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16. Abstract

A three-year study of urban arterial work zones is currently in progress. The objective of the study is to develop improved guidelines for selecting and implementing work zone traffic control on urban arterials. This report is the first year interim report for the research effort. The first year tasks included a literature review, a survey of local agencies to determine arterial work zone practice, selection of three sites for data collection, collection of data at two of these sites, performing a survey of motorists to evaluate their understanding and opinions of work zones, and developing a study methodology.

The general findings of the first year confirm the need for improved guidelines. Current research and guidelines do not adequately address the topic. Field practice indicates a variation in the significance given to work zone control on arterials. Field data indicates a decrease in traffic performance in the vicinity of construction zones. A survey of motorists indicated they do not adequately understand construction signing and are concerned about the impacts of the construction on their mobility.

Data collection and analysis will continue in the second and third years of the study. The improved guidelines for urban arterial work zones will be a part of the final report, published at the conclusion of the study.

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
AREA				
in²	square inches	645.2	millimetres squared	mm²
ft²	square feet	0.0929	metres squared	m²
yd²	square yards	0.836	metres squared	m²
mi²	square miles	2.59	kilometres squared	km²
ac	acres	0.395	hectares	ha
MASS (weight)				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
VOLUME				
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft³	cubic feet	0.0328	metres cubed	m³
yd³	cubic yards	0.0765	metres cubed	m³

NOTE: Volumes greater than 1000 L shall be shown in m³.

TEMPERATURE (exact)

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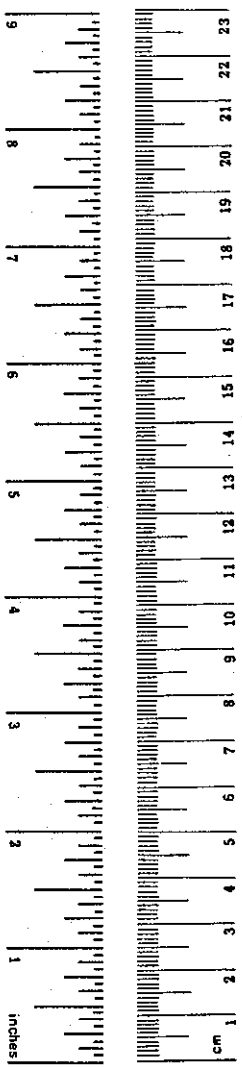

APPROXIMATE CONVERSIONS TO SI UNITS

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LENGTH				
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
AREA				
mm²	millimetres squared	0.0016	square inches	in²
m²	metres squared	10.764	square feet	ft²
km²	kilometres squared	0.39	square miles	mi²
ha	hectores (10 000 m²)	2.53	acres	ac
MASS (weight)				
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T
VOLUME				
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m³	metres cubed	35.315	cubic feet	ft³
m³	metres cubed	1.308	cubic yards	yd³

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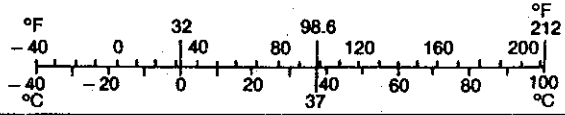

These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements

TRAFFIC CONTROL GUIDELINES FOR URBAN ARTERIAL STREET WORK ZONES

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Design Process for Work Zone Speed Control
and
Traffic Control Guidelines for Urban Arterial Street Work Zones

Sponsored by
Texas State Department of Highways and Public Transportation
in Cooperation with the
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Federal Highway Administration

Texas Transportation Institute
The Texas A&M University System
College Station, Texas 77843

August, 1989

ABSTRACT

A three-year study of urban arterial work zones is currently in progress. The objective of the study is to develop improved guidelines for selecting and implementing work zone traffic control on urban arterials. This report is the first year interim report for the research effort. The first year tasks included a literature review, a survey of local agencies to determine arterial work zone practice, selection of three sites for data collection, collection of data at two of these sites, performing a survey of motorists to evaluate their understanding and opinions of work zones, and developing a study methodology.

The general findings of the first year confirm the need for improved guidelines. Current research and guidelines do not adequately address the topic. Field practice indicates a variation in the significance given to work zone control on arterials. Field data indicates a decrease in traffic performance in the vicinity of construction zones. A survey of motorists indicated they do not adequately understand construction signing and are concerned about the impacts of the construction on their mobility.

Data collection and analysis will continue in the second and third years of the study. The improved guidelines for urban arterial work zones will be a part of the final report, published at the conclusion of the study.

Keywords: Arterial Work Zone, Urban Work Zone, Work Zone, Urban Arterial Work Zone Guidelines

IMPLEMENTATION STATEMENT

This study was sponsored by the Texas State Department of Highways and Public Transportation with the major objectives of establishing a comprehensive work zone speed control design process and developing improved traffic control guidelines applicable to urban arterial work zones. The results of this research effort will provide more uniform implementation of work zone speed zoning and speed control measures as well as lead to improved operations and safety for both workers and drivers in urban arterial work zones.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the Texas State Department of Highways and Public Transportation. This report does not constitute a standard, specification, or regulation.

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SUMMARY

Urban arterials are being required to carry a greater traffic load than in the past. Therefore, arterial construction has increased in order to provide additional capacity for the vehicular demand. The SDHPT has established the PASS (Principal Arterial Street System) program for the upgrading of major arterial streets. The resulting construction has led to a recognition of the lack of adequate guidelines for work zones on urban arterials.

The objective of this three year research study is to develop improved guidelines for selecting and implementing work zone traffic control on urban arterials. The majority of the first year's effort was spent determining the state-of-the-art for urban arterial work zone control and collecting field data at two urban arterial work zones. Preliminary analysis of this information has been completed.

State-of-the-art was determined through a literature search and a survey of local traffic professionals. The literature review indicated a large discrepancy between the availability of research information on freeway and rural highway work zones, and that on urban arterial work zones. The majority of the information was found in the MUTCD and supporting documents, however, separate research material was also identified. The local agency survey involved asking traffic professionals about their experiences with urban arterial work zones. The findings indicate a variation in the importance given to arterial work zones by the agencies. Virtually everyone contacted indicated a need to expand the MUTCD to provide specific guidelines about urban arterials.

Three study sites were selected for data collection. Two are in Houston and one is in Dallas. Data was collected at both of the Houston sites during the first year. Collected data included traffic volumes, travel time comparisons, and accident information. Analysis of the data indicates that traffic volumes, both average daily and peak period, have decreased on the roadways under construction; travel time delays have increased; and accidents have substantially increased. Possible causes include absence of continuous center left-turn lane, presence of construction barrels, narrow travel lanes, adjacent opposite direction travel lanes with no separation barrier, driver diversion to other routes because

of the construction area, and a difference in grade for newly constructed roadway versus existing pavement.

A survey of motorists was conducted to determine their reaction to and understanding of work zone traffic control. The survey of F.M. 1960 users confirmed previously conducted studies that show that all aspects of signing are not fully understood by motorists. However, sign and message interpretation are not primary sources of concern for users of F.M. 1960. More important issues involve the length (time and distance) of the project, problems associated with turning, and travel delay. In general, the survey participants indicated a tolerance for construction and its related problems, and have positive attitudes toward the SDHPT.

This research study will continue for two more years. The second year of the study will concentrate on continuing data collection, refining the study methodology, and performing interim analysis and evaluation. Data collection will continue during the final year of the study and the final guidelines will be developed.

SECTION 1
BACKGROUND

The arterial street systems of major Texas cities are being forced to carry an expanding share of the traffic burden as a result of the continued increase in congestion on the freeways in these cities. The Texas State Department of Highways and Public Transportation (SDHPT) recognized this fact and, in September 1987, the Texas Highway Commission gave approval to a $100 million project for the overhaul and upgrading of major urban arterial streets. The intention of this program is to relieve a portion of freeway traffic congestion by providing additional capacity and improving traffic flow on the urban arterials. This ambitious program is entitled PASS (Principal Arterial Street System) and is fully endorsed by the cities of Houston, Dallas, Fort Worth, San Antonio, Austin, Corpus Christi, El Paso, and Arlington.

The initiation and implementation of the PASS program has led to the recognition of shortcomings in the area of construction traffic management. A major shortcoming is the lack of adequate guidelines for use with construction work zones and construction traffic control on urban arterials. Due to the complex nature of the urban driving environment, proper planning and implementation of traffic and pedestrian management techniques are essential to work zone safety. The problems related to urban arterial work zones are not fully addressed in the Manual of Uniform Traffic Control Devices (MUTCD) (1). Consequently, there is a need to develop guidelines for the planning and implementation of traffic and pedestrian control in major urban arterial work zones.

The SDHPT has sponsored a significant amount of research evaluating work zone traffic control on typical highway facilities such as urban and rural freeways, rural highways and low volume intersections. However, there is a lack of documented research related to construction traffic management on urban arterials. This work has historically fallen under the responsibility of municipalities. The implementation of the PASS program has compelled SDHPT to assume a greater responsibility for urban arterial work zone traffic control. As a result of this responsibility, SDHPT is sponsoring research to gather

additional information on work zone traffic control on urban arterials. Various traffic control techniques need to be evaluated to determine their effectiveness in the urban arterial work zone given various surrounding factors such as limited right-of-way, volumes, vehicle travel times, traffic signals, access to adjacent property, and turning movements.

The successful completion of construction associated with the PASS program involves assurance of safety within major urban arterial work zones. Guidelines and standards for traffic control would be of definite benefit in accomplishing this objective and would likely see immediate implementation by both the SDHPT and municipal agencies. These guidelines should lead to improved worker and driver safety, improved traffic operations in advance of and through work zones, and reduced risk of tort liability at work zones across the state.

SECTION 2
OBJECTIVES AND WORK PLAN

Objectives

This research study is part of SDHPT's effort to better understand the special requirements of work zones in general. There are two focal points to the study, each with a single major objective:

1) Develop improved guidelines for selecting and implementing work zone traffic control on urban arterials.
2) Develop a comprehensive design process for selecting and implementing appropriate speed zones, devices, and techniques for speed control in work zones.

This document is an interim report which addresses the first year efforts in developing guidelines for use in urban arterial work zones. A separate interim report addresses work zone speed control.

Work Tasks

The work plan for developing guidelines for urban arterial work zones has a total of eleven tasks. The first six tasks were initiated in the first year of the study. Future efforts will include work on all eleven tasks. All tasks are described below along with a brief description of the work accomplished during the first year of the study.

Task 1 -- Select Study Sites

A minimum of two long-term (i.e., two years or longer) construction work zone sites on highly developed urban arterials will be selected for study. Traffic control plans developed for the construction will be obtained for review. Three sites were selected for

work zone evaluation. A detailed description of these sites is contained in Section 4, Urban Arterial Construction. No further work is anticipated on this task.

Task 2 -- Review Current Practice

Current published material addressing traffic control on major urban arterials will be obtained. This information will be used to identify and review current practices for traffic control applications on major urban arterials. Any similarities and differences between current practice and the traffic control plans for the study sites of Task 1 will be identified and evaluated.

Current practice was reviewed through two efforts. Each effort is described in Section 3, Current Practice. The first was a literature review of urban arterial work zone research. The literature review is essentially complete. The second effort was a survey of city transportation officials. This survey attempted to identify the problems cities encountered in dealing with urban arterial work zones. The survey of city personnel is complete. Future survey efforts will include contacting SDHPT personnel to assess work zone problems and concerns.

Task 3 -- Document and Evaluate Traffic Control Plans

Implementation of the Traffic Control Plans for the study sites, as well as major changes that are made in the original Traffic Control Plan set-up, will be documented using field inspections and photographic procedures so that a historical record is obtained which can be used to evaluate the effectiveness of various aspects of the Traffic Control Plans.

A historical record of the traffic control at two of the study sites was established through the use of video, photography, and field inspections. These records were updated each time a change in traffic control took place. Portions of the traffic control plans are documented in the Appendices. This is an ongoing effort and will continue throughout the duration of construction at each of the study sites.

Task 4 -- Collect and Validate Data

Data will be collected at the beginning of the project and as necessary throughout the study during all phases of construction. This data will include such information as roadway geometrics, traffic volumes, speeds, physical appearance, lighting and nighttime conditions, and accident history. The data will be used to evaluate the effectiveness of the Traffic Control Plans. The data will also be validated, as permissible, to indicate its precision.

Various data were collected at the two study sites under construction. Preliminary analysis of some of the data was also performed. A detailed description of the data collection is included in Section 4, Urban Arterial Construction. This is an ongoing effort and will continue throughout the duration of construction at each of the study sites.

In addition to traffic related data, a survey of motorists was performed to determine how they interact with urban arterial construction traffic controls. The motorist survey and results are described in Section 4, Urban Arterial Construction. No future survey efforts are anticipated.

Task 5 -- Formulate Study Methodology and Analysis Procedures

The methodology for the remainder of the study will be determined along with the analysis procedures to be used. The methodology and procedures will indicate how the effectiveness and safety of the traffic control measures will be determined and conditions which affect the use of the various measures.

Initial efforts have begun evaluation of the effectiveness and safety of the traffic control measures identified during the first year. Some of the findings are described in portions of Section 4, Urban Arterial Construction and Section 5, Conclusions and Study Continuation. Work on this task will continue during the second year of the project.

Task 6 -- Submit Interim Report

An interim report will be submitted to the SDHPT at the end of the first year. This report will discuss the selection of parameters of study sites, implementation of Traffic Control Plans, data collection, study methodology and analysis procedures, and preliminary

findings to date, if any. This document represents the first year interim report. No further efforts will be necessary on the first year interim report.

Task 7 -- Conduct Interim Analysis and Evaluation

After sufficient data has been collected, an analysis will be performed using the methodology and procedures developed in Task 5. The analysis will evaluate safety and operational features of the work zones and will determine, to the degree possible, which aspects of the work zones traffic control are most effective for given situations. This task is scheduled to be addressed during the second and third years of the project.

Task 8 -- Submit an Interim Report

An interim report will be submitted which describes the additional data collected, the interim analysis and evaluation, study findings, and recommendations for the second year of study. This task is scheduled to be completed during the second year of the project.

Task 9 -- Complete Work Zone Evaluation

A final evaluation of the effectiveness of the Traffic Control Plans for each study site will be made in the third year of the study. Changes in traffic control, work site, and traffic conditions during the study period will also be evaluated to determine their effect on traffic management in the construction area. This task is scheduled to be addressed during the second and third years of the project.

Task 10 -- Develop Guidelines for Work Zone Traffic Control on Urban Arterials

Factors which influence the effectiveness of the Traffic Control Plans will be identified and recommendations will be developed for the use of various work zone control factors on urban arterials. Guidelines for controlling traffic and pedestrians for one-lane and multilane closures on major urban arterial streets will be developed. This task is scheduled to be completed during the third year of the project.

Task 11 -- Submit Final Report

A final report will be submitted to SDHPT which will document all aspects of the study. The final report will include findings and recommendations for traffic control standards and

management techniques on major urban arterial streets. This task is scheduled to be completed during the third year of the project.

Summary and Future Efforts

Tasks 1 through 6 were begun during the first year of the project. These tasks included the selection of a study site, a review of current practice, documentation and evaluation of Traffic Control Plans, collection and validation of field data, formulation of study methodology and analysis procedure, and submission of this interim report. The tasks addressing the study sites, current practice, and interim report are virtually complete. During the second year of the study, research efforts will continue on the tasks addressing the Traffic Control Plans, field data, and the study methodology. The remaining tasks will be addressed in the second and third years of this research study.

Section 3
CURRENT PRACTICE

Literature Review

Obtaining and evaluating available research material is a crucial task in developing guidelines for urban arterial work zones. One of the early project efforts was to conduct a literature search to collect reference material which addressed urban arterial work zones. The reference material was then evaluated to determine its applicability to the project.

