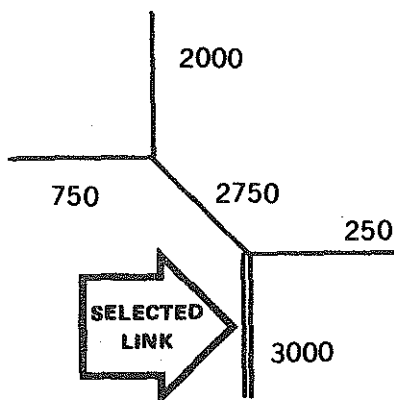
Figure 4-A:
Partial loads due to trips
through selected link
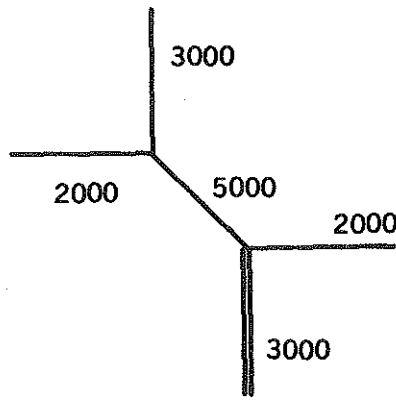
Figure 4-B:
Total trips on links
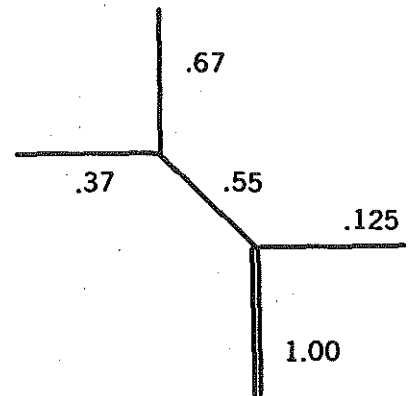
Figure 4-C:
Ratio of A to B, providing measure
of influence of selected link

FIGURE 4:
DETERMINING THE LINK CHARACTERISTIC

THE SCHEDULE OF INCREASES

A schedule of increases, unlike the measures of link characteristic,

cannot be straightforwardly stripped off existing network information.

Instead the schedule required a new component to the Statewide Trans-

portation Modeling System. Since this effort is a benchmark in DHV

modeling, no data existed as to what shape of curve--linear, concave, or

convex--would most accurately model the reality of DHV increases.

A simple approach was deemed advisable, rather than a complex

statistical analysis, due to several factors:

(1) Lack of hard data of documented DHV increases due to major

facility openings;

(2) the initial approach is a learning process, not a finished product; and

(3) the DHV model to which the routine is an input is itself a simplistic process.

Accordingly the initial DHV increase program assigns increases in DHV percent according to a simple step function, of which the step endpoints are user selected. For maximum flexibility, the program has options for internal step functions approximating concave, linear, and convex curves, and for user input of step endpoints to create any four-step function. An example is provided in Figure 5 using the increase routine's internal "curve #2," approximating a linear schedule of increases for the ratios from Figure 4.
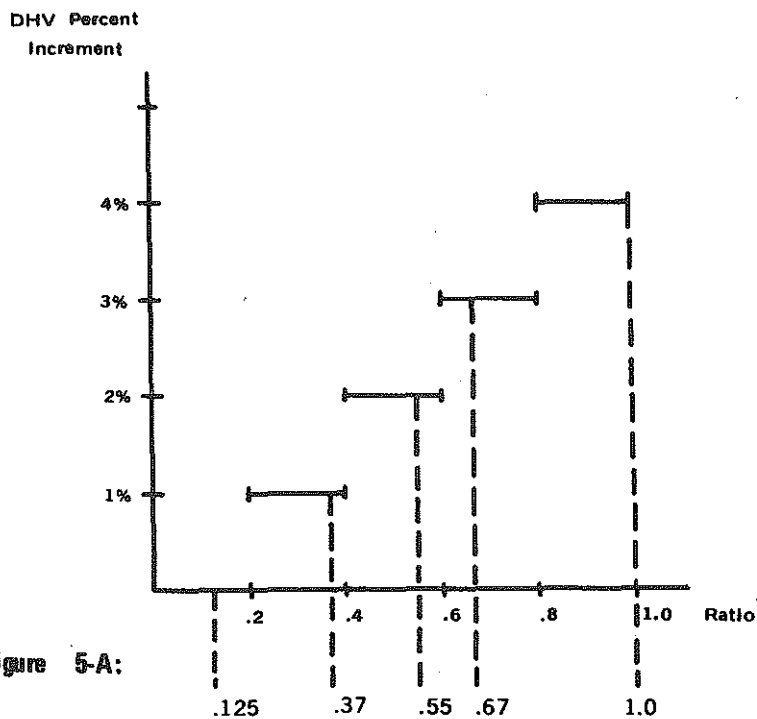
Figure 5-A:

Plot of "curve 2" with ratios from Figure 4-C
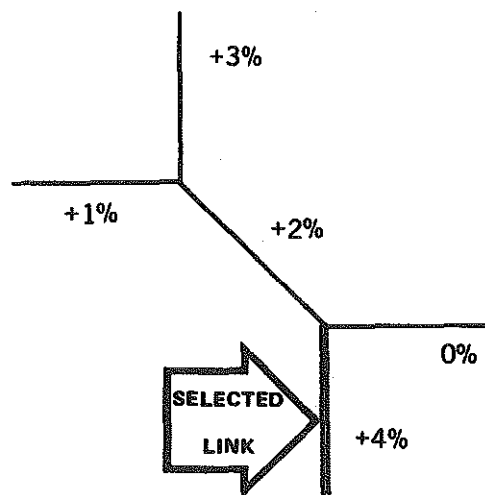
Figure 5-B:

Increments in DHV assigned due to influence of selected link

FIGURE 5: DETERMINING THE DHV INCREMENT

MODELING DHV INCREASES

These two steps, calculating the ratio of trips due to a selected link or zone and applying that ratio to a schedule of increases, comprise the DHV increase routine. The procedure, within the larger Statewide Modeling process, is illustrated in Figure 6, in a simple flowchart. Note the component structure of the process which allows for piecewise refinement as data or theory of DHV behavior expands.