The literature search was initiated with a computerized search of the Transportation Research Information Service (TRIS) data base. A total of 147 citations were obtained. The citations included the title, author, publication, and an abstract. They addressed a wide variety of issues related to work zones. These citations were evaluated to determine those which might contain information related to urban arterial work zones. The study team then obtained as many of the pertinent papers as possible. The reference list of these papers was then evaluated to determine if additional research information was available. Other published material was also reviewed.

The literature review indicated that there is a large discrepancy between the availability of research information on freeway and rural highway work zones, and that on urban arterial work zones. Nevertheless, a number of references were found to contain some degree of pertinent information about the desired subject matter. The most important of these are described in the following paragraphs.

Guidelines, Standards, and Handbooks

The 1961 edition of the Manual on Uniform Traffic Control Devices (MUTCD) (2) included, for the first time, an extensive special treatment of traffic control devices for highway construction and maintenance operations. One section of this part of the MUTCD dealt with urban applications of work zones. The 1961 MUTCD recognized the unique

characteristics of urban work zones and directly addressed the most important of these, as follows:

- *The general principles outlined in the previous sections of this Manual are applicable to both rural and urban areas. Discussion of their application, however, has emphasized rural conditions. The differences between rural and urban situations warrant some separate treatment of urban traffic control requirements, though basically it is possible only to point out certain ways in which the standards already set forth can be adapted to peculiarly urban problems.*

- *Urban traffic conditions are characterized by relatively low speeds, high traffic volumes, limited maneuvering space, frequent turns and cross movements, and a significant pedestrian movement. There is already ample conflict inherent in urban traffic movement, and further conflict due to construction or maintenance operations should be kept to a minimum. On arterial streets such work should, if possible, be restricted to off-peak hours.*

The Texas MUTCD (3) is the state standard for all traffic control devices. It sets forth the basic principles that govern the design and usage of traffic control devices. These devices are used to direct and assist vehicle operators in the guidance and navigation tasks required to traverse safely any facility open to public travel. The Texas MUTCD addresses devices in individual sections, such as regulatory signs, warning signs, signals, markings, and others. Part VI of the Texas MUTCD is devoted to "Traffic Controls for Street and Highway Construction and Maintenance Operations." Part VI of the Texas MUTCD is also available as a separate document (4) containing exactly the same information found in Part VI of the entire Texas MUTCD.

The construction and maintenance section of the Texas MUTCD sets forth basic principles and prescribes standards for the design, application, installation, and maintenance of the various types of traffic control devices required for road or street construction, maintenance operations, and utility work. Minimum standards of application are prescribed

for typical situations, and for methods of controlling traffic through work areas. The standards in the Texas MUTCD should be adopted by all public authorities concerned with highways, and all traffic control devices used on street and highway construction or maintenance work shall conform to the applicable specifications of the Texas MUTCD.

There are seven subsections to Part VI of the Texas MUTCD. These subsections include:

A. Introduction and General Specifications
B. Signs
   General
   Regulatory
   Warning
   Guide
C. Channelizing Devices
D. Markings
E. Lighting Devices
F. Control of Traffic Through Work Areas
G. Expressways and Limited Access Facilities

Each of these subsections address specific control devices and the use of those devices. There is no section directly addressing traffic control on urban arterials, as there is with expressways and limited access facilities. However, urban conditions are addressed briefly in the introduction subsection which contains the following statements regarding urban arterial work zones:

- *The general principles outlined are applicable to both rural and urban areas. As used in this section, the term street refers to all the streets in any municipality, including cities, towns, villages, or other local jurisdictions.*

- *Traffic conditions on streets are characterized by relatively low speeds, wide ranges of volumes, limited maneuvering space, frequent turns and cross*

movements, a significant pedestrian movement and other obstructions. Construction and maintenance operations are more numerous and varied, including such diverse activities as pavement cuts for utility work, pavement patching and surfacing, pavement markings renewal and encroachments by adjacent building construction. Work on arterial streets should be restricted to off-peak hours to minimize conflicts with traffic.

- *In situations not adequately covered by the provisions of the MUTCD, the protection of the traveling public, pedestrians, and of the workmen on the scene will dictate the measures to be taken, consistent with the general principles set forth in this section.*

The other subsections of Part VI address the specific use of individual traffic control devices. In most instances, the use of devices is described for a highway type environment. There are some cases where traffic control for low-speed or intersection work zones is addressed. Urban streets are addressed by using speed to determine spacing of devices. The lower speeds found on urban streets generally require shorter spacing of traffic control devices.

The Texas MUTCD is based on the 1978 National MUTCD (1). A new edition of the National MUTCD was released near the end of the first year of this study. Therefore, the information contained in this document is not included in this interim report. Pertinent information from the revised National MUTCD will be evaluated and included in the second year interim report.

The Traffic Control Devices Handbook developed in 1983 (5) is primarily intended to augment the National MUTCD by serving an interpretative function. The Handbook offers guidelines for implementing the standards and applications contained in the National MUTCD. It should be noted that the requirements of the National MUTCD take precedence in all cases. The part of the Handbook dealing with work zones is designed and written to be used with, not to replace, the National MUTCD and explains how to apply the standards to various work situations. The Handbook addresses urban arterial

work zones in greater detail than the National MUTCD. Throughout this section of the Handbook, work zone applications on urban streets are specifically mentioned. Some of the specifics of these urban arterial conditions are mentioned below:

- *Length of Advance Warning Area:*
  - * *At least one block for urban streets*
- *Rule of Thumb for Sign Spacing:*
  - * *250 feet for urban, residential, or business districts, or with speeds under 40 mph; 500 feet for urban arterials and rural roads, or with speeds over 40 mph.*
- *Other Considerations for the Location of Advance Warning Area:*
  - * *Urban: distance restrictions can be imposed by the length of city blocks; additional advance warning may be necessary due to extra intersections created by alleys, shopping centers, and side streets.*
  - * *Signs should not block the view of vehicles entering the area from gas stations, restaurants, cross roads, etc.*

The Handbook also addresses typical applications or layouts for work zone traffic control for different situations. One of these typical applications is for urban areas. Pedestrians, bicycles, and intersections are also addressed. Diagrams of typical work zone layouts for different situations are provided and some of the major concerns are briefly mentioned.

The City of Austin has the part of their Transportation Criteria Manual which deals with traffic control and work zone safety (6) available as a separate document. This 47 page manual is intended to assist contractors in the proper use of traffic control devices in urban work zones. It addresses work zone safety in Austin with the following sections:

1) Procedures
2) Requirements
3) Work Zone Traffic Control Devices
4) Typical Applications

5) Maintenance and Inspection

The Austin manual is intended to supplement the Texas MUTCD, recognizing that the MUTCD is the primary manual governing work zone traffic control on public streets. Unique aspects of the Austin manual include:

- Identification of a downtown urban area with restrictions on work zone activities, including:
  - * Time restrictions.
  - * Temporary lane closures.
  - * Pedestrian protection.

The Austin manual addresses the use of various traffic control devices in work zones, describing many of the devices and typical applications. Most of this information is a repeat of the MUTCD, but the City of Austin has also added their own requirements, such as the number of signs and placement of signs at a work zone and requirements for bore pits.

Research Reports

A report prepared by the Texas Transportation Institute in 1980 for the Federal Highway Administration (7) addresses highway safety from a number of perspectives. One of these areas is traffic operations and planning, of which safety design in construction and maintenance operations is a concern. Work zones on urban streets are addressed briefly in several locations. These are restated as follows:

Urban Multi-lane Facilities

Because facilities of this type are likely to exhibit relatively high traffic volumes, maintaining adequate capacity and a reasonable level of service become a primary concern. Traffic may need to be detoured over other major arterials or work activities may have to be prohibited during peak traffic periods. During non-peak periods when traffic is flowing more freely, the speed differential between normal traffic and traffic in work areas may become more critical.

Urban Two-lane Facilities

This type of roadway includes residential streets and other relatively low volume city streets. A major concern is the provision of access to abutting property during street renovation work. Capacity and speed differential problems are relatively minor.

Control Device Selection Criteria

The type and extent of traffic control depends to a considerable degree on the classification of the roadway and the area in which the work is located. On urban streets, traffic control may be complicated by the proximity of intersecting streets, the need to provide access to abutting property, and in general the many more possible movements desired by motorists.

Professional Journal Papers

A study conducted in 1981 (8) evaluated the present state-of-the-art of city traffic control programs for construction and maintenance work zones. The study consisted of two efforts; a survey of 49 cities and field inspections of work zones in eight of the cities. The general findings were that the importance of traffic control programs varies widely and the majority of the cities surveyed do a less-than-adequate job in controlling construction and maintenance activity.

This study cited the U.S. General Accounting Office (GAO), which reviewed efforts by the Federal Highway Administration to increase safety through road construction work zones. The study found that at all levels:

- Officials did not always know how to make work sites safe.
- They did not always appreciate the need for safety.
- They placed higher priority on construction quality, economy, and deadlines, than on work zones.

The GAO review recommended that the National MUTCD be revised to include specific management guidelines for the implementation of traffic control measures in work zones. Existing city programs were analyzed through a questionnaire along with field

investigations of sites. The questionnaire was sent to 100 cities with populations between 50,000 and 1,000,000. It consisted of a series of twelve questions addressing four general areas:

- Permit and authorization procedures.
- Development, approval, and implementation of a traffic control plan and field inspection.
- Enforcement and training policies.
- General problems and areas for improvement identified by the cities.

Evaluation was split into two groups; answers to five rated questions which determined how active a role the cities had in regulating the traffic control for construction and maintenance activity, and seven nonrated questions which determined what the typical practices were. A significant finding of the study was that, despite the fact that the majority of cities' traffic control programs was less than satisfactory, 60 percent thought they had an adequate program. The findings also indicate that cities, in general, do not place heavy emphasis on urban traffic control. This was evidenced by the fact that primary responsibility for developing and inspecting traffic control did not lie with the cities, and that most cities did not conduct training programs.

The field investigation was conducted using a panel of traffic control experts to review slides of construction and maintenance zones in eight of the survey cities. Deficiencies at each of the work zones were ranked on hazard, risk, and preventability. The results of the field investigation indicate that the quality of the traffic control in work zones is dependent on the degree of involvement the cities have in regulating construction and maintenance work zones. Good traffic management programs are apparently effective in achieving improvement in traffic control through work zones.

This research is significant because it indicates that there is a weakness in urban traffic control. The reason for the weakness is not fully apparent from the questionnaire results. However, the results do indicate that cities need to be informed of the need for better and more effective traffic control.

An Alabama study included a comprehensive evaluation of implemented traffic control plans so that more effective guidelines for work area traffic control could be developed. The principle objectives here were to assess current practices in the design, installation, and operation of work area traffic controls and to provide quantitative information on the effects of traffic control devices on motorist behavior in construction work zones. Three sites were selected for evaluation, one of which was an urban arterial.

The urban arterial work zone involved the construction of an urban interchange. An overpass was constructed over the cross street. Frontage roads were located on the overpass street. Comparisons between the Traffic Control Plan (TCP) and the field reviews of the work zone revealed evidence of the following:

- *Motorist confusion in distinguishing between signs for frontage road traffic and those for detoured East Boulevard traffic.*
- *Lack of advisory speed signs at warranted locations.*
- *Motorist confusion due to the large number of traffic control devices competing for attention.*
- *Motorist difficulty in following guide signs for a designated route.*
- *Unusually short lengths of crossovers for the prevailing speeds.*
- *Unusually short spacing between successive construction signing.*
- *Inadequate pavement markings on entering a detour route.*
- *Improper placement of some traffic control devices.*
- *Inadequate continuous visibility of some construction signing.*
- *Inconsistencies between advisory and regulatory speed limit signs.*
- *Improper storage of traffic control devices.*
- *Damaged traffic control devices.*

The majority of the analysis used speeds in different sections of the work zone to evaluate the effectiveness of the traffic control devices. The conclusions indicate: some confusion with work zone traffic control, TCP frequently not developed with full consideration of actual site conditions, unreliable motorist response to advisory speed signs,

inadequate design standards for on-site detours, and problems with maintaining traffic control devices.

The general recommendations contained in this study are:

- *Traffic control plans should be as simple as possible and overuse of traffic control devices should be avoided.*
- *Since motorist compliance with advisory speed reductions is difficult to predict, traffic control plans should be designed such that speed reductions are not required.*
- *In traffic control zones where speed reductions are critical to safe operations, considerations should be given to the use of positive measures of speed control to supplement advisory speed signing.*
- *Because on-site detours often result in undesirable traffic operating characteristics, they should be avoided whenever possible. If unavoidable, they should exhibit design standards equal to those of the facility from which traffic is being detoured.*

A recent study (10) describes the development of a computer based methodology for the evaluation of traffic control systems at arterial street lane closure in the vicinity of signalized intersections. This effort was necessary in order to develop measures-of-effectiveness for evaluating urban arterial work zones.

The study conducted a review of previous research concerning the evaluation of arterial street lane closure performance. It found that no literature is available with respect to determining delay in work zones on arterials. The goal of the study was to develop a ranking procedure for the variables that affect traffic flow quality at arterial street lane closures.

The result of the study is the ARTWORK microscopic computer model. The model calculates the movement of individual vehicles through a work zone and the vehicles' reactions to the roadway, traffic control devices, and traffic signals. The model can only

simulate movement through a two intersection system, with the work zone located slightly upstream of the second intersection. The model was found to represent true system behavior closely enough to be used as a substitute for the actual system.

Shortcourse Materials

The American Traffic Safety Services Association has developed a shortcourse (11) which addresses work zone control in a general manner. The course focuses on work performed by utility companies and municipal service organizations which install and maintain facilities within public streets and highways. For the most part, the notebook repeats information in the National MUTCD and the Traffic Control Devices Handbook.

Topics addressed in this notebook include:

- *Devices used in utility work zones.*
- *Device location and placement.*
- *Designing traffic control zones.*
- *Planning and installing traffic control zones.*
- *Operating and managing work zones.*

The notebook specifically addresses the problems of urban arterial work zones in a limited fashion. It states that high-speed urban arterials should be treated in a similar manner to that used for open highways. The required distances on low-speed, low-volume minor streets can be shortened and the number of advanced warning signs can be reduced from three to two. Urban work zone problems mentioned in the notebook include: intersections, driveways, pedestrians, and detours. Several diagrams for work zone situations on urban streets are shown.

The Public Works Training Division of the Texas Engineering Extension Service, Texas A&M University System, teaches a number of short courses related to work zones. There are currently three notebooks used in these courses (12, 13, 14). These notebooks address all aspects of work zone traffic control.

Agency Survey

Early on, it was realized that the guidelines developed as a result of this study would be used, not only by Department personnel, but also by many local transportation agencies. Therefore, it was deemed desirable to contact some of these local agencies to determine the problems they were encountering with urban arterial work zones, how they dealt with those problems, and the sort of guidelines they would like to see.

In the second part of the review of current practice, a telephone interview was used to determine how local agencies addressed urban arterial work zones. A total of five agencies have been contacted at this time, with plans to contact others in the future. The five agencies and the person interviewed are listed in Table 1. The interview was based on a survey questionnaire which addressed a number of the key issues related to urban arterial work zones. The questionnaire consisted of thirteen questions and is shown in Table 2. The questionnaire had several purposes including:

- Identify the level of effort of individual cities in providing traffic control for urban arterial work zones.
- Identify guidelines used by cities for urban arterial work zones.
- Identify problem areas in implementing urban arterial work zones.
- Identify deficiencies in the Texas MUTCD related to urban arterial work zones.
- Identify division of responsibility when more than one agency is involved in a project.
- Identify responsibility for implementing and inspecting work zone traffic control.