More explicit flow charts are provided in the following section on program operation.

```
┌─────────────────────────────┐
│  BASIC STATEWIDE ALTERNATE  │
│  MODELING PROCESS THROUGH   │
│  CREATION OF NETWORK FILE   │
└─────────────────────────────┘

┌─────────────────────────────┐
│  GENERATE NETWORK WITH      │
│  SELECTED LINK OR ZONE      │
│         LOADINGS            │
└─────────────────────────────┘

┌─────────────────────────────┐
│  CALCULATE DHV INCREMENT    │
│    FOR AFFECTED LINKS       │
└─────────────────────────────┘

┌─────────────────────────────┐      ┌──────────────────┐
│  INPUT INCREMENTED DHV      │      │    PLOT FOR      │
│  PERCENT TO CALCULATE       │─────▶│  INTERMEDIATE   │
│  FUTURE YEAR DHV PERCENT    │      │     REVIEW      │
└─────────────────────────────┘      └──────────────────┘

┌─────────────────────────────┐
│ CONTINUE STATEWIDE ALTERNATE│
│       MODELING PROCESS      │
└─────────────────────────────┘
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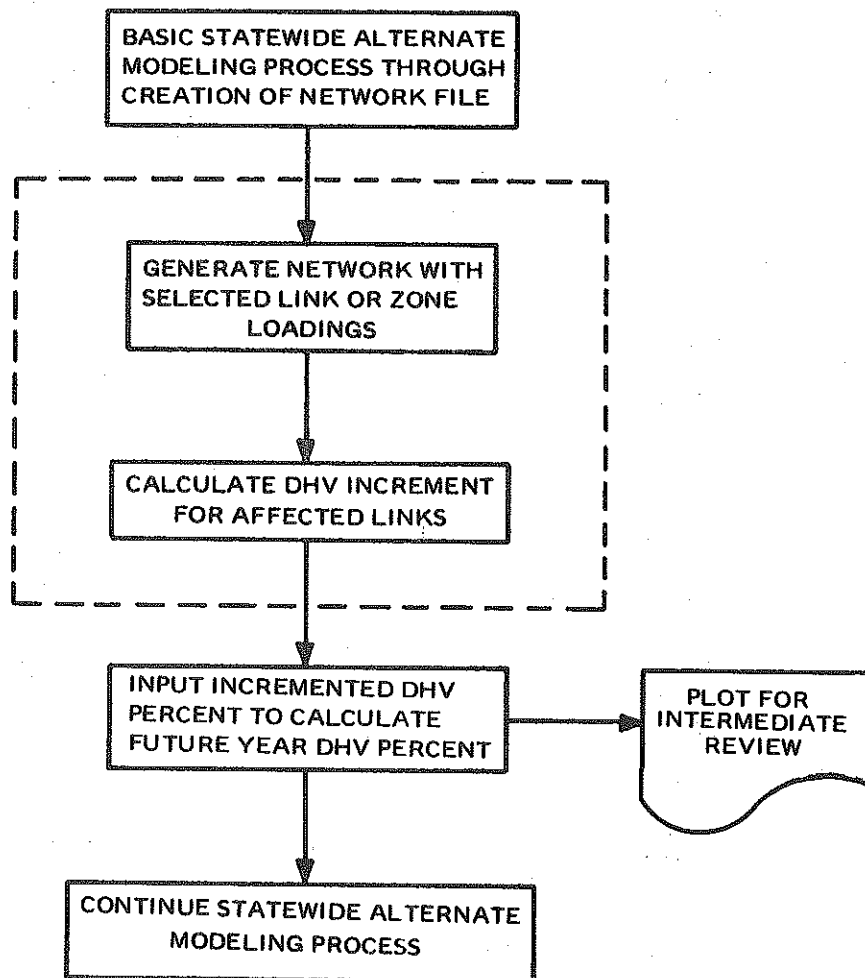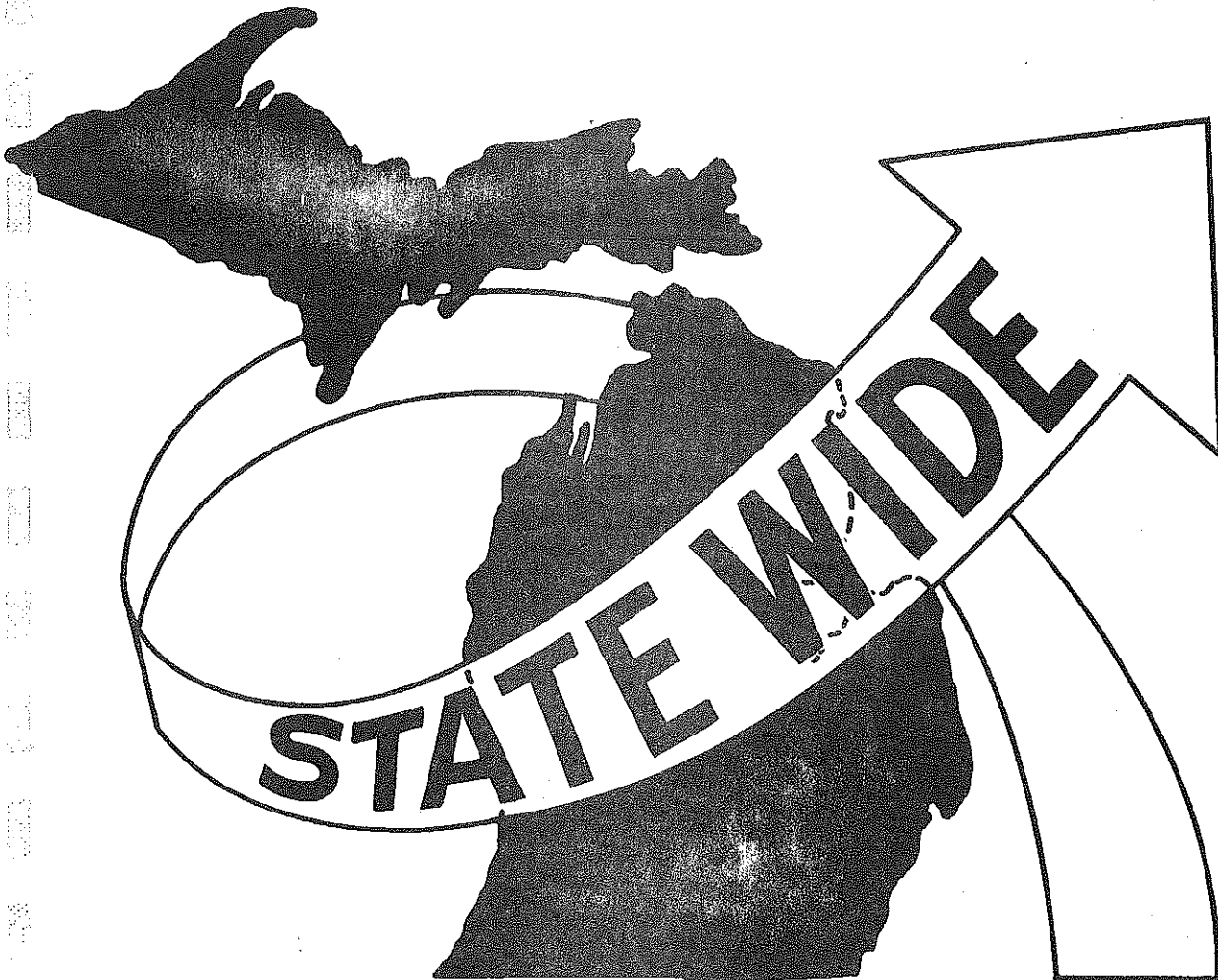
FIGURE 6:   GENERALIZED FLOWCHART OF DHV INCREMENT
MODELING PROCESS

SYSTEM OPERATION

STATE WIDE

SYSTEM OPERATION

As described previously, the DHV increase routine has two components:
(1) the creation of a network with partial loads due either to a selected
zone or a selected link and (2) calculation of ratios and the DHV
increases corresponding to the ratios. This section details the operation
of these two components.

This section assumes some knowledge of transportation modeling
terminology: A total trip table is a matrix of the number of trips
occurring between all pairs of zones. A network tree is a file of the
shortest time paths from a zone to all other zones. A loaded network
contains the trips from the trip table applied to the shortest travel
paths, resulting in the total trips for each link. A network is packed
when it is stored in the computer in a very compressed form, i.e. with
more than one piece of information in a computer word. A volume field
is one of fifty areas in which historical and current information for
each link is stored in a network file. Pattern factor is a figure for
each link to resolve the difference between link trip data, which is
heavily influenced by June-July weekday vacation travel, and average
daily traffic. For more detailed explanation of these terms, the reader
is referred to Volume X-A, Statewide Travel Impact Analysis Procedures.

With an understanding of those terms, the reader is prepared to
understand the DHV increase program operation.

CREATING A NETWORK WITH PARTIAL LOADS

The procedure for creating a network with partial loads is illustrated
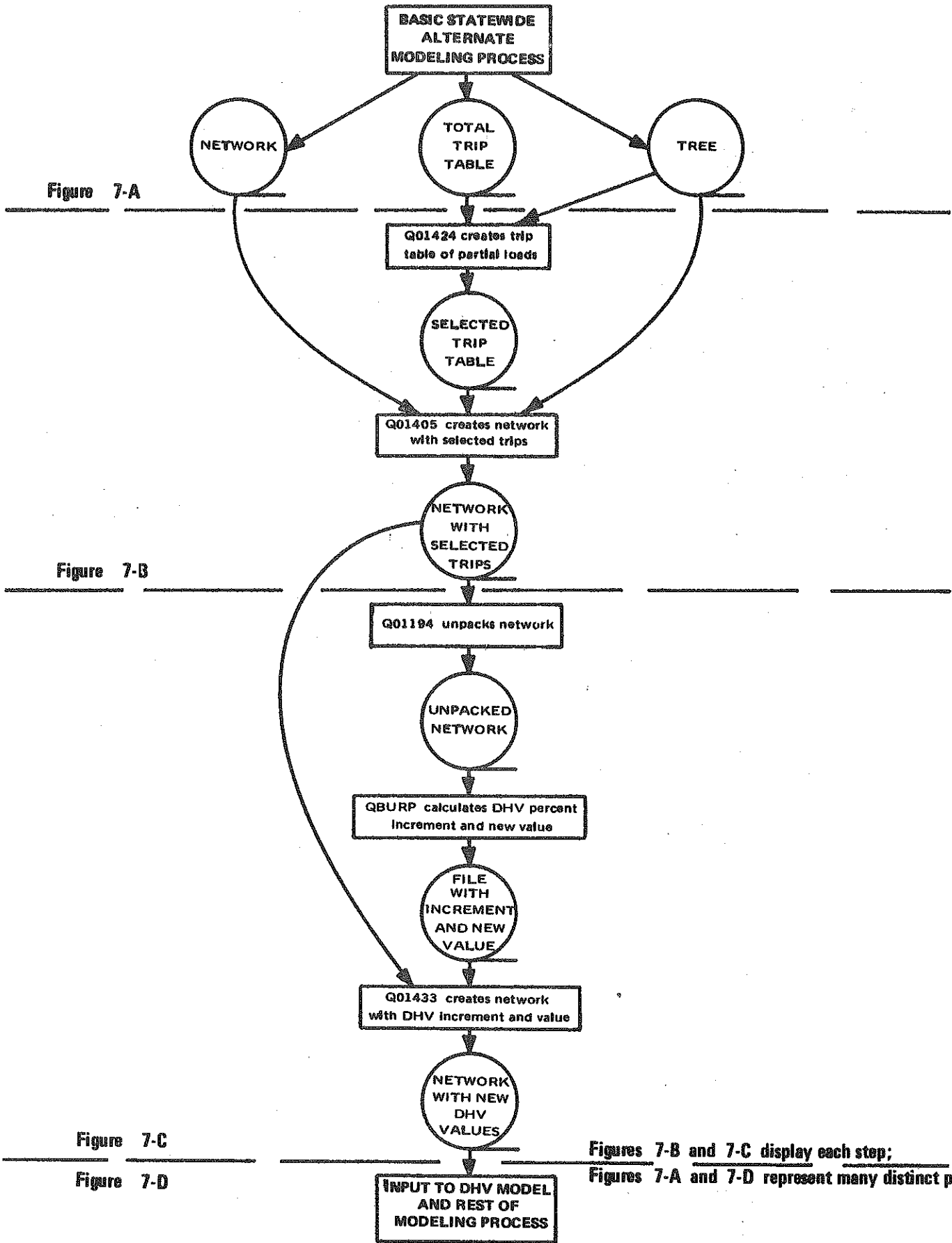in Figure 7-B. A total trip table and a network tree are input to

BASIC STATEWIDE
ALTERNATE
MODELING PROCESS

NETWORK

TOTAL
TRIP
TABLE

TREE

Figure 7-A

Q01424 creates trip
table of partial loads

SELECTED
TRIP
TABLE

Q01405 creates network
with selected trips

NETWORK
WITH
SELECTED
TRIPS

Figure 7-B

Q01194 unpacks network

UNPACKED
NETWORK

QBURP calculates DHV percent
increment and new value

FILE
WITH
INCREMENT
AND NEW
VALUE

Q01433 creates network
with DHV increment and value

NETWORK
WITH NEW
DHV
VALUES

Figure 7-C

Figures 7-B and 7-C display each step;

Figure 7-D

Figures 7-A and 7-D represent many distinct processe