Table 1. Agency and Personnel Contacted

City of Houston	Bill Graham
County of Dallas	Richard Peterson
City of Dallas	Sam Wilson
City of San Antonio	Andy Ballard
City of Austin	Tony Maldanado

Table 2. Urban Arterial Work Zone Questionnaire

URBAN ARTERIAL WORK ZONE SURVEY

NAME: PHONE:

AGENCY: DATE:

DESIGN PROCESS BACKGROUND:

1. What traffic control (TC) standards or guidelines do you use for long term construction work on urban arterials?
2. What problems have you experienced in applying the MUTCD to urban conditions?
3. How does your agency interact with projects where traffic flow is diverted from a city street onto a freeway or highway, or vice versa?
4. What efforts are extended before construction begins to insure that the contractor follows the traffic control requirements?
5. What person or position is responsible for insuring that traffic control requirements are followed once construction has begun?
6. Does this person receive specialized training in traffic control?
7. What enforcement measures are available to the responsible supervisor if the requirements are not being followed?
8. What are the major problems you have encountered with work zones on urban arterials and how do you deal with each problem?
9. How do you differentiate between short and long term arterial construction?
10. What traffic control requirements do you place on short term construction on urban arterials?
11. Do you employ any special traffic control techniques addressing driveway access within the work zone?
12. To what degree are other governmental agencies involved in work zone traffic control on urban arterial construction projects?
13. How is the responsibility for traffic control determined?

OTHER INFORMATION AND COMMENTS:

A number of conclusions can be drawn from the results of the questionnaires. The major conclusions are described below:

- Most cities are not directly responsible for developing a TCP; it is either developed by the consultant or not included at all.
- All work zone traffic control is based on the Texas MUTCD; no other references are used by the cities.

- Most cities feel that the Texas MUTCD seems to be directed more toward rural situations. Urban difficulties include:
  * Street/blocks are not long enough to contain all required information.
  * Most problems occur at approaches to project rather than within.
  * Physical constraints of roadway restrict implementation.
  * Minor/major cross-street intersections.
  * Moving traffic signals.
  * Detours at major-major intersections.
  * Texas MUTCD is too complicated for some field personnel.
  * Traffic control for special events (parades, marathons, etc.).
- Construction inspection responsibilities belong to the Public Works Department. Some cities have traffic control inspectors which are part of the Transportation Department.
- Driveway access must be maintained at all times, but it is normally up to the contractor how that access should be provided.
- In projects involving other governmental agencies, traffic control is the responsibility of the agency initiating and funding the project.
- In general, there is a lack of communication between the cities and the SDHPT in the area of work zone traffic control.
- The major traffic control problems in urban areas include:
  * Poor maintenance of devices.
  * Restoration of control devices struck by traffic.
  * Poor nighttime visibility.
  * The effects of detours on traffic.
  * Minimum width of traffic lanes.

Summary and Future Efforts

The review of published material addressing urban arterial work zones indicated a lack of detailed information about the subject. Some previous research efforts have documented the lack of information on urban arterial work zones and indicate a need to expand the National MUTCD in this area. Additional research material will be evaluated as it becomes available. There are no plans to perform additional searches of data bases for research material.

The agency survey indicated that, among the local agencies surveyed, there is variation in the degree in which traffic control is stressed. Most cities are not directly responsible for the development of a TCP. Several agencies indicated the Texas MUTCD did not sufficiently address work zone traffic control on urban arterials. Contact with local and state agency personnel will be continued throughout the course of the project. Some telephone interviews of additional city and county personnel may be performed during the second year of the study, if needed. Local level SDHPT personnel will also be contacted during the second year of the study to gather information about how urban arterial work zones are handled at the Department level.

SECTION 4
URBAN ARTERIAL CONSTRUCTION

Study Sites

An important task of this study was to select a minimum of two urban arterial construction sites where needed data could be collected. The selection of appropriate study sites was critical to the success of the study. A study site had to meet several qualifications. They included: located on an arterial street in an urban area, construction duration of at least one year, and a convenient location for data collection.

Three construction work zone sites on highly developed urban arterials were selected for study. Two of the project sites are F.M. 1960 and State Highway 6, which are both located in Houston, Texas as shown in Figure 1. The construction at these sites began during the first year of this research study. The third project site is Skillman Avenue located in Dallas, Texas as shown in Figure 2. Construction has yet to begin at this location.

F.M. 1960

F.M. 1960 is a major urban arterial located in the Houston area. It is roughly concentric to the I.H. 610 loop, being approximately 14 miles outside the loop. F.M. 1960 begins at U.S. 290 in northwest Houston and extends past U.S. 59 to the northeast part of Harris County. The total length of F.M. 1960 in Harris County is approximately 37 miles.

The F.M. 1960 construction study site is approximately seven miles long and is located between I.H. 45 (North Freeway) and S.H. 249, as shown in Figure 1. Land use along F.M. 1960 consists mainly of commercial strip development and residential areas. Much of the development (banks, fast-food restaurants, gasoline stations, etc.) front directly on F.M. 1960 and therefore create a very congested area.

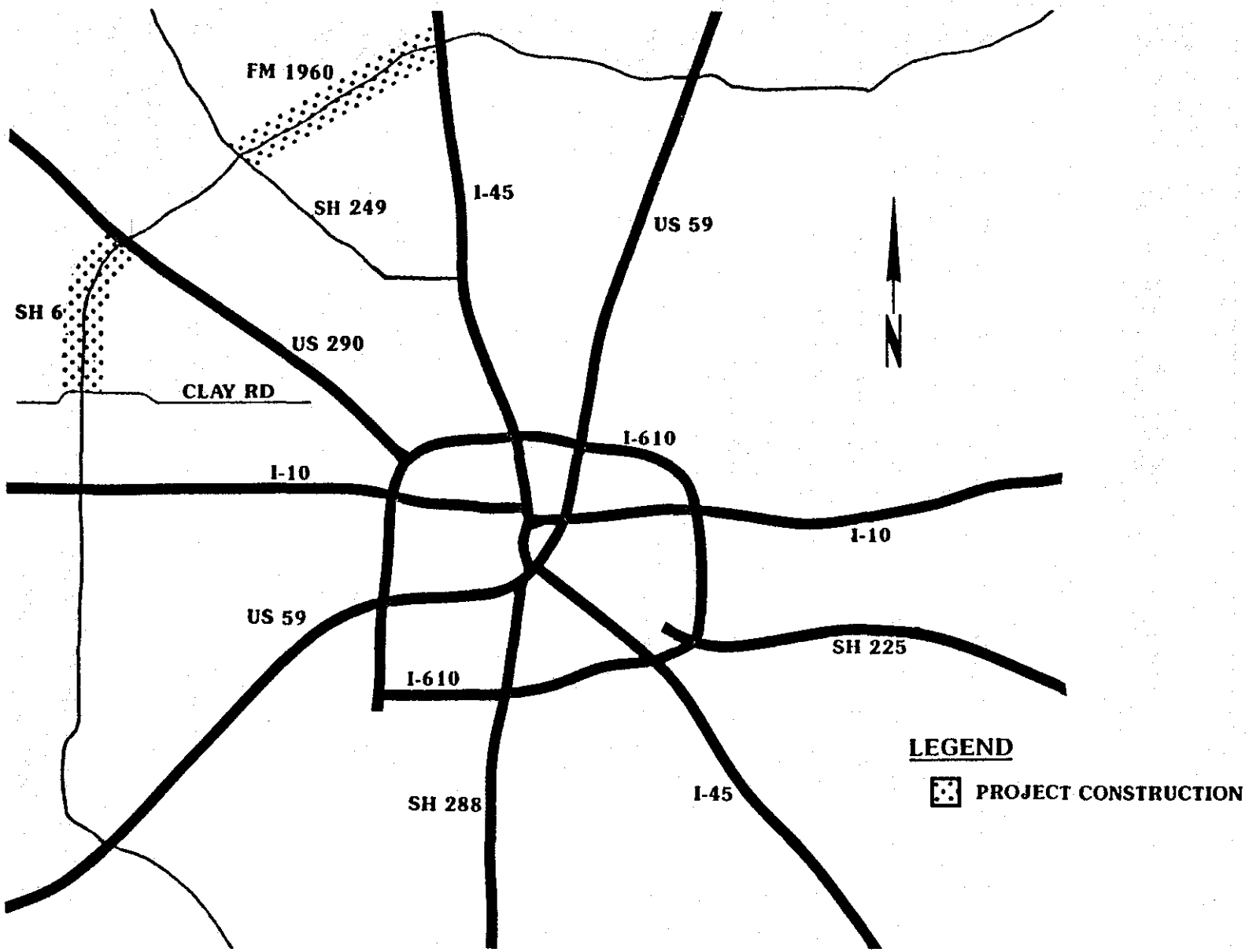

Figure 1. Houston Area Project Site Locations

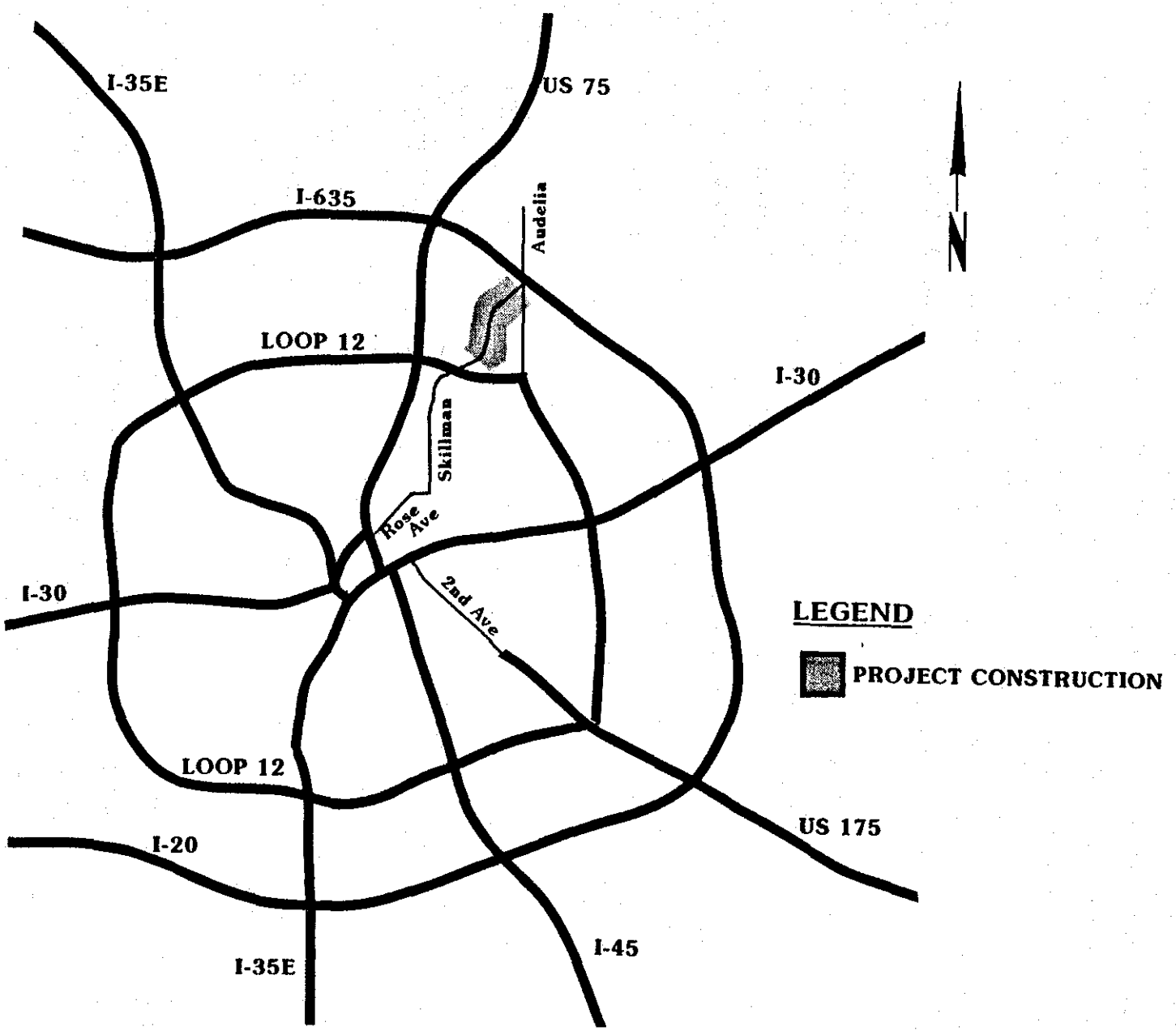

Figure 2. Dallas Area Project Site Location

Figure 3 shows F.M. 1960 before the beginning of construction. Preconstruction geometrics included two lanes in each direction with a center continuous left-turn lane. There were drainage ditches along both sides of the roadway. The completed roadway configuration will include three lanes in each direction with a center continuous left-turn lane. A storm sewer will also be constructed. The construction zone along F.M. 1960, as previously described, is highly commercial and hence there are 360 access driveways. There are a total of 50 intersections in the construction zone, of which 27 are signalized.

The F.M. 1960 construction project was split into two contracts with each lasting from three to three and a half years to complete. The contracts were to be constructed simultaneously and the sequence of construction for both contracts was divided into five phases. The Traffic Control Plan (TCP) for each phase of construction is in **Appendix A - - F.M. 1960 Traffic Control Plan**. A description of each phase of construction is given below. It should be noted that two lanes of traffic in each direction will always be provided during construction. However, there will be no center left-turn lane during construction.

Phase I - Construction on the north side of the roadway consists of overlaying the existing shoulder with temporary pavement. This is to accommodate traffic during the next two phases. Figure 4 illustrates a typical cross-section of the roadway during Phase I.

Phase II - During Phase II, all traffic was moved to the north side of the roadway. Construction on the south side of the road included new pavement and storm sewer. Figure 5 illustrates a typical cross-section of Phase II construction.

Phase III - During Phase III, construction activity was moved to the center of F.M. 1960. Eastbound traffic used the new pavement on the south side of the roadway and westbound traffic used the north side temporary pavement. Figure 6 illustrates a typical Phase III cross-section.

Phase IV - The permanent pavement on the north side of F.M. 1960 is constructed during Phase IV. All traffic is moved to the south side of the road as shown in Figure 7.