INPUT TO DHV MODEL
AND REST OF
MODELING PROCESS

FIGURE 7: DETAILED FLOWCHART OF DHV INCREMENT
MODELING PROCESS

MDSH&T program QO1424. That routine, with the necessary parameter cards, creates a trip table of only those trips which pass through a selected link. For the selected zone case, the centroid link for that zone is input; the result will then be a trip table of only those trips which end or begin in the selected zone, since only those trips use the centroid link.

The table of selected trips, the network tree, and a loaded network are then input to program QO1405, which creates a network with the selected trips in a volume field.

CALCULATING DHV INCREASES

The procedure for calculating the ratios of selected trips to total trips and the corresponding increases in DHV is illustrated in Figure 7-C. The network with the selected trips is "unpacked" by program QO1194 so that it is in a form that is accessible to a FORTRAN program.

The unpacked network is then input to program QBURP (a program number has not yet been assigned). QBURP is the new component of the Statewide Transportation Modeling System, which calculates both the ratios and the increases. Inputs to QBURP are:

(1) volume field numbers on the network for:

pattern factor

existing DHV percent

total trips, either factored or unfactored

selected trips;

(2) the selected internal "curve" or the endpoints of a user-specified step function (the internal step functions are graphed in Figure 8);
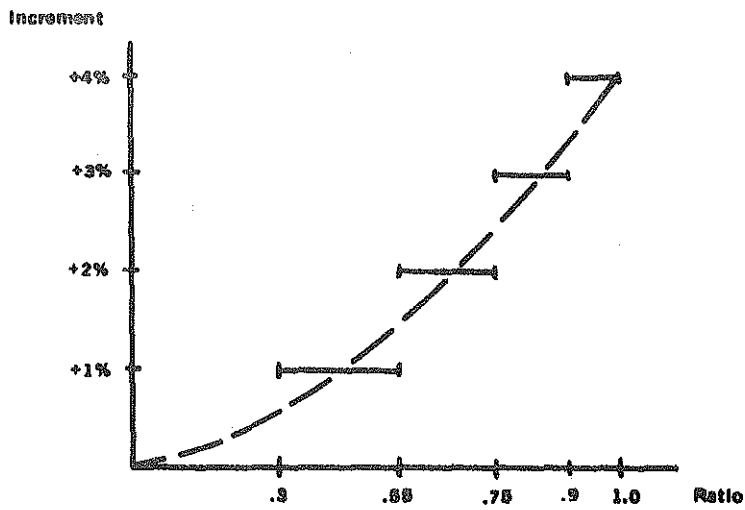
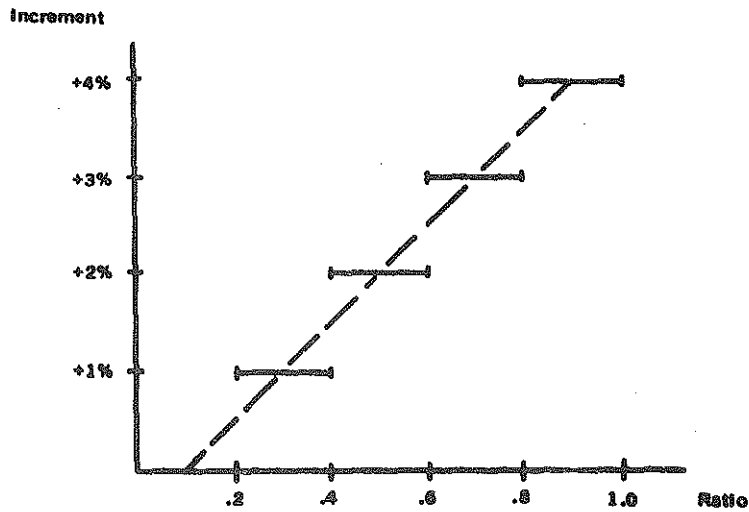Figure 8-A: "Curve 1" approximates concave schedule

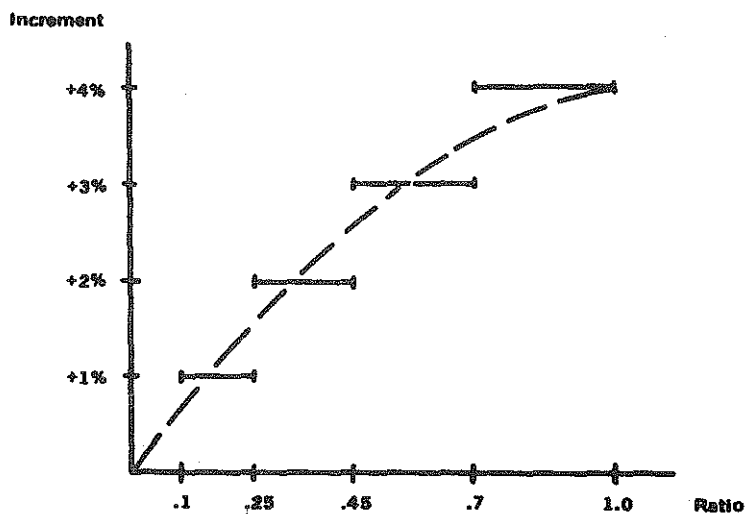Figure 8-B: "Curve 2" approximates linear schedule