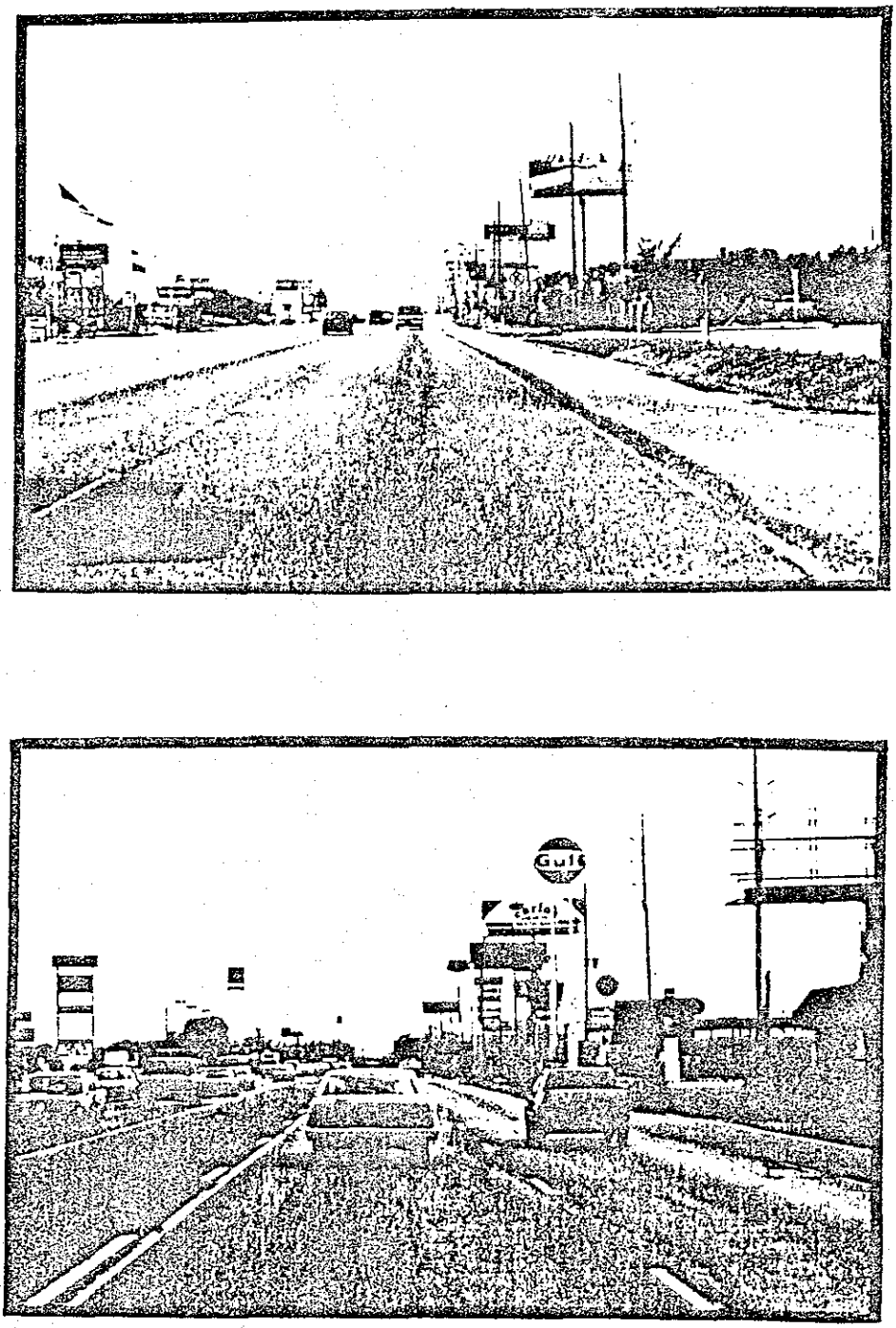

Figure 3. F.M. 1960 Preconstruction Roadway Conditions

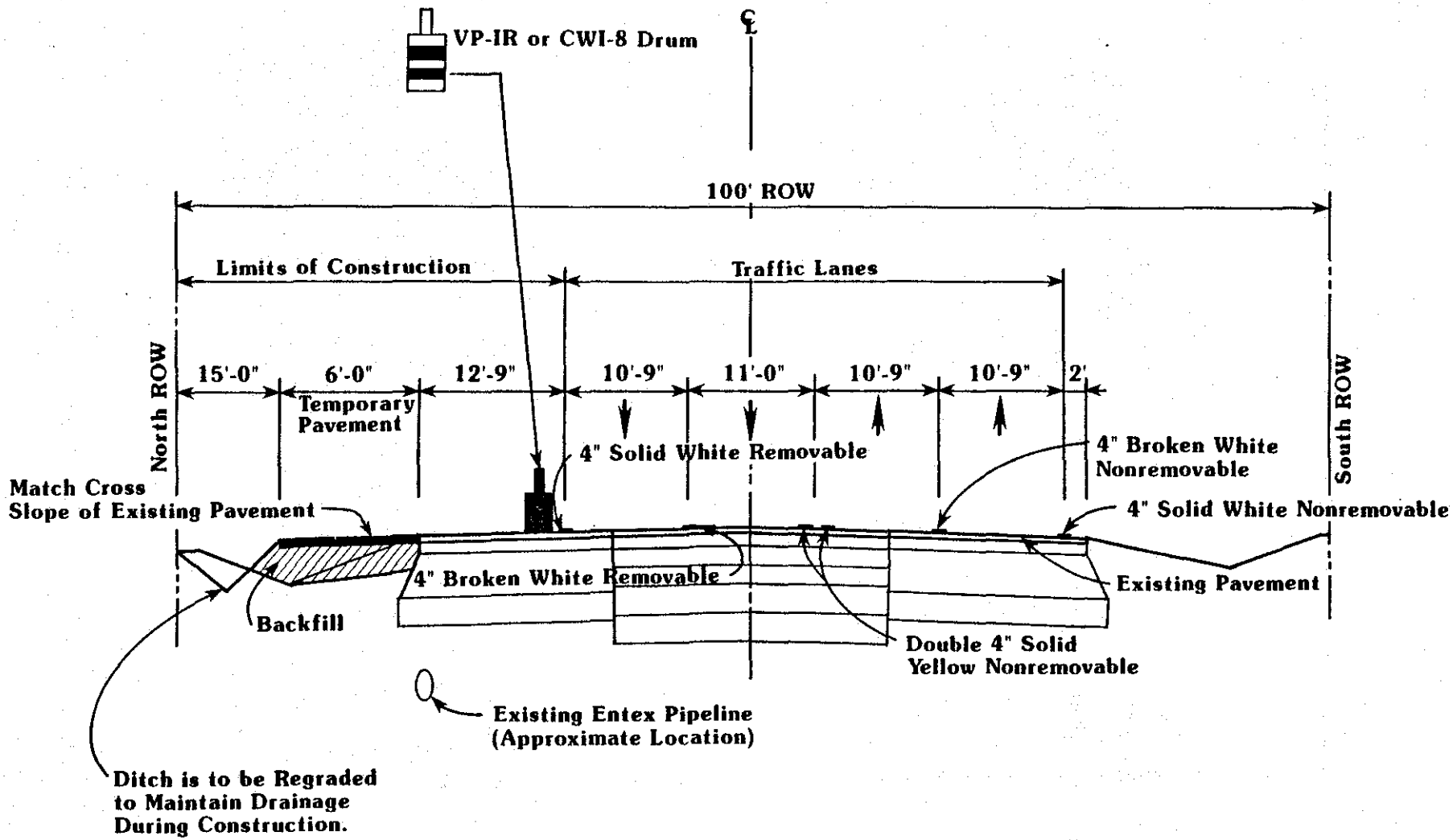

Figure 4. F.M. 1960 and S.H. 6, Phase I Construction

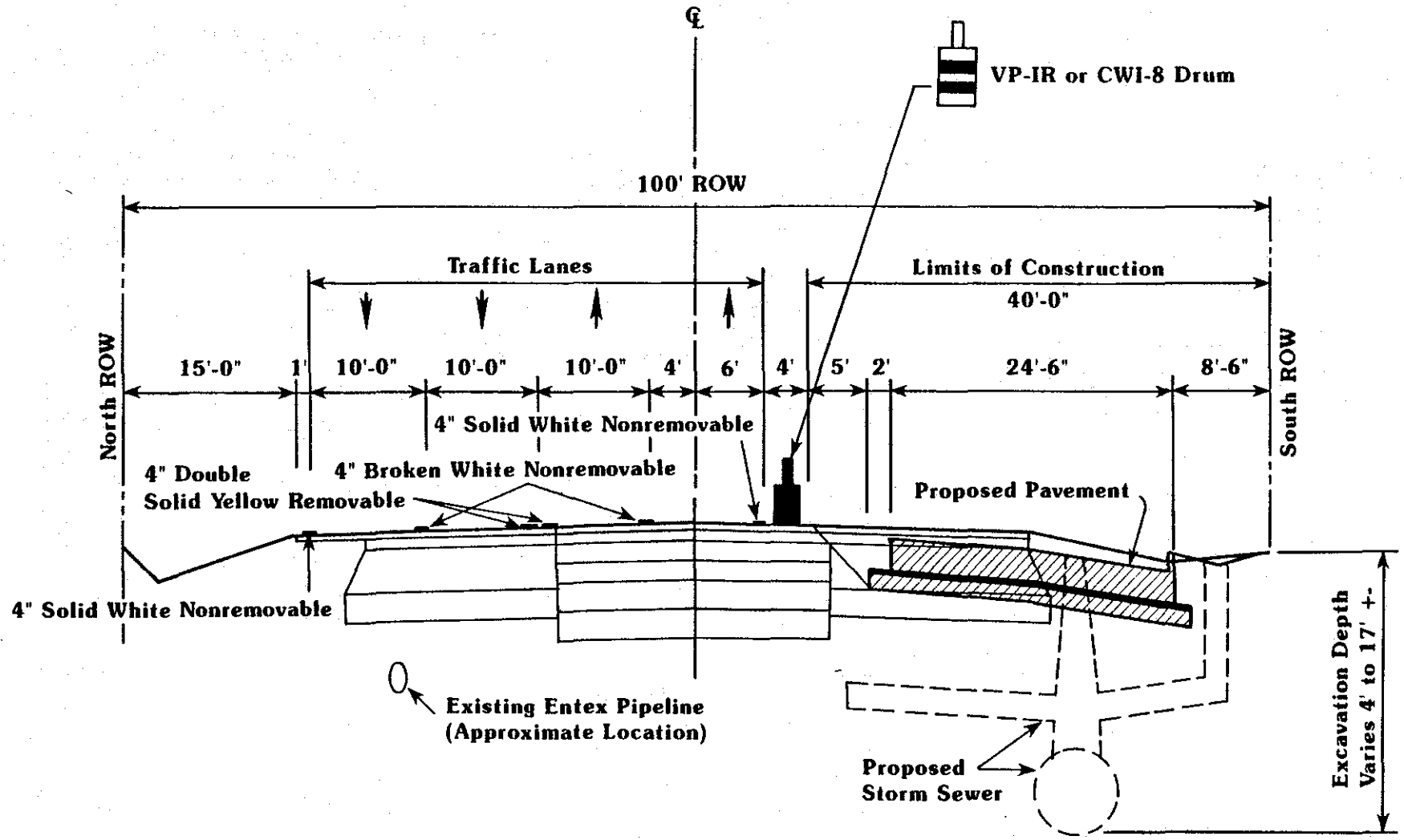

Figure 5. F.M. 1960 and S.H. 6, Phase II Construction

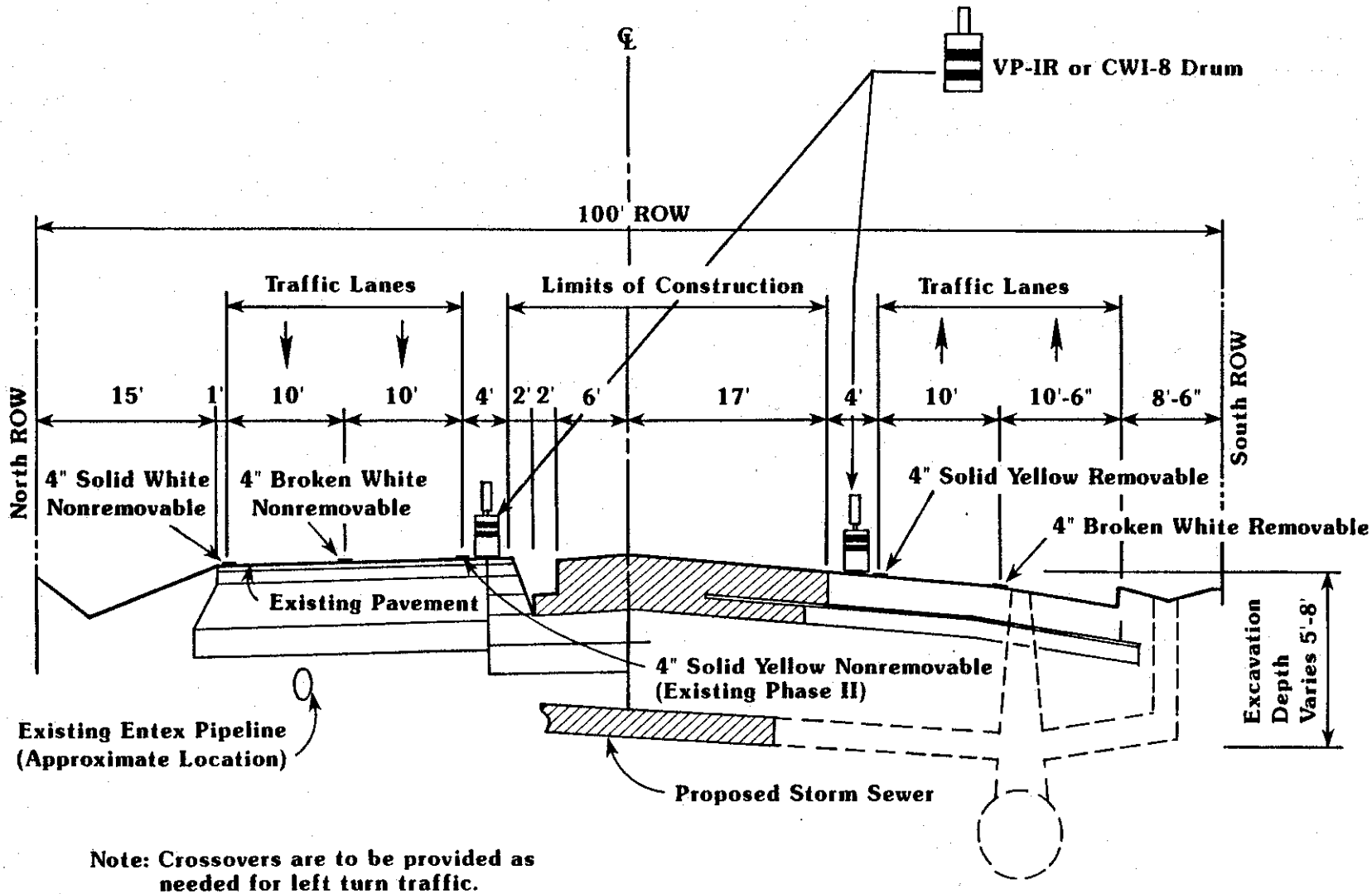

Figure 6. F.M. 1960 and S.H. 6, Phase III Construction

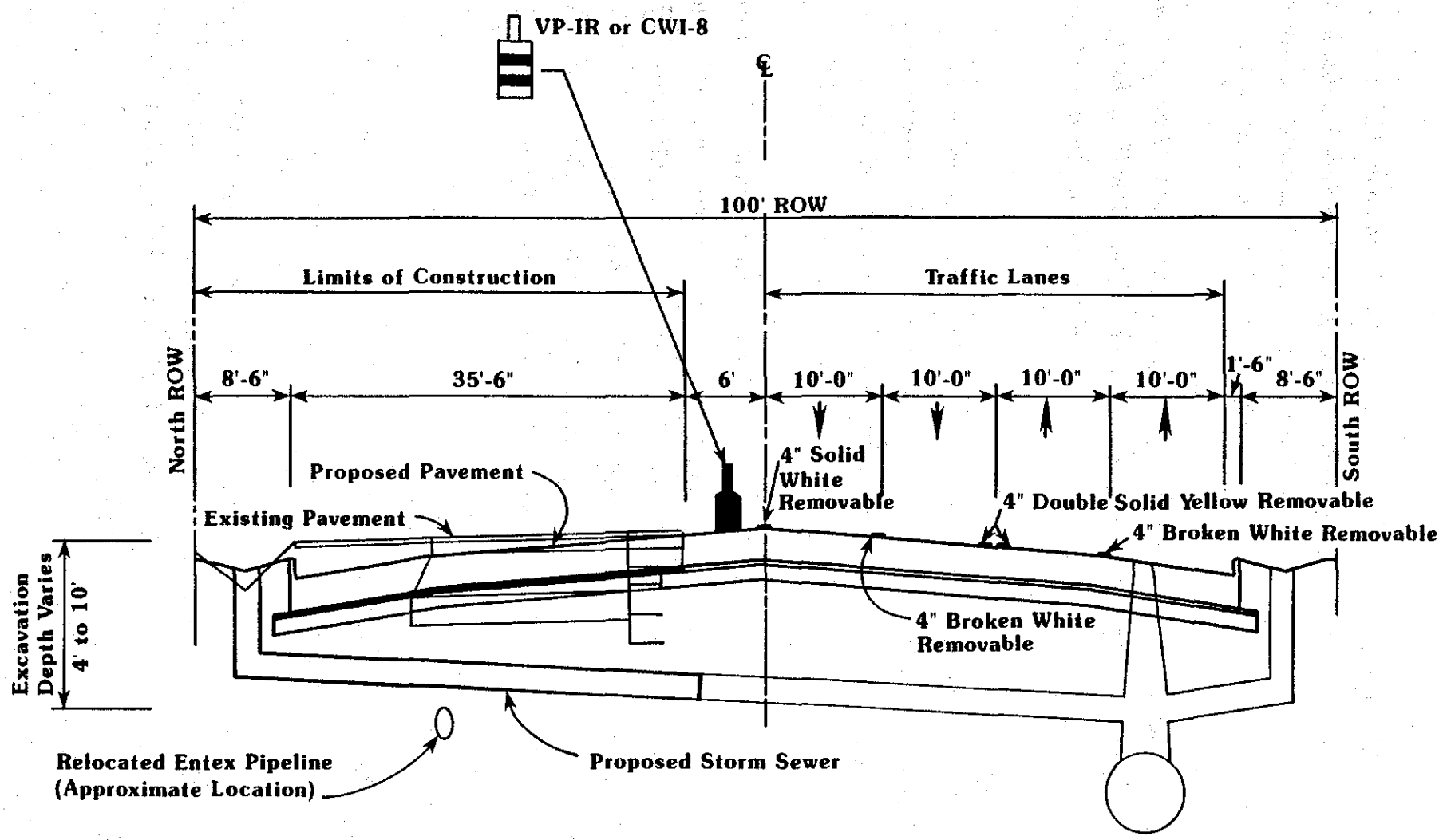

Figure 7. F.M. 1960 and S.H. 6, Phase IV Construction

Phase V - The signing and striping of the center lane are completed in Phase V. The eastbound traffic is on the south side and the westbound traffic is on the north side of F.M. 1960 as in Phase III. Figure 8 illustrates a cross-section of typical roadway conditions during this phase of construction.