Figure 8-C: "Curve 3" approximates convex schedule

FIGURE 8:

PLOTS OF RATIO OF SELECTED TRIPS TO INCREMENT OF DHV PERCENT

(3) a flag to inform QBURP whether total trips are factored or unfactored; and

(4) additional cards, which are the setup for the next routine.

QBURP outputs a file containing the DHV increment and a revised DHV percent value.

The output of QBURP is the setup for program Q01433. Q01433 adds QBURP's output to the loaded network, creating a network including the new DHV information. This step completes the DHV increase process; the network at this step is input to the rest of the Statewide alternate modeling process.

SYSTEM APPLICATION

STATE WIDE
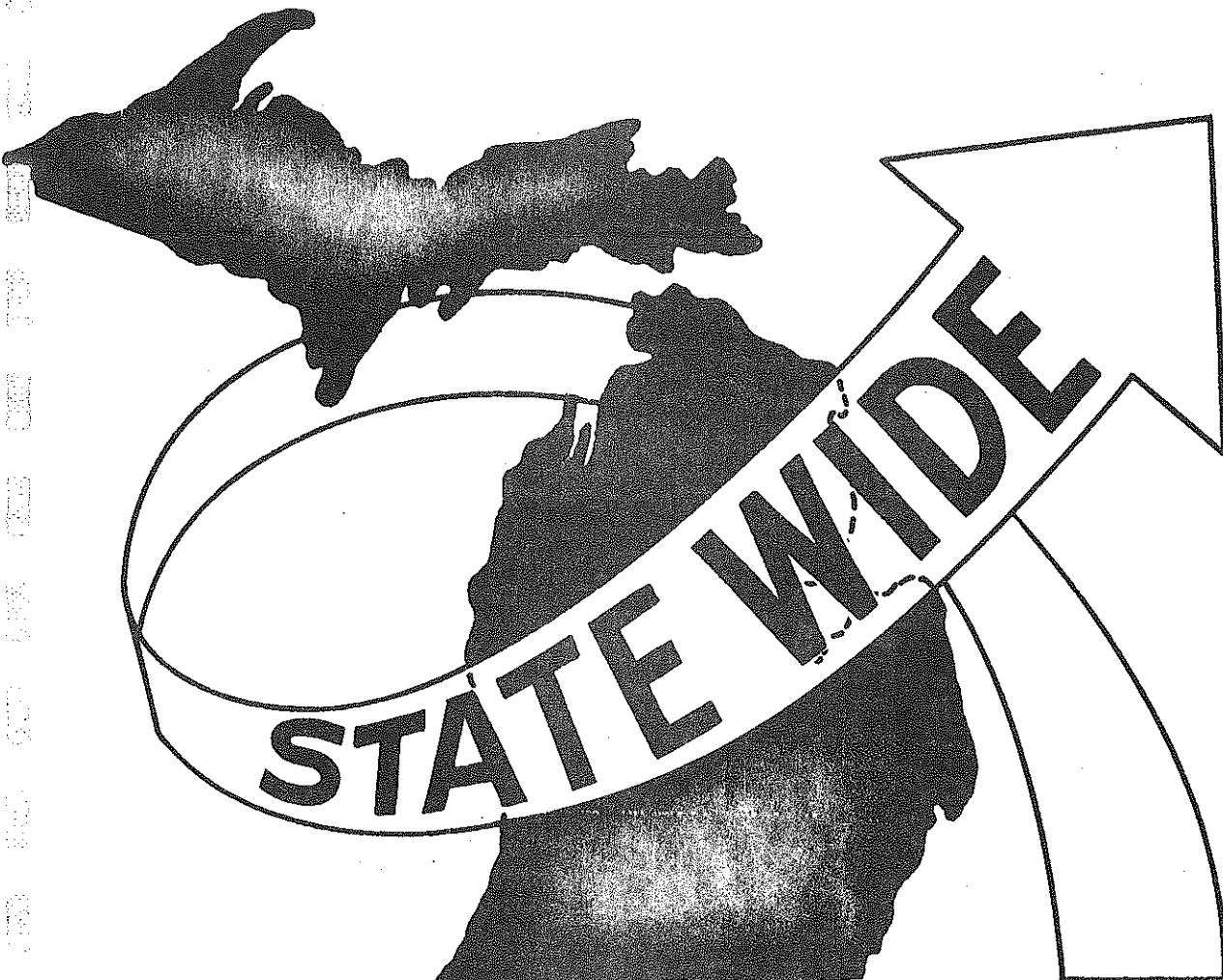
SYSTEM APPLICATION

For testing and demonstration purposes, the DHV increase routine
was run for a selected zone and a selected link. Figures 9-A through
9-F are bandwidth plots of the magnitude of the increase in DHV percent;
i.e. for a given link, each band along a link represents an increase of 1%.

The selected zone test, shown in Figures 9-A through 9-C for each
schedule of increases, simulates the effect of the opening of Sleeping
Bear National Park. Even with the convex curve, most of the effect is
on the roads in the immediate vicinity of the zone, the shaded area;
that is, for that selected zone, the effect is localized.

The selected link test, shown in Figures 9-D through 9-F, simulates
the effect of the opening of a major link of US-131 freeway. The effect
is much more visible, even with the concave curve. Using the convex
curve stretches the effect nearly from end to end of the State. Note,
however the effect heavy local traffic can have, that of diluting the
freeway's impact and causing apparent gaps of no DHV increase. Such
a gap shows up in Figures 9-D through 9-F, on the link immediately
below the selected link. The influence of the selected link is diluted
by the zone 508 centroid loading at the link's northern node. Aside
from such gaps however, the influence of the selected link generally
declines with distance.

A link informational plot can display the actual values of the
increment, the new DHV percent, and/or the new future year DHV (after
a run through the DHV model). Figure 10 is such a plot for the small
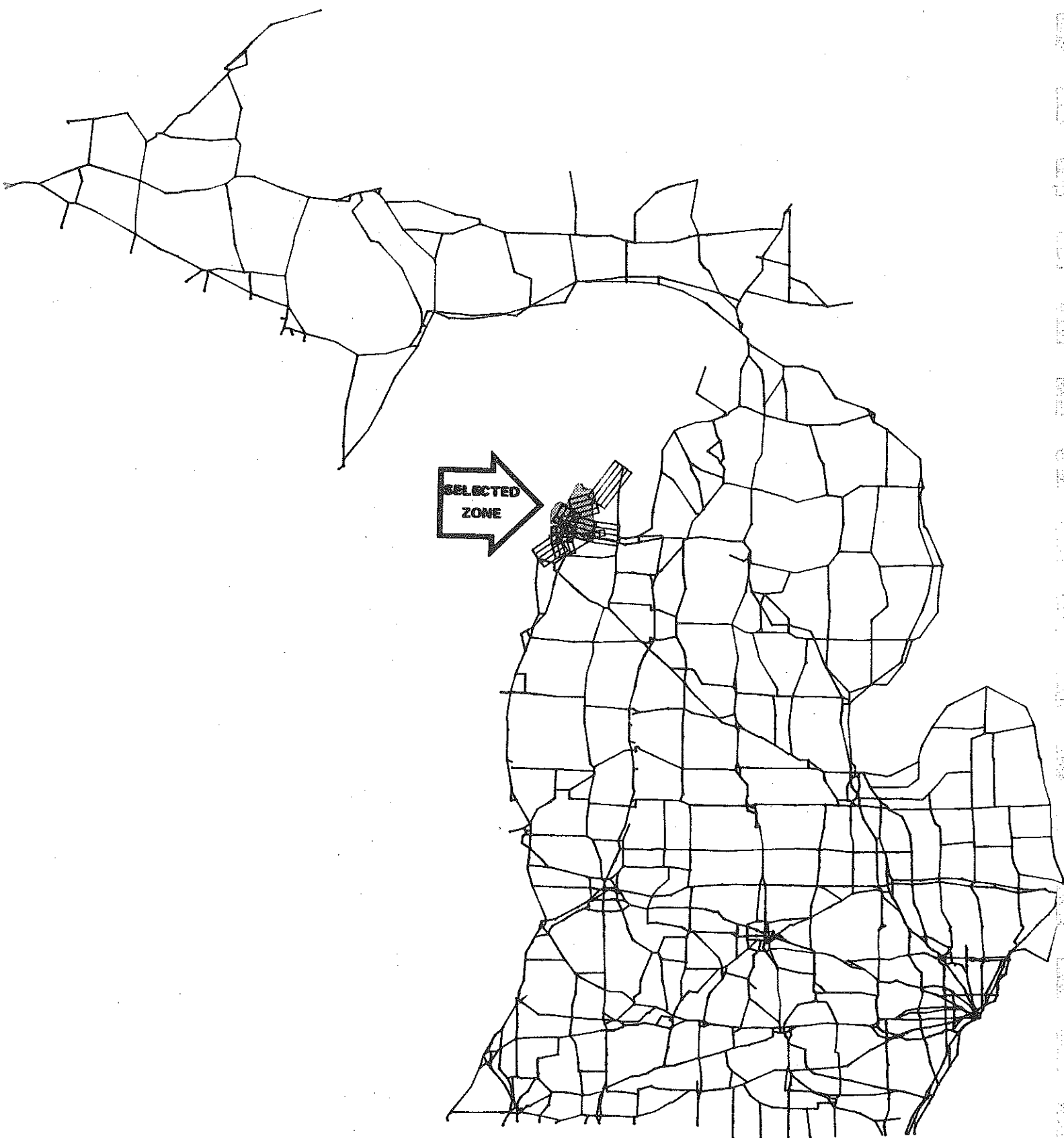area delineated on Figure 9-F.

FIGURE 9-A:

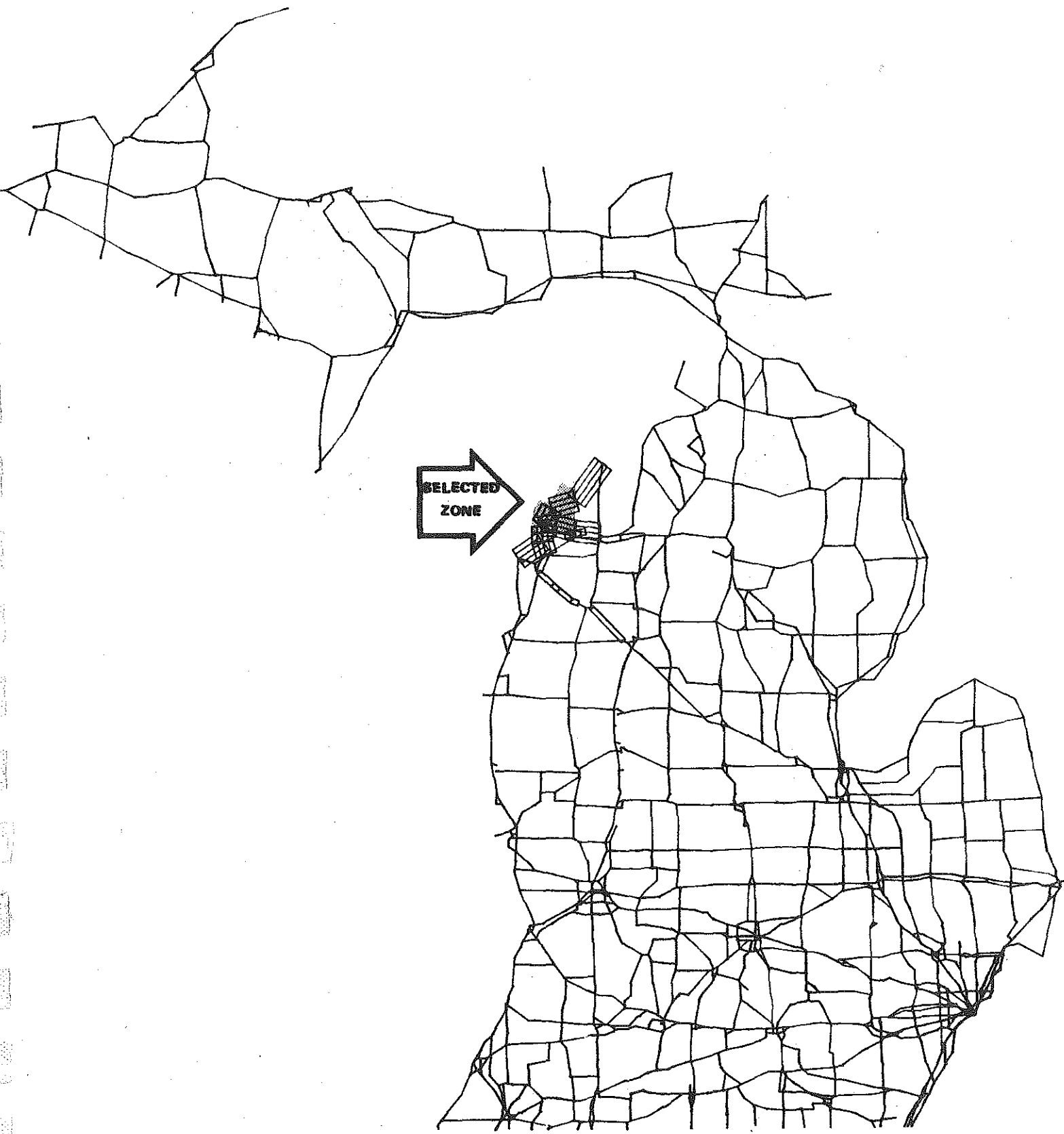DHV INCREMENTS FOR SELECTED ZONE TEST USING CURVE NO. 1

FIGURE 9-B:

DHV INCREMENTS FOR SELECTED ZONE TEST USING CURVE NO. 2
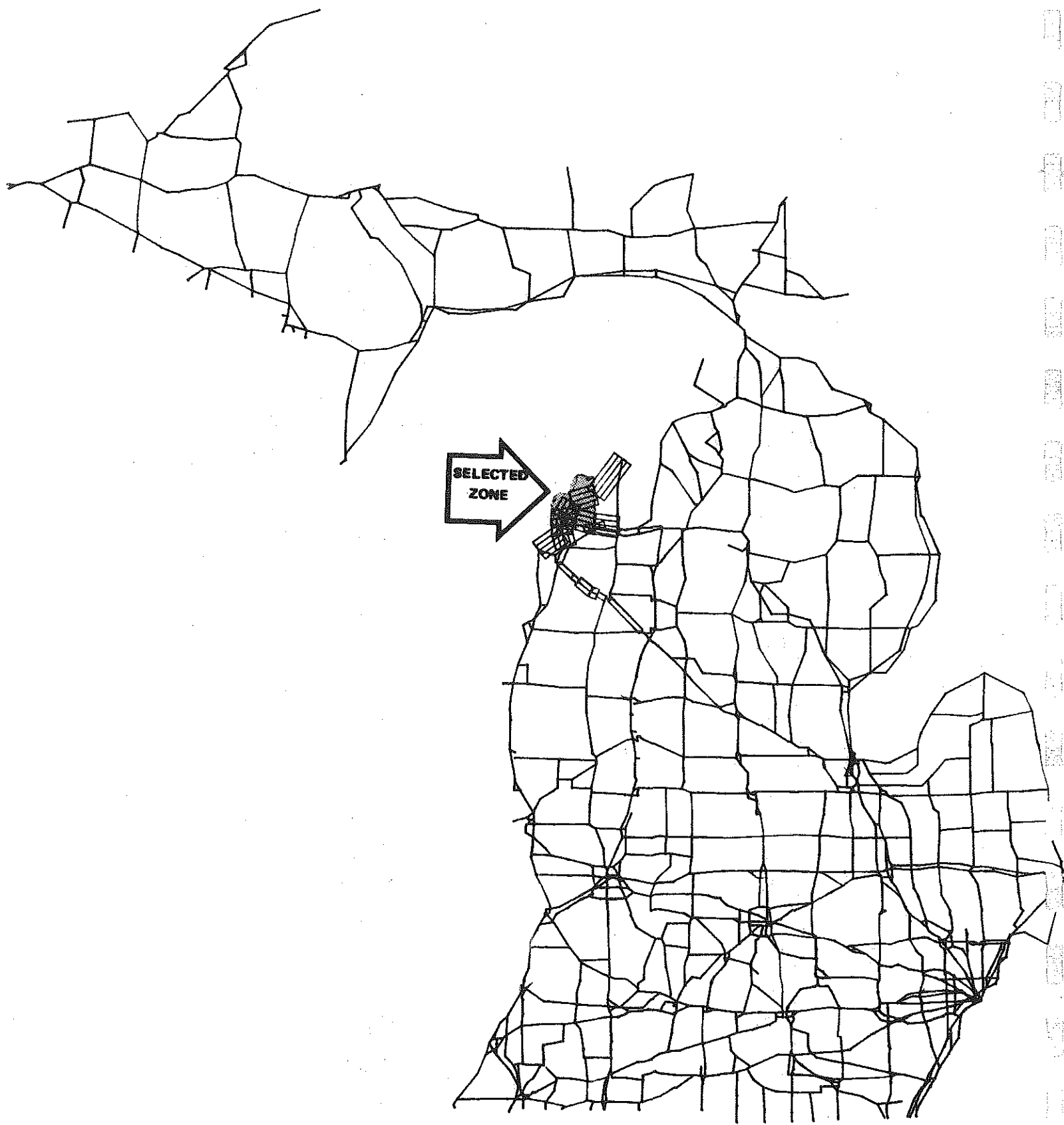
FIGURE 9-C:

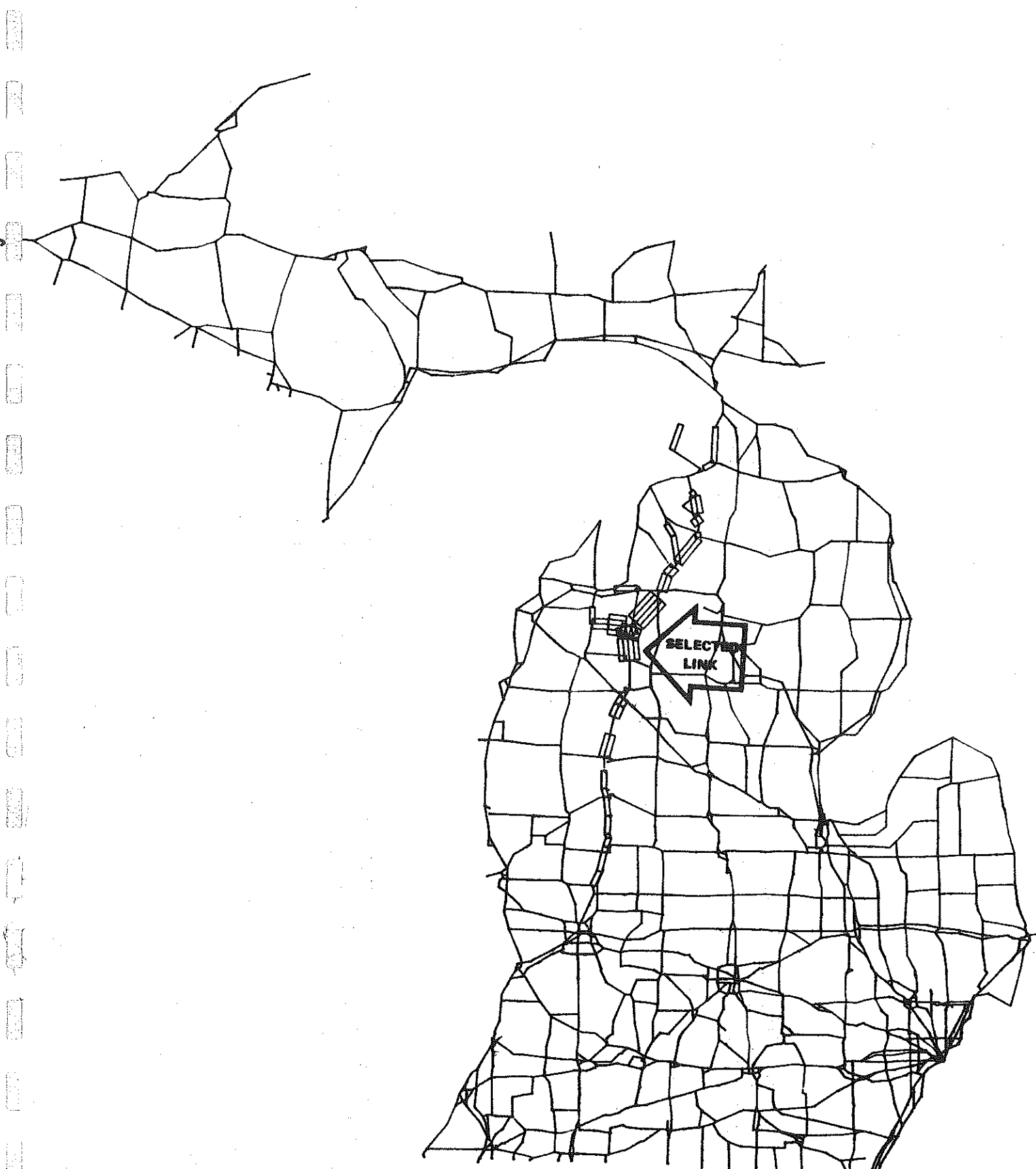DHV INCREMENTS FOR SELECTED ZONE TEST USING CURVE NO. 3

FIGURE 9-D:
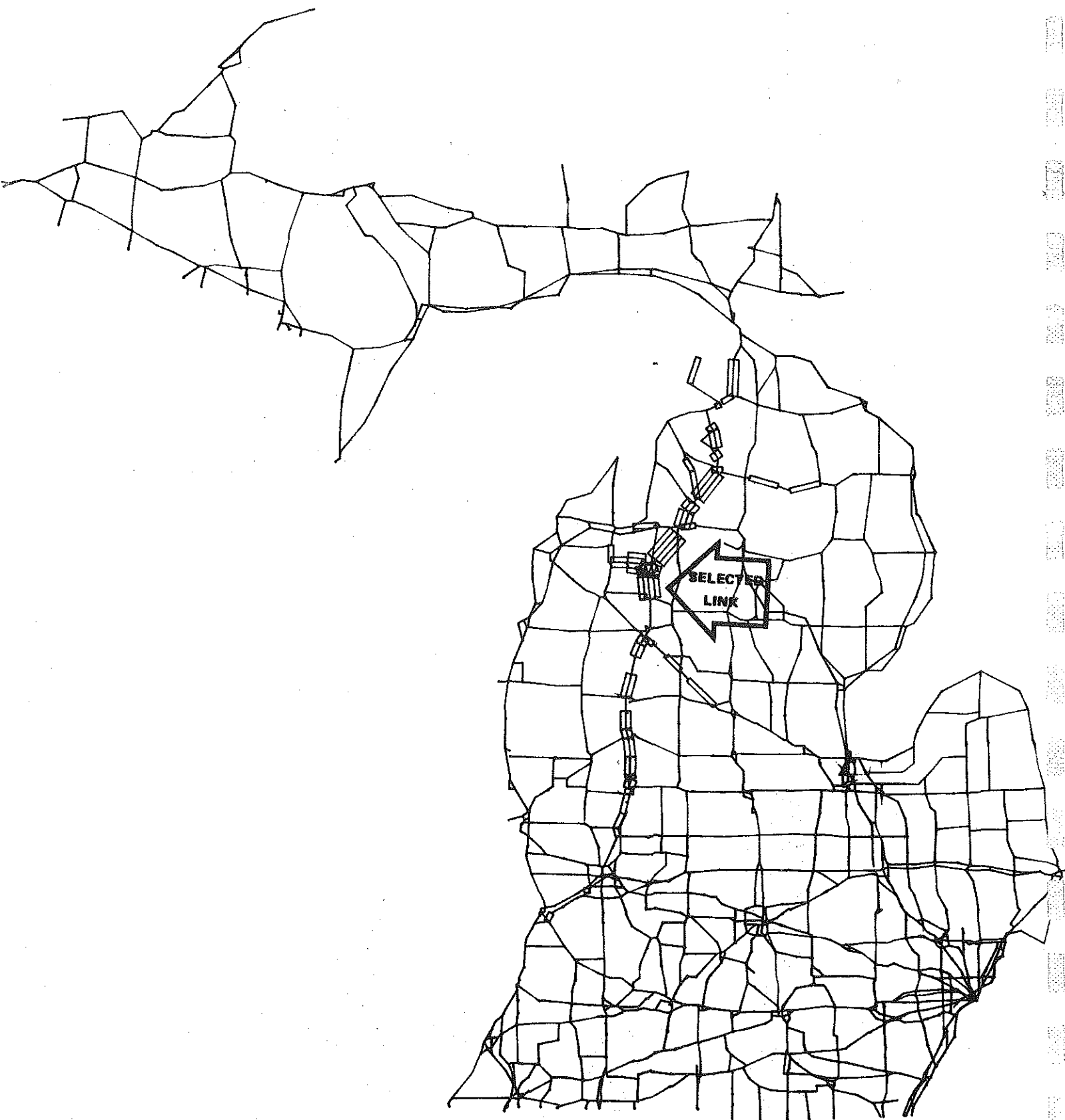
DHV INCREMENTS FOR SELECTED LINK TEST USING CURVE NO. 1

FIGURE 9-E:

DHV INCREMENTS FOR SELECTED LINK TEST USING CURVE NO. 2

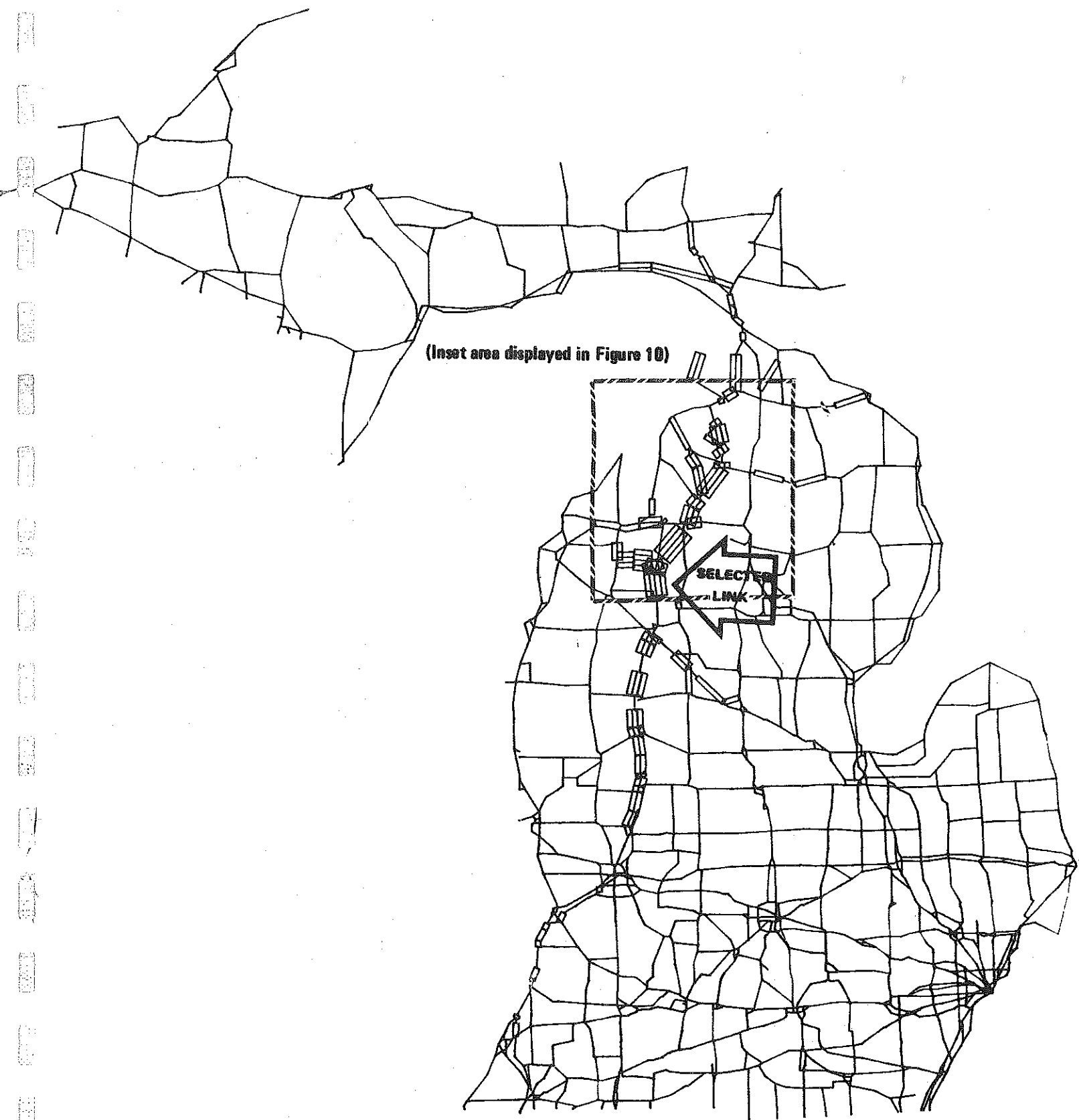(Inset area displayed in Figure 10)

SELECTED
LINK

FIGURE 9-F:

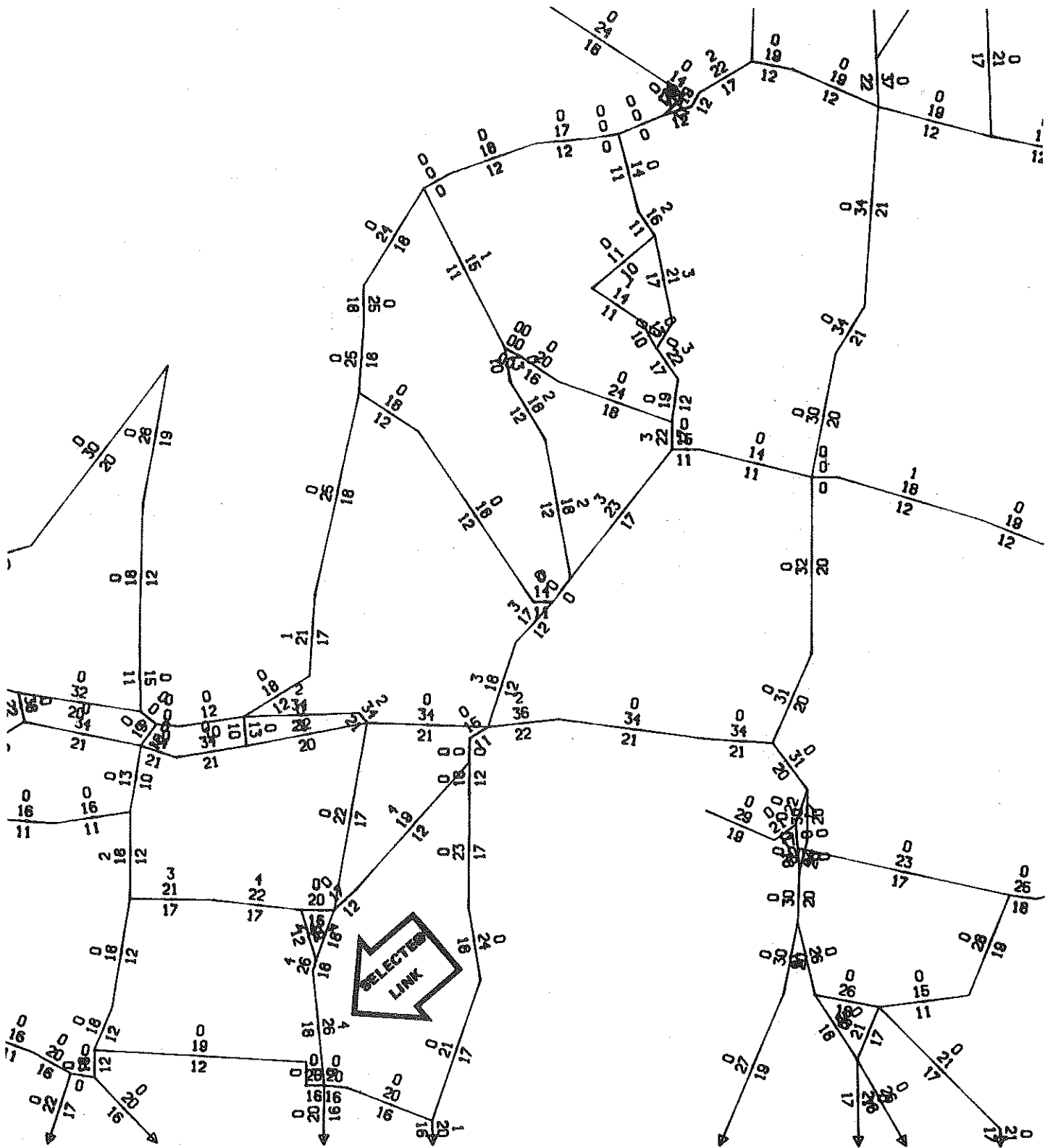DHV INCREMENTS FOR SELECTED LINK TEST USING CURVE NO. 3

FIGURE 10: INFORMATIONAL PLOT OF INSET OF FIGURE 9-F
SHOWING DHV PERCENT INCREMENT
REVISED DHV PERCENT
FUTURE YEAR DHV PERCENT