Phase I construction on F.M. 1960 began in January, 1988. Phase II began in March, 1988 with the completion of Phase I. Construction was fully into Phase III by January, 1989 as Phase II was finished. At the present time, F.M. 1960 is in Phase IV of construction.

State Highway 6

Construction on S.H. 6 extends from U.S. 290 (Northwest Freeway) to Clay road, as shown in Figure 1. The length of construction on S.H. 6 is approximately three miles. Land use in the area consists of residential areas with some commercial development. The development along State Highway 6 is much less crowded than along F.M. 1960.

Figure 9 shows the State Highway 6 area before construction. Preconstruction geometrics included two lanes in each direction with a continuous center left-turn lane. There are 25 at-grade intersections, of which 11 are signalized, and 155 access driveways within the construction zone. The completed lane configuration on S.H. 6 will include three lanes in each direction with a center continuous left-turn lane. The planned time to complete the construction is three and a half years. The project is split into three segments as listed below:

Segment 1 - U.S. 290 to F.M. 529
Segment 2 - F.M. 529 to Keith Harrow
Segment 3 - Keith Harrow to Clay Road

Each segment includes five phases of construction. The description and layout of each phase is identical to that for the F.M. 1960 project with the east side of S.H. 6 corresponding to the south side of F.M. 1960. The TCP for S.H. 6 construction is located in **Appendix B -- S.H. 6 Traffic Control Plan.**

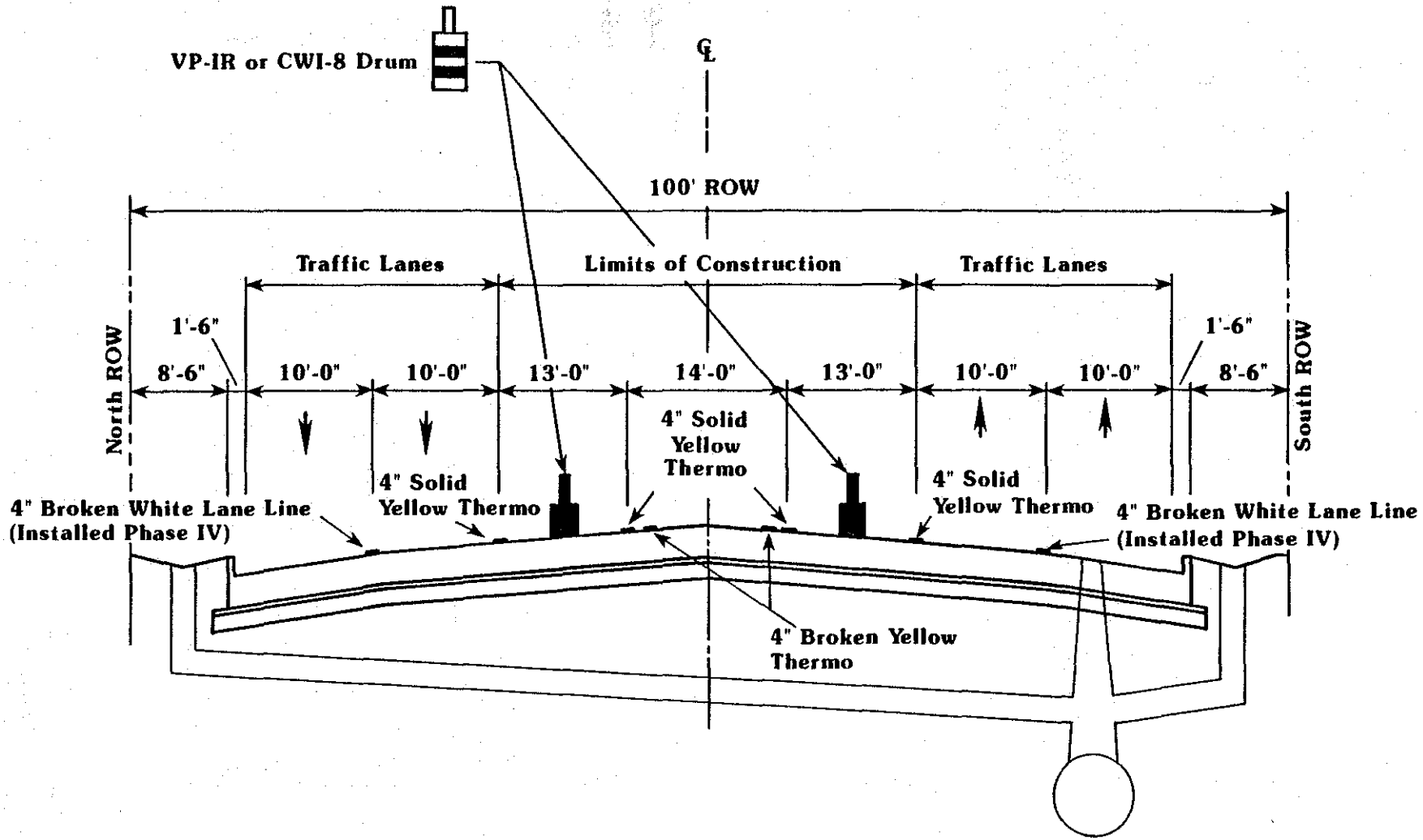

Figure 8. F.M. 1960 and S.H. 6, Phase V Construction

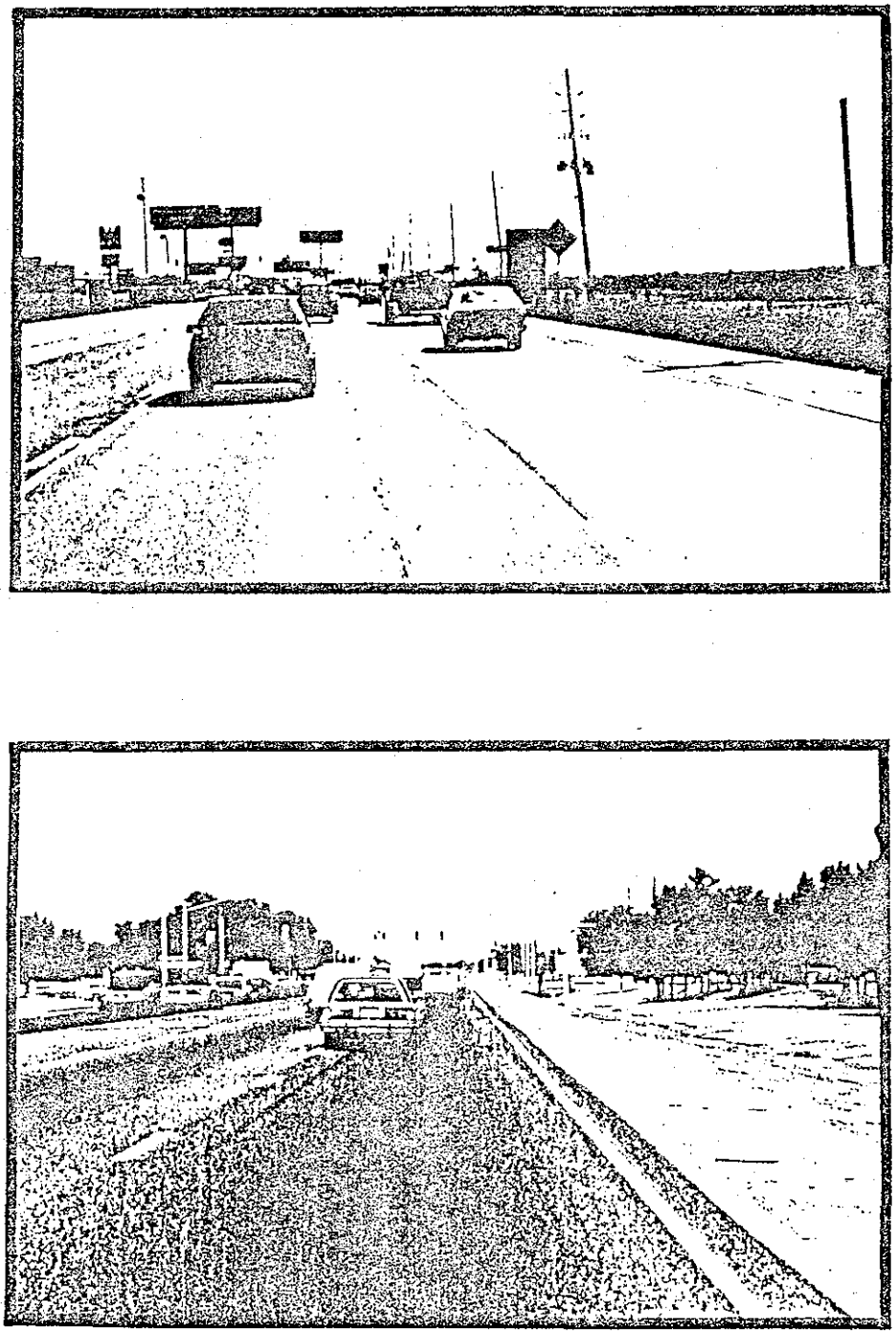

Figure 9. S.H. 6 Preconstruction Roadway Conditions

Phase I of the S.H. 6 project began simultaneously for all three segments. However, Phase II construction began in Segment 1 two months before construction in Segment 2. The construction of Phase II in Segment 3 did not begin for another three months. S.H. 6 is currently in Phase III of construction for Segment 1 and in Phase II of construction for Segments 2 and 3. The progression of construction will follow similarly to that in Phase II for the remaining phases.

Skillman Avenue

Skillman Avenue will be under construction from Merriman Parkway to Audelia, which is approximately 2.6 miles. Land use along Skillman is primarily residential. Figure 10 shows Skillman Avenue at the present time. The present lane configuration of Skillman Avenue is a four-lane rural divided arterial. The construction zone includes 11 at-grade intersections of which 4 are signalized, and 57 access driveways. The completed geometrics of Skillman Avenue will be a six-lane urban divided arterial roadway. The construction is to be completed in two years and the project is split into two segments. Segment 1 is between Merriman Parkway and Stone River Road, and Segment 2 is between Stone River Road and Audelia. Each segment is split into four phases of construction as listed below:

Phase I - During Phase I, all traffic will be moved to the west side so that the east side can be constructed. Two travel lanes will be provided in each direction. Figures 11 and 12 illustrate the cross-section view of the construction for Segments 1 and 2, respectively.

Phase II - During the west side construction in Phase II, traffic will be moved to the east side and two lanes will be provided in each direction. The construction plan is shown in Figures 13 and 14 for each segment.

Phase III - The median construction will be performed in Phase III. The northbound traffic will be moved to the east side of Skillman and southbound traffic to the west side of Skillman. Two lanes will be provided in each direction. The cross-section views of the construction plans are shown in Figures 15 and 16 for both segments.

Phase IV - The curb construction on both sides of Skillman will be completed in Phase IV.