After program review, refinement, and acceptance, such plots of DHV increment would usually not be made except for intermediate review. Rather, the output of the DHV increase routine will be simply another step in the Statewide process of alternate transportation systems modeling. Currently such increases are added to transportation modeling process by the "eagle-eye" method, i.e. educated and experienced guesswork. Full acceptance and incorporation of the DHV increase routine into the Statewide Transportation Modeling System will permit consistent, systematic modeling of this important phenomenon for the first time.

SYSTEM EXTENSIONS
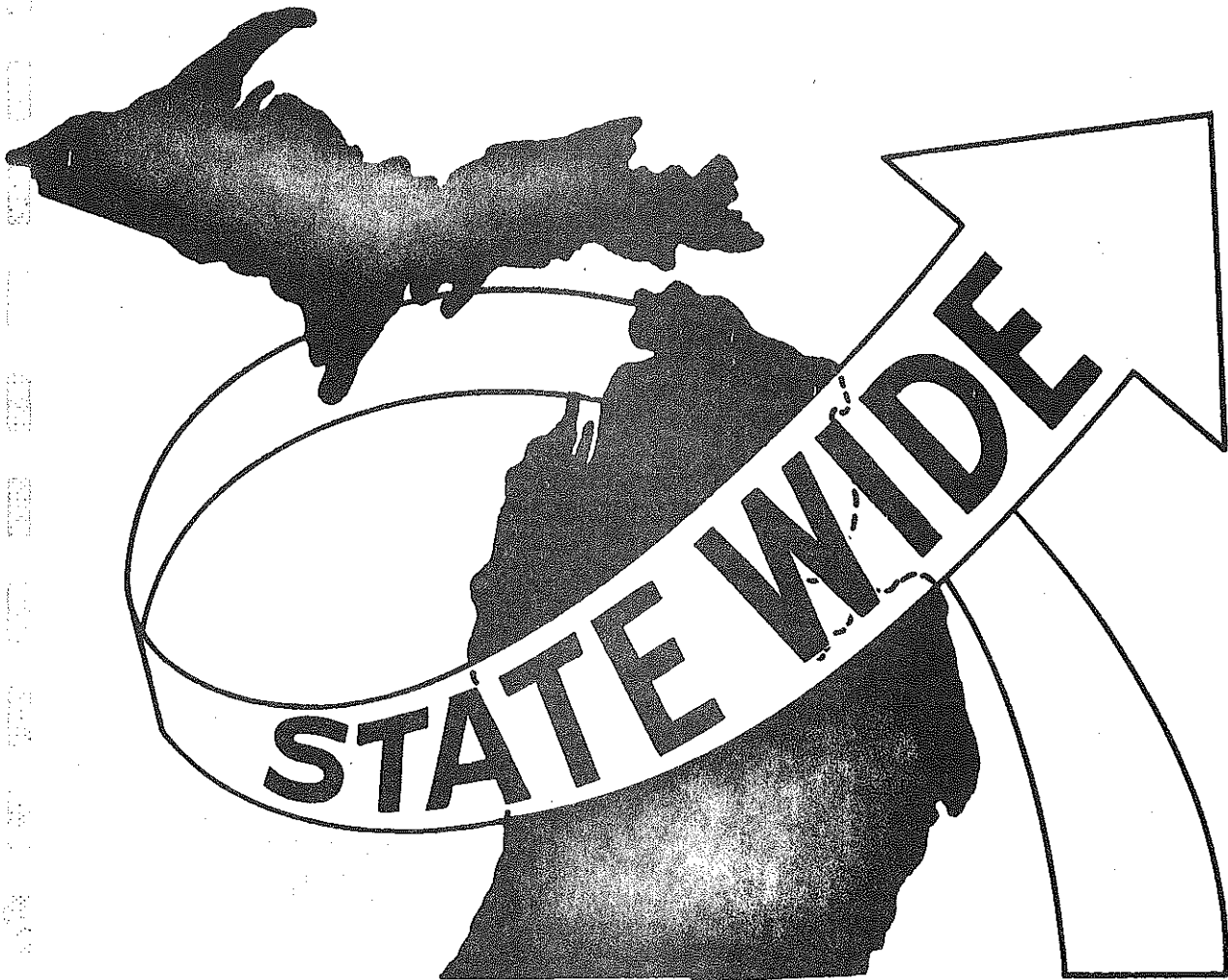
SYSTEM EXTENSIONS

Since the DHV increase routine is a simple, benchmark effort, there are refinements which conceivably could be made in the future. Such refinements may go hand in hand with improvements in the basic DHV model or may become apparent after further testing of the routine.

The schedule of increases in DHV is the most obvious area of potential refinement. Increased experience with the routine may indicate that a smooth curve is much more desirable than the step functions presently used. The shape of the curve which most accurately reflects realities may also become apparent. The size of potential increments may be expanded past the current maximum of 4% if testing and experience so indicate.

A more subtle refinement could occur in the measurement of the link characteristic. A factor may be necessary to scale ratios so that increases better approximate reality. Other factors besides trips may be taken into account.

Currently, the method for determining which zones or links may have an influence on system DHV's is still the "eagle-eye" method. As the total system becomes more refined and automated, a method of internally determining for which zones and links to assess DHV increases may be added to the system.

The goal of the modeling process is to simulate reality. Thus as knowledge and experience with DHV percents and sharp increases grow, the process which models those phenomena can be expected to be refined proportionately.

CONCLUSIONS
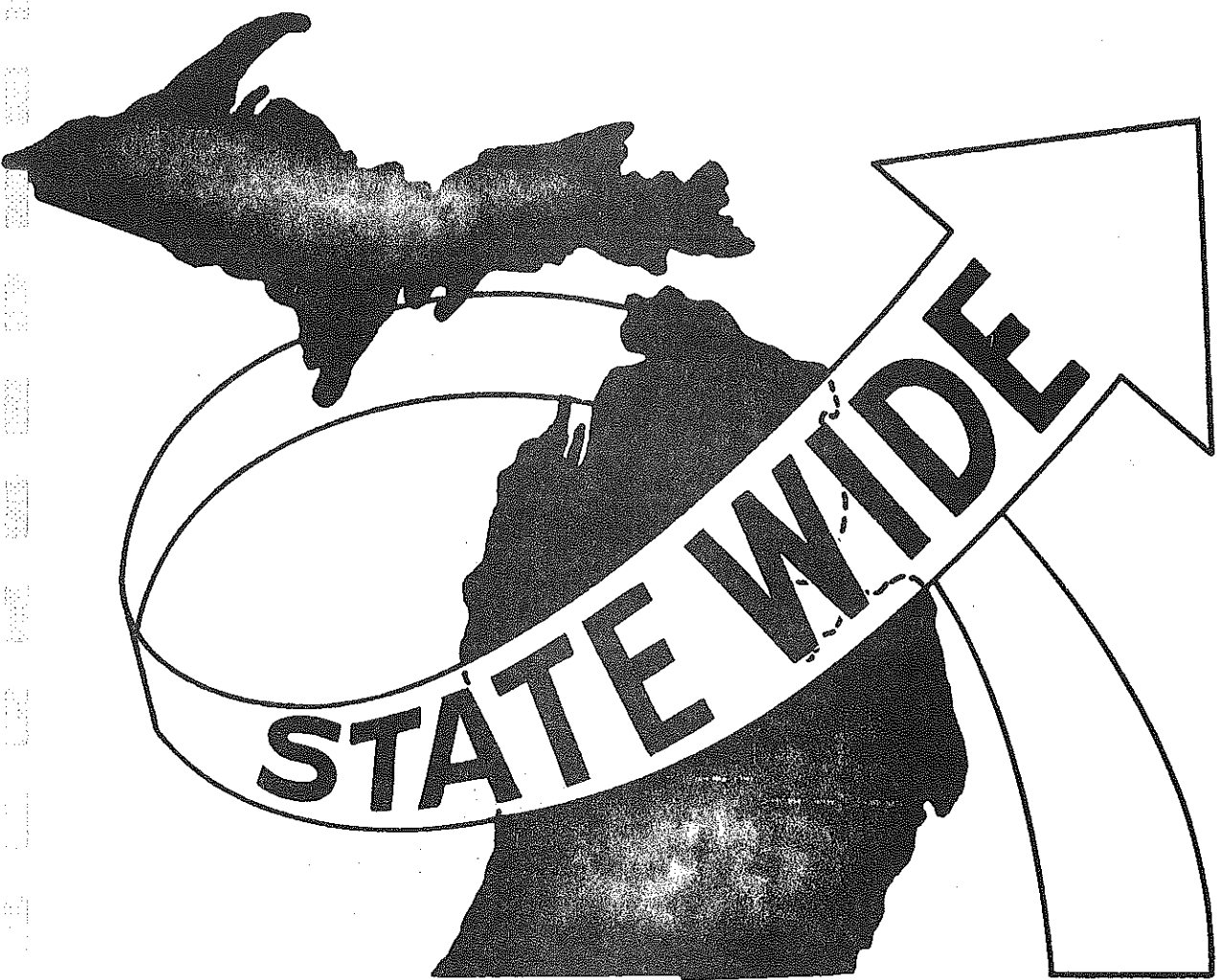
CONCLUSIONS

From the results of the tests illustrated in Figures 9-A through 9-F, the output of the DHV increase routine seems consistent. That is, increases generally are higher on links which are nearer or more directly related to the selected link or zone than on other links. The increases generally decline constantly in magnitude as one moves away from the selected zone or link; the only exception seems to be where local traffic plays a large part in DHV. Thus as an initial refinement to the DHV model, the increase routine appears adequate.

What is lacking for the routine is calibration, that is, scaling the increases to respond to a special event so that increments are not significantly too high or low. Before that can be done, the routine must be tried on many more than two cases. Thus users are encouraged to utilize the routine, varying the schedule of increases as desired. Comments and evaluation are welcomed.

Typically new highways are constructed to Design Hour Volume standards. Without a model of sharp increases in DHV due to special events, new highways may become overcrowded sooner than anticipated. With such a model, the planning division can use the DHV figures the Statewide Transportation Modeling System generates with assurance that the effect of special events has been considered.