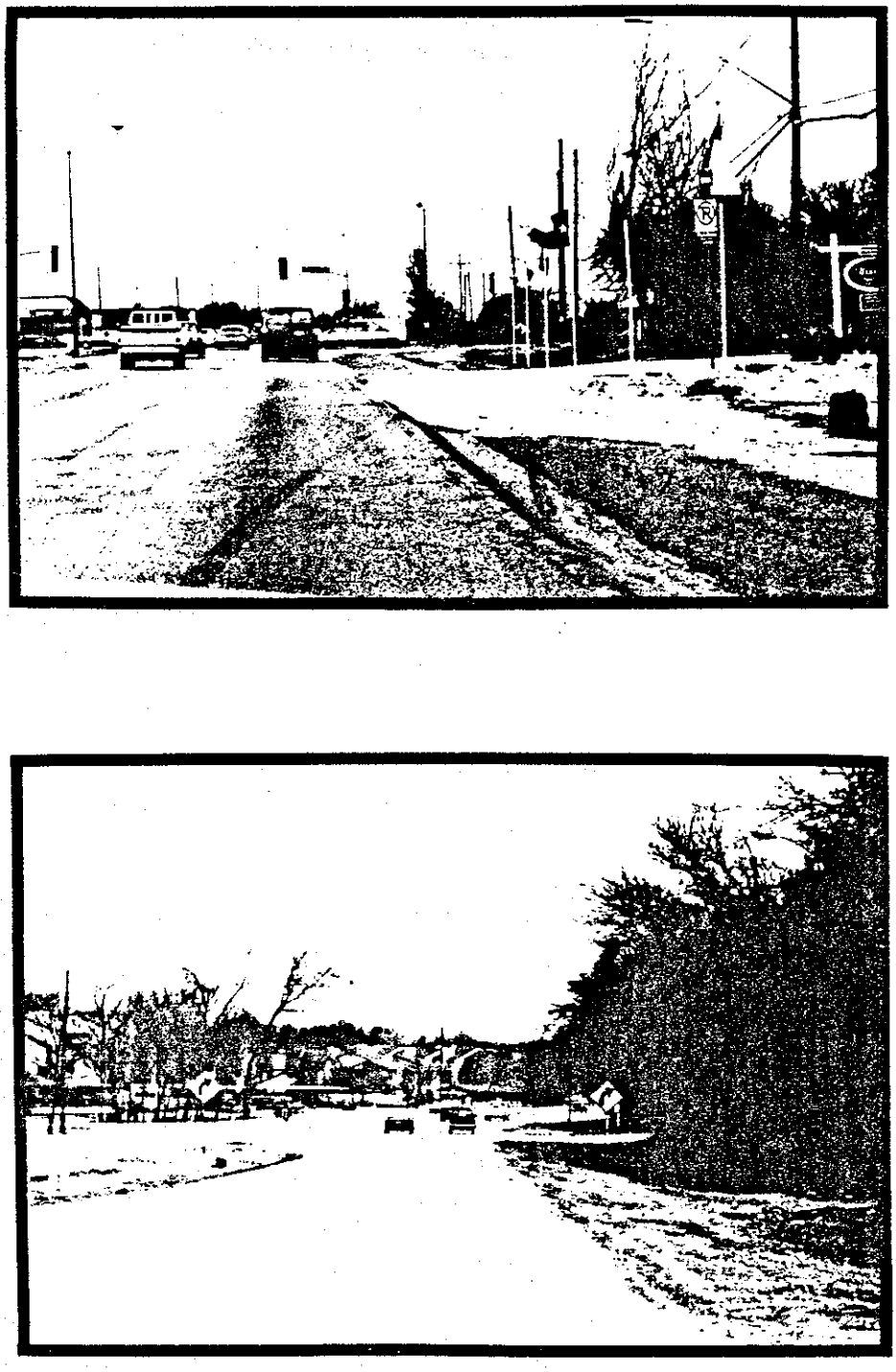

Figure 10. Skillman Avenue Preconstruction Roadway Conditions

TYPICAL SECTION SEGMENT I, PHASE I
from STA 151+50 to STA 223+00

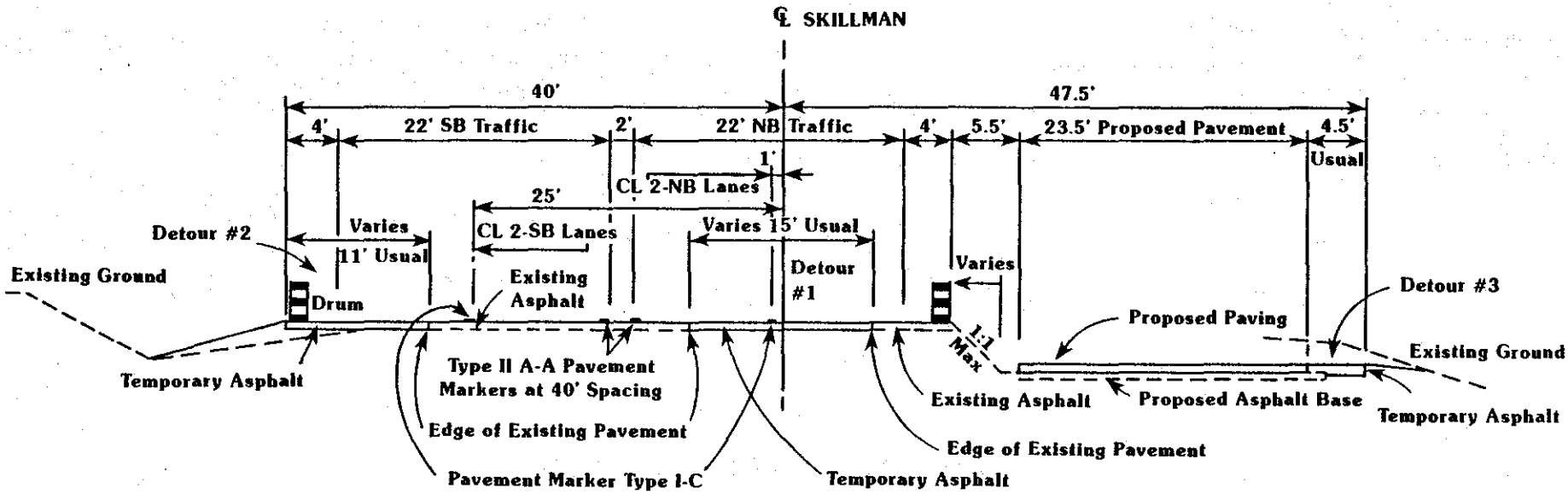

Figure 11. Skillman Avenue, Segment 1, Phase I Construction

TYPICAL SECTION SEGMENT II, PHASE I
from STA 223+00 to STA 226+50

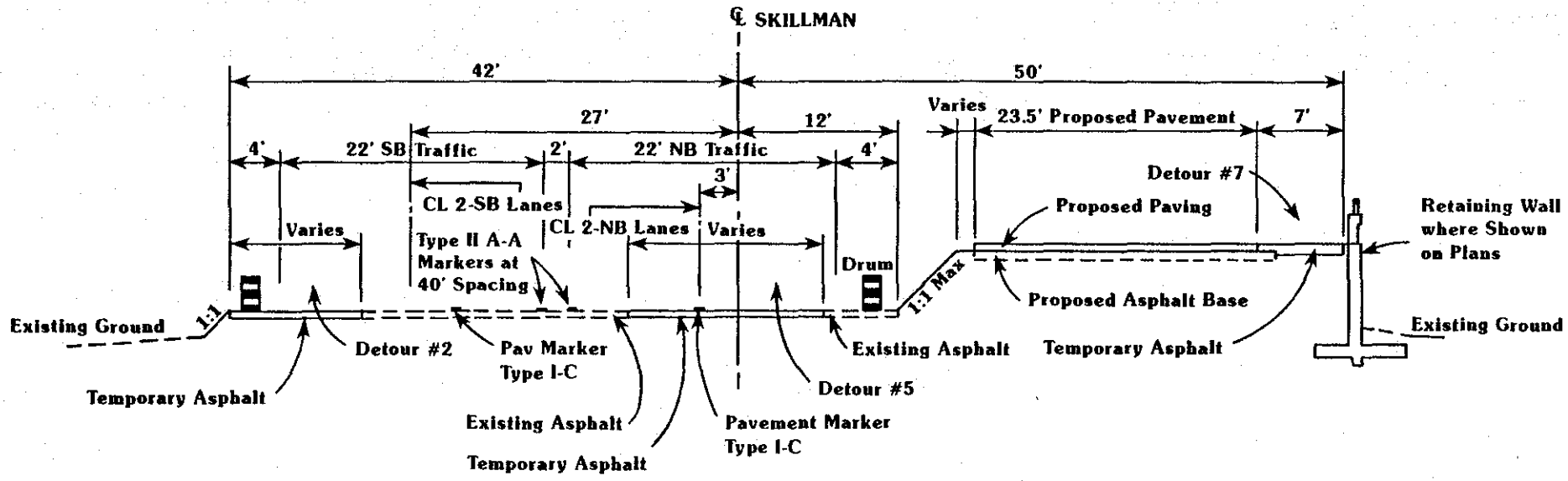

Figure 12. Skillman Avenue, Segment 2, Phase I Construction

TYPICAL SECTION SEGMENT I, PHASE II
from STA 151+50 to STA 223+00

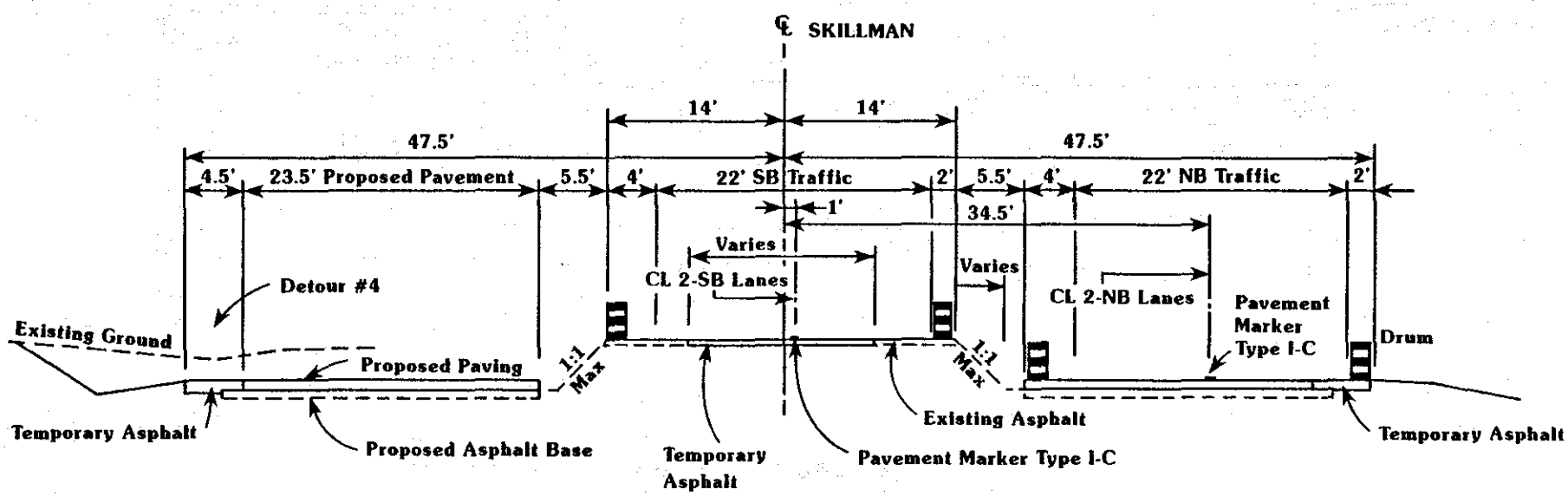

Figure 13. Skillman Avenue, Segment 1, Phase II Construction

TYPICAL SECTION SEGMENT II, PHASE II
from STA 223+00 to STA 226+50

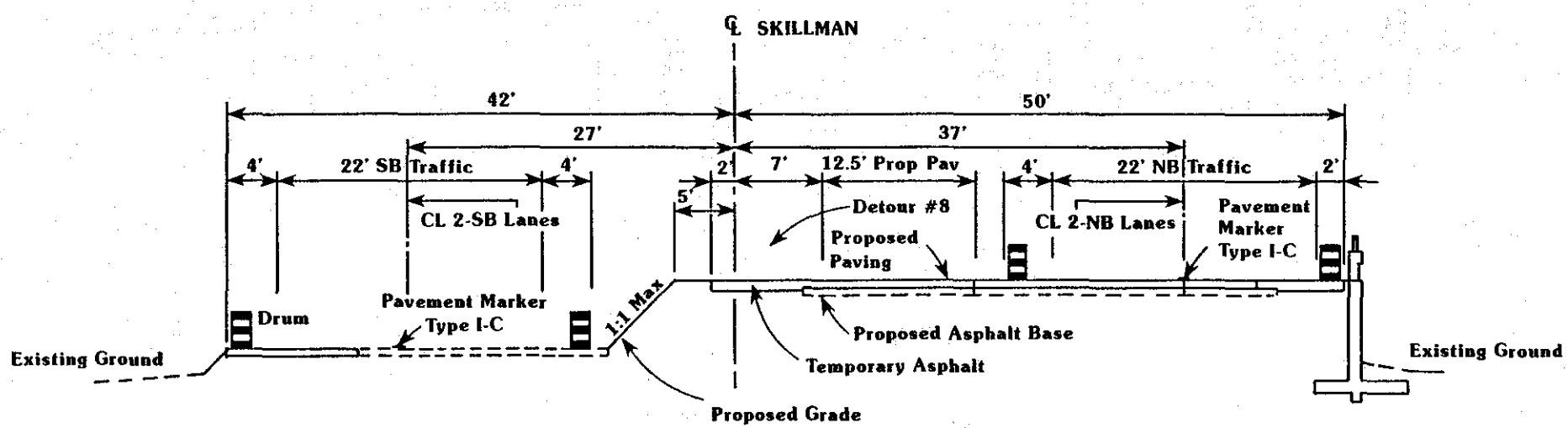

Figure 14. Skillman Avenue, Segment 2, Phase II Construction

TYPICAL SECTION SEGMENT I, PHASE III
from STA 151+50 to STA 223+00

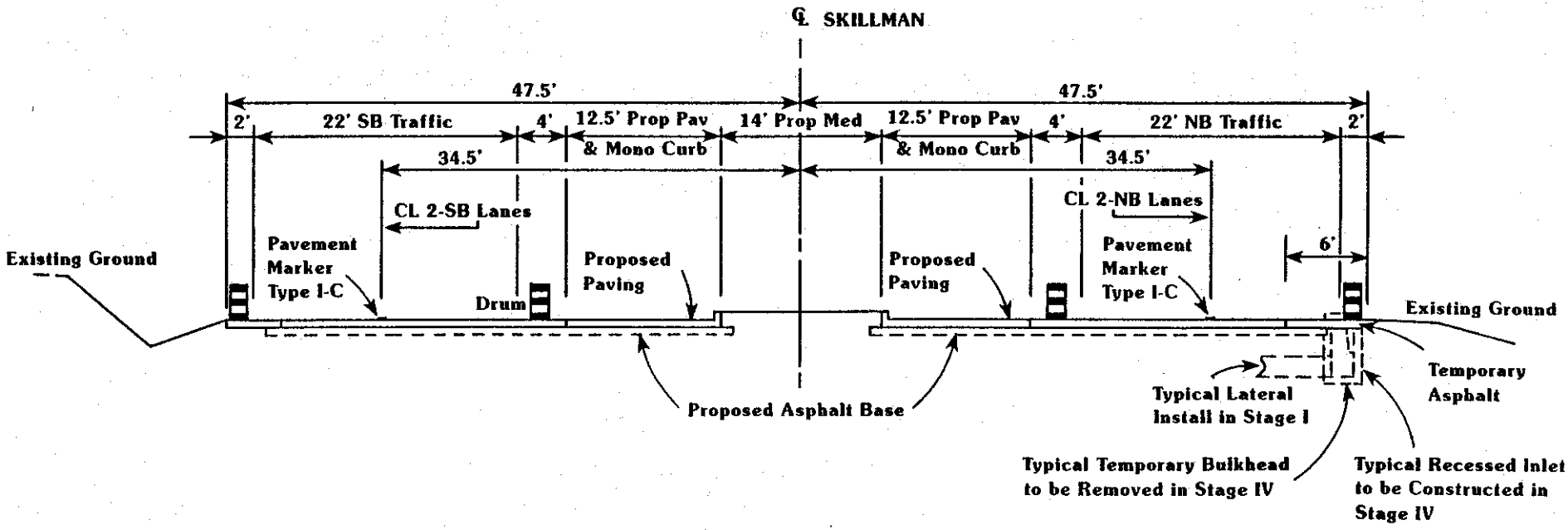

Figure 15. Skillman Avenue, Segment 1, Phase III Construction

TYPICAL SECTION SEGMENT II, PHASE III
from STA 223+00 to STA 226+50

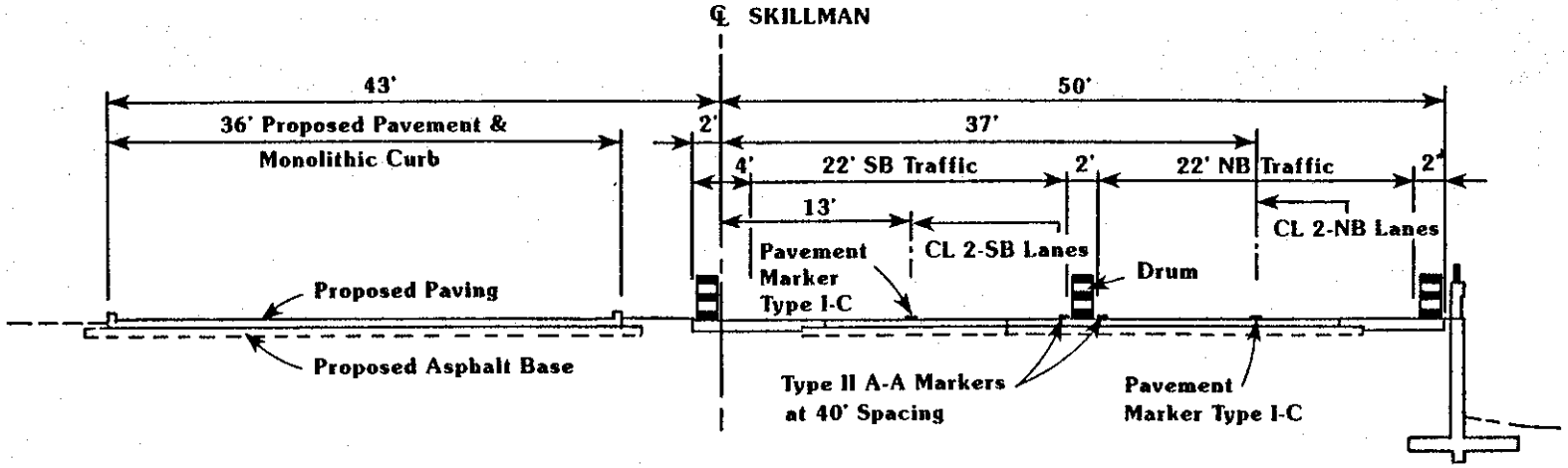

Figure 16. Skillman Avenue, Segment 2, Phase III Construction

The figures in **Appendix C -- Skillman Avenue** show the preconstruction base roadway conditions for the limits of the project. Skillman Avenue is presently not under construction. Tentatively, construction is scheduled to begin in September, 1989. It is not known if Segments 1 and 2 will be concurrently under construction.

Data Collection and Analysis

After study sites had been selected for evaluation, the data collection process began. Data collection took place both before and during the construction so that changes in traffic conditions could be documented. The data collected included such information as daily and peak hour traffic volumes, turning movement volumes, travel times, and accident history.

As previously mentioned, the F.M. 1960 project is currently in Phase IV, S.H. 6 is in Phase II and the Skillman Avenue project has not yet begun. Therefore, the most extensive data collection and analysis has been performed on the F.M. 1960 project.

F.M. 1960 Traffic Data

The F.M. 1960 project began construction (Phase I) on January 4, 1988. This phase lasted approximately two months until March 12, 1988 when Phase II began. Construction remained in Phase II for the remainder of 1988 and the project was fully into Phase III by January 5, 1989. By April 11, the entire project had transitioned to Phase IV. Construction currently remains in Phase IV.

Traffic Volumes

Automatic traffic counters were used to collect data from Monday afternoon to Friday morning in order to obtain average weekday roadway volumes during each phase of construction. Volumes on four segments of F.M. 1960 as well as at three major approaches to F.M. 1960 were counted. In most instances, two counters were placed at each location to insure accuracy against low or high-counting. Since this research study was initiated at approximately the same time as construction on F.M. 1960 began, preconstruction data was limited. However, daily traffic volumes from 1986 and 1987 were available and have been included for comparison.

A comparison of the average weekday two-way traffic volumes within the study area is illustrated in Figure 17. The general trend for traffic along F.M. 1960 shows that the volumes initially decreased at the beginning of Phase I (overlaying the north side shoulders), and then increased during Phase II (south side construction). The initial decrease in volumes may be the result of driver diversion from the construction area. The increase noted in Phase II may be indicating that motorists became accustomed to the roadway construction and have returned to F.M. 1960. During Phase III, volumes dropped again and with Phase IV, the volumes once again increased, but not to the previous preconstruction level. As Figure 6 indicates, Phase III of the project entailed construction in the center of F.M. 1960. With the construction work area in the center of the road, left-turns from both directions must pass across the work zone and visibility is hindered by the construction barrels. The delays associated with these conditions may have led motorists to choose alternate routes. Phase IV construction plans illustrate that both directions of travel are on the new pavement. This may have influenced the increase in vehicles using the facility noted on Figure 17.

Another factor that could have influenced traffic volumes in the project vicinity is the time of the year they were collected. Phases I and III occurred during the winter months when commercial activity is typically lower than during the summer months when the data for Phases II and IV were collected. As described, the F.M. 1960 construction corridor is highly commercial and the seasons may have had some bearing on the traffic volumes.

Traffic volumes along F.M. 1960 were also collected by District 12 of SDHPT. The volumes which represent Annual Average Daily Traffic are shown in Table 3 for years 1987 and 1988.

As Table 3 indicates, the average daily volumes decreased on every segment of F.M. 1960 from 1987 to 1988. With F.M. 1960 construction beginning in January 1988, this decrease in volume appears to have been attributed to the construction conditions.

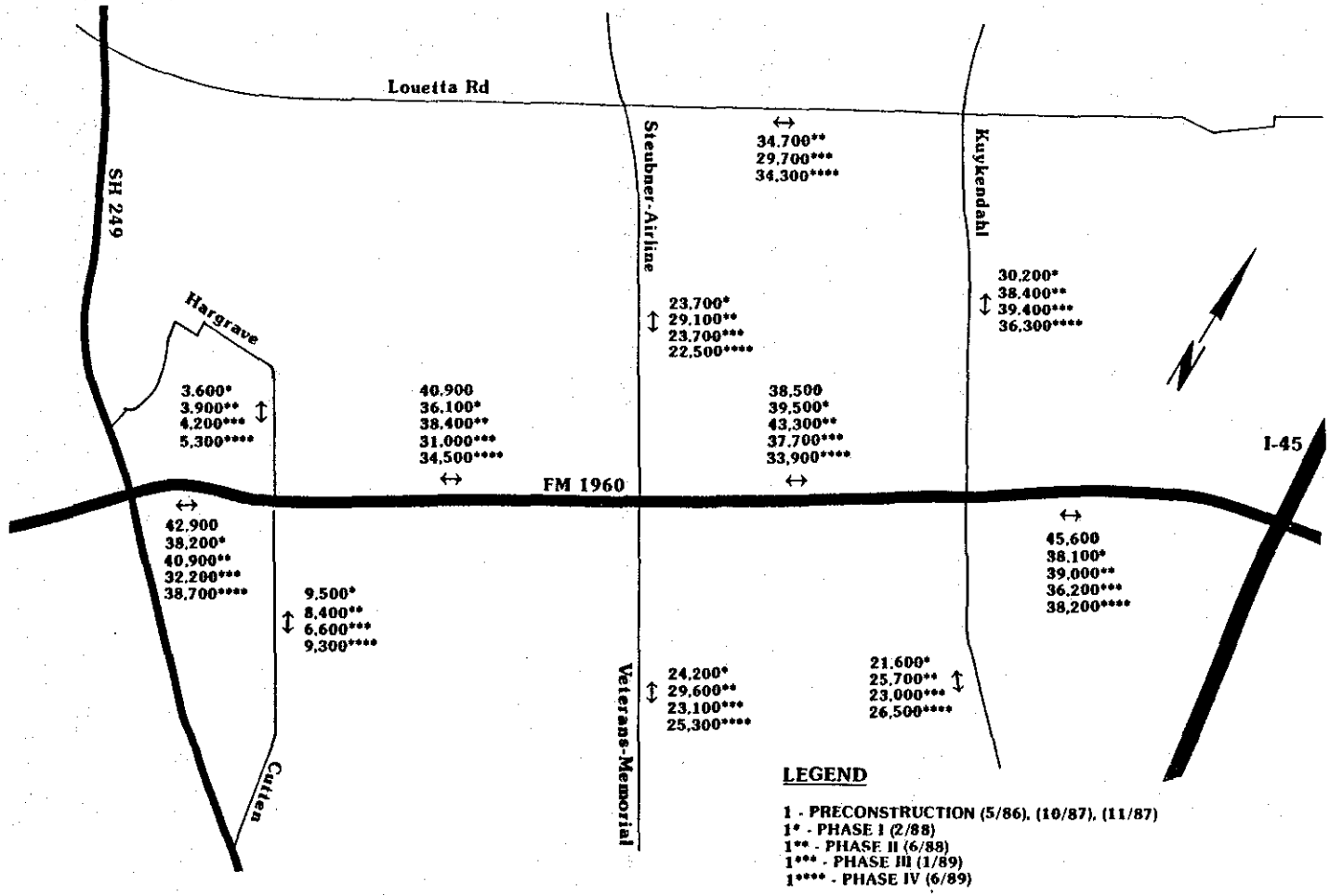

Figure 17. Average Weekday Traffic Volume, F.M. 1960

Table 3. F.M. 1960 Annual Average Daily Traffic (AADT)

Roadway Segment	AADT		% Decrease
	1987	1988	
S.H. 249 to Cutten	33,000	30,000	- 9%
Cutten to Veterans Memorial	35,000	31,000	-11%
Veterans Memorial to Kuykendahl	33,000	29,000	-12%
Kuykendahl to I.H. 45	38,000	36,000	- 5%

Source: District 12, SDHPT.

Volumes along alternate routes and approach volumes to F.M. 1960 were also collected. Figure 17 shows that the traffic volumes on Louetta, as well as on the approach streets to F.M. 1960, behaved similarly to the volumes along F.M. 1960. From Phase II to Phase III the volumes dropped and during Phase IV they increased. Some diversion to Louetta from F.M. 1960 may have occurred, but neither preconstruction nor Phase I volumes were available for comparison. Some fluctuations in volumes occurred on a few roadway segments revealing no apparent trends.

Turning movement counts were also obtained during the morning and evening peak periods and off-peak periods. The F.M. 1960 intersections which were counted include:

- Cutten Road
- Veterans Memorial (Stuebner Airline)
- Kuykendahl

These manual counts helped to verify the machine count data as well as monitor the turning movements. Figures 18 and 19 illustrate the morning and evening peak period traffic volumes for the study area. The volumes on the majority of roadway links for F.M. 1960 show a decreasing trend from preconstruction traffic levels to Phase IV for both peak periods. This drop in traffic volumes may be attributed to drivers choosing alternate routes

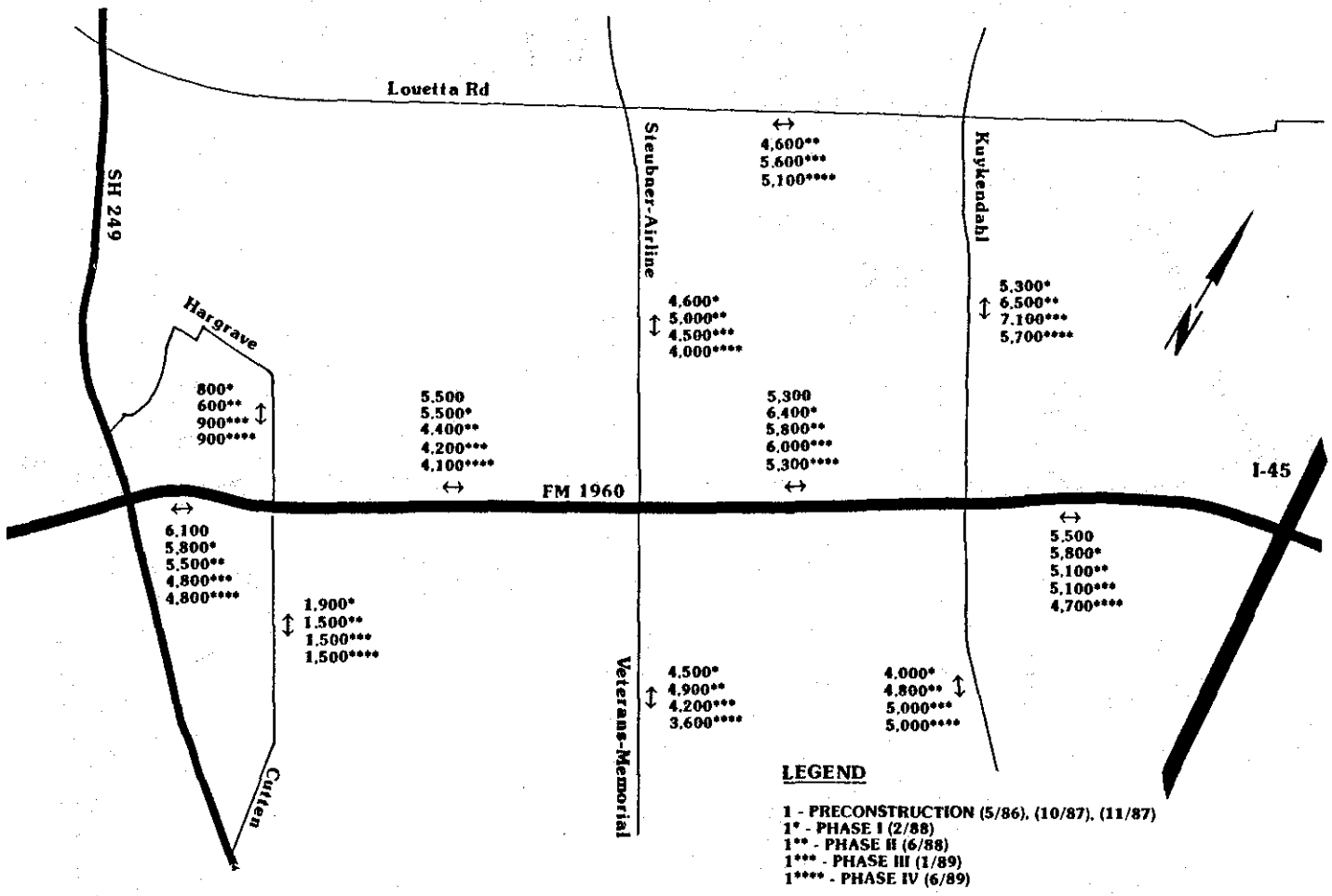

Figure 18. F.M. 1960 Area Morning Peak Period Volumes (6:00 - 9:00 a.m.)

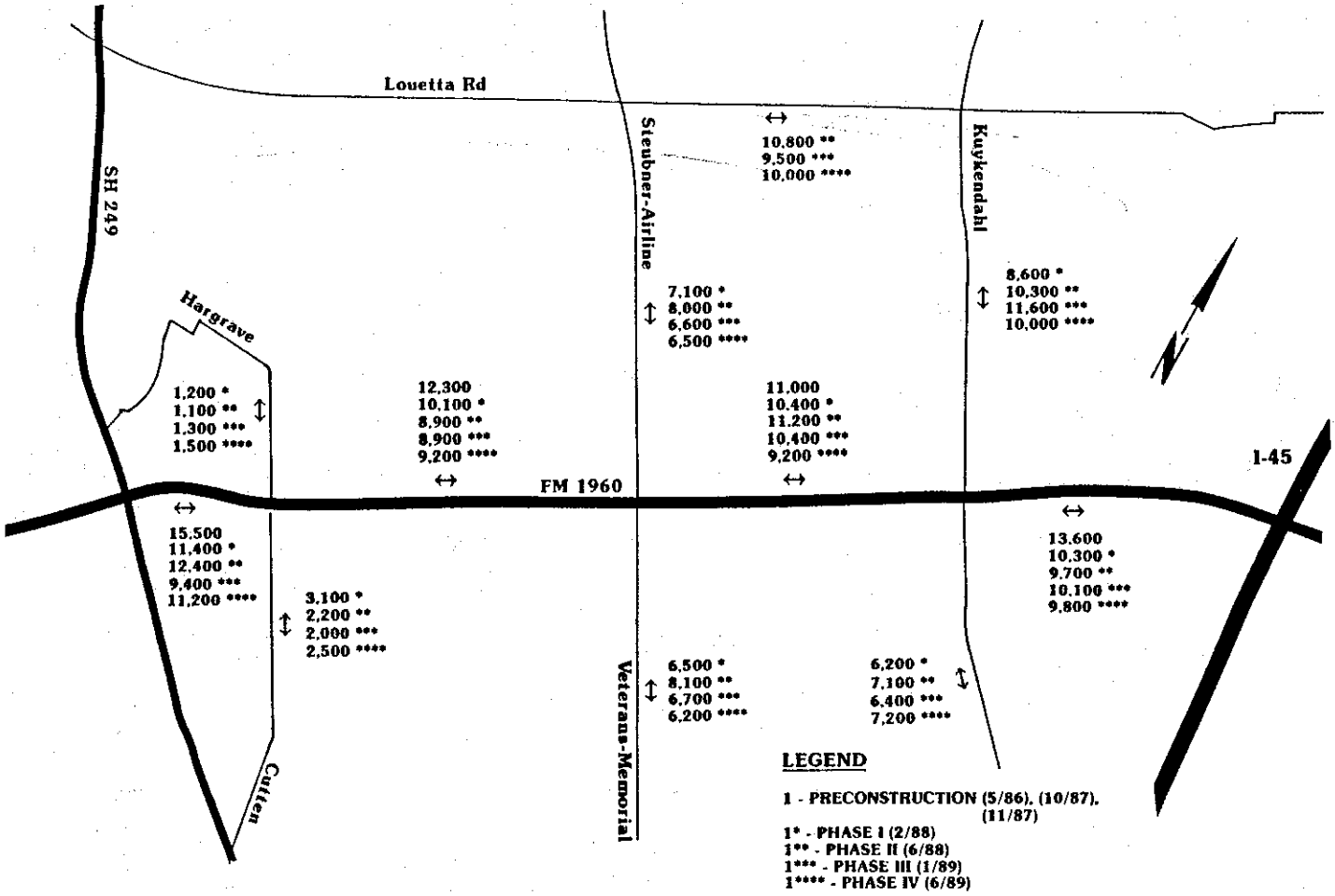

Figure 19. F.M. 1960 Area Evening Peak Period Volumes (3:00 - 7:00 p.m.)

because of the expected delays associated with roadway construction. The peak period volumes on the approach street Kuykendahl increased above Phase I level during all other phases. Since Kuykendahl, south of F.M. 1960, bends to east and intersects I.H. 45, this route may have been selected by travelers to avoid construction delays on F.M. 1960. The motorist survey subsection discusses traveler diversions.

The traffic volumes collected represent a sample from each of the construction phases. On any given day, the volumes in the F.M. 1960 area may fluctuate 5 to 10 percent. These fluctuations must be considered when examining specific data.

Travel Time Comparison

Travel time runs were also performed along F.M. 1960 during the morning peak, evening peak, and off-peak periods. As previously noted, preconstruction data is limited. Phase I information for travel times is also very limited and therefore, comparisons are based on Phases II through IV. Table 4 shows the results of the data collected.

Table 4. F.M. 1960 Travel Time Comparison

Direction	Phase	Average Travel Time During Peak Period, Minutes		
		Morning Peak	Off-Peak	Evening Peak
Eastbound	II	16.8	22.7	21.5
	III	19.8	22.5	26.1
	IV	20.7	25.7	27.8
Westbound	II	17.7	23.1	22.6
	III	17.4	21.4	23.3
	IV	19.5	25.1	26.5

As Table 4 indicates, there was an increase in travel time for both the morning and evening peak periods from Phase II to Phase III construction and also from Phase III to Phase IV for both the eastbound and westbound directions. The one exception is the morning peak period for westbound travel from Phase II to Phase III where the travel time

remained relatively constant. Delays experienced within the F.M. 1960 corridor may have occurred due to the construction zone conditions. The absence of the continuous left-turn lane appears to be the major contribution to the delays. The narrower than usual traffic lanes and presence of construction barrels also seemed to affect the driver's speed. The motorist survey included in this section explains drivers' perceptions of the F.M. 1960 construction conditions.

Accident Information

Accident information throughout the F.M. 1960 corridor from I.H. 45 to S.H. 249 was obtained for 1987 and 1988. The accident files from the Department of Public Safety were accessed and data was classified into several categories and also by milepoint. Table 5 shows the comparison by total number of accidents per year.

Table 5. F.M. 1960 Accidents by Year

Number of Accidents		Difference	% Increase
1987	1988		
727	1055	328	45%

A substantial increase in accidents was noted between 1987 and 1988 which appears to be attributable to the construction that began January 4, 1988. As shown, there was a 45 percent increase in accidents within the construction zone corridor between 1987 (preconstruction) and 1988 (Phases I and II). The 1989 accident data is not currently available. Therefore, it is not yet possible to compare the influence of Phases III and IV on accidents. This will be addressed in the second year interim report.

By examining the number of accidents occurring at each milepoint, several key intersections showed significant increases (+18 or more) from 1987 to 1988. Intersections with a number of accidents included Cutten Road, Glen Erica, Stuebner Airline, T.C. Jester, Kuykendahl, and Red Oak Road. A summary of the number of accidents occurring at or near intersections or driveway related is shown in Table 6.

Table 6. F.M. 1960 Traffic Accidents by Location

Location	1987	1988	Difference	% Increase	% of Total
At Intersection	203	338	135	67%	41%
Intersection Related	124	138	14	11%	4%
Driveway Access	224	304	80	36%	25%
Non Intersection	176	275	99	56%	30%
Total	727	1055	328	45%	100%

Table 6 indicates that 45% of the total accident increase occurred at intersections or were intersection related. The absence of the continuous center left-turn lane may have contributed to this increase in accidents. Another possible influence may have been the steep grades associated with some intersections and driveways along F.M. 1960. During Phase II, Phase III, and Phase IV construction, there were differences in elevation between the new pavement and the preconstruction roadway elevations. When vehicles crossed the area with the grade change, they sometimes approached at a steep grade and visibility was decreased.

The accident data was also classified by type of accident. A tabulation of the accidents by type and a comparison between the two years is shown in Table 7. As Table 7 indicates, the angle type accident occurred most frequently during both years and makes up the highest percentage of the total number of accidents. Rear-end accidents also make up a significant portion of the total accidents. The absence of the left-turn lane appears to be a contributing factor for the increase in these types of accidents.

Although the sideswipe type of accident shows the least frequency, it is apparent that the large increase from 1987 to 1988 is of significance. The roadway construction conditions for Phases I and II place the eastbound and westbound traffic lanes adjacent to each other with no barrier to separate them. The width of the travel lanes was also decreased. These conditions may have influenced the increase in number of sideswipe accidents.

Table 7. F.M. 1960 Accidents by Type

Type of Accident	1987	1988	Difference	% Increase	% of Total
Angle	262	357	95	36%	29%
Rear-End	260	332	72	28%	22%
Sideswipe	32	82	50	156%	15%
Other	173	284	111	64%	34%
Total	727	1055	328	45%	100%

The accident data was also categorized to determine the factors contributing to the accidents. Table 8 shows this data comparison. Table 8 indicates that the majority of accidents occur because of no apparent contributing factor. A high number of accidents occurred with failure to yield right-of-way as a contributing factor. Included in this category are:

- Disregarding stop sign or stop beacon.
- Disregarding traffic signal.
- Disregarding flashing yellow signal.

Table 8. F.M. 1960 Accidents by Contributing Factor

Contributing Factor	1987	1988	Difference	% Increase
No Factor Applies	348	570	222	64%
Speeding	115	128	13	11%
Failure to Yield ROW	193	312	119	62%
Other	4	9	5	125%
Total	660	1019	359	54%

During the first year of the study, accidents were analyzed for a one year period before construction (1987) and a one year period during construction (1988). The accident data indicates an increase in accidents after construction began. This increase in accidents may be attributable to a number of factors. Some of those factors which have been identified in the preliminary analysis include the absence of a left-turn lane, eastbound and westbound traffic lanes unseparated by barrier, a high number of driveways, and roadway transitioning from one phase of construction to another. While these factors are not uncommon to urban arterials, their impacts during urban arterial construction have not been addressed.

Future efforts will attempt to identify the impact of these factors on the accident rate and include analysis of accident data from other years in order to better determine the relationship between accidents and construction.

State Highway 6 Traffic Data

The phase changes that occurred for the S.H. 6 construction project are shown in Table 9. Segments 2 and 3 are scheduled to begin Phase III in September and October 1989, respectively.

Table 9. S.H. 6 Construction Schedule

Phase	Segment	Date of Construction
I	1	September 1988-October 1988
	2	September 1988-December 1988
	3	September 1988-March 1989
II	1	October 1988-August 1989
	2	December 1988-September 1989*
	3	March 1989-October 1989*
III	1	August 1989-completion
	2	September 1989*-completion
	3	October 1989*-completion

* Scheduled Phase Change

Traffic Volumes

The two-way average weekday traffic volumes for the S.H. 6 project area are shown in Figure 20. As indicated, preconstruction data is limited to one roadway segment volume collected in 1985 south of Clay Road. The Phase I volumes do not represent a significant change from this preconstruction volume. However, the construction conditions in Phase II appear to have contributed to fewer vehicles traveling on S.H. 6. The daily volumes have decreased on every segment. More specifically, the volume between West Road and F.M. 529 decreased by 18%, the volume between West Little York and Keith Harrow decreased by 17% and the volume south of Keith Harrow decreased by 13%.

The morning and evening peak period volumes for S.H. 6 are illustrated on Figures 21 and 22. These figures show a decrease in volume from preconstruction to Phase I as well as from Phase I to Phase II. The construction characteristics discussed for F.M. 1960 are assumed to have also affected the traffic volumes on S.H. 6. Included in these are the absence of the center left-turn lane, presence of construction barrels, adjacent north- and southbound travel lanes, and narrower lanes.

Travel Time Comparison

Travel time runs were collected during Phases I and II construction. Table 10 shows the comparison during the three time periods.

Table 10. State Highway 6 Travel Time Comparison

Direction	Phase	Average Travel Time During Peak Period, Minutes		
		Morning Peak	Off-Peak	Evening Peak
Northbound	I	23.7	24.7	25.3
	II	25.9	24.5	27.5
	% Change	+ 9%	- 1%	+ 9%
Southbound	I	24.9	22.7	25.2
	II	27.2	24.1	26.1
	% Change	+ 9%	+ 6%	+ 4%

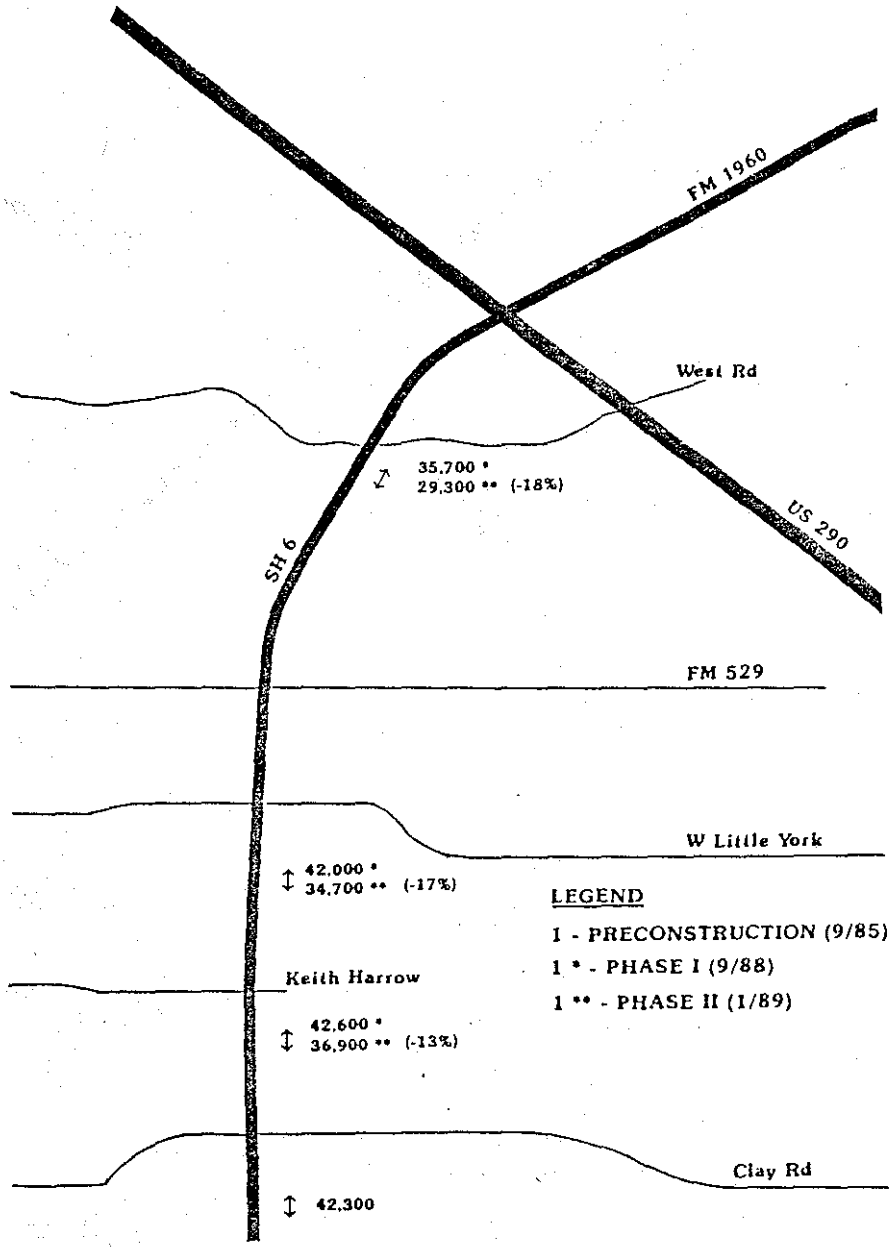

Figure 20. Average Weekday Traffic Volumes, S.H. 6

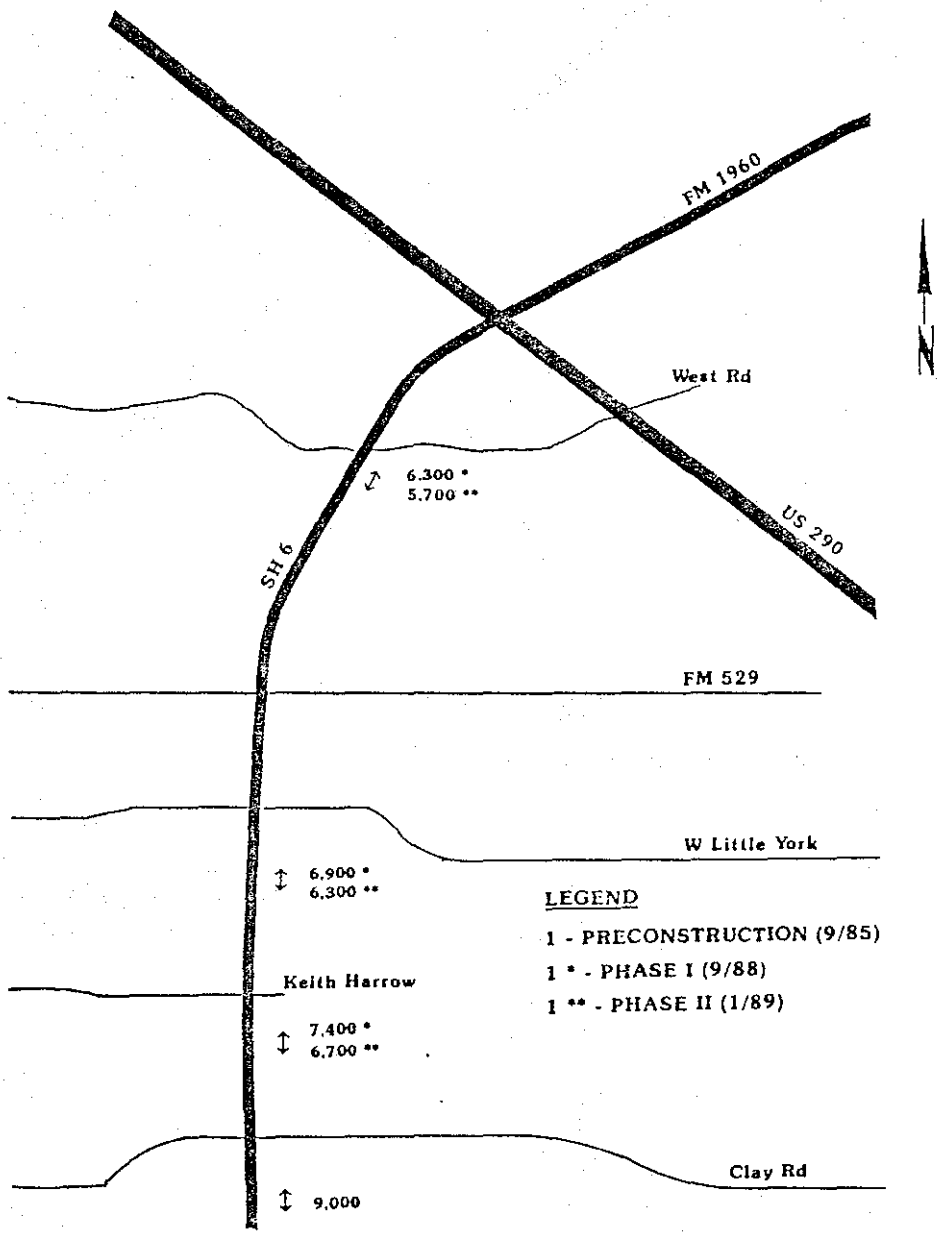

Figure 21. S.H. 6 Morning Peak Period Volumes (6:00 - 9:00 a.m.)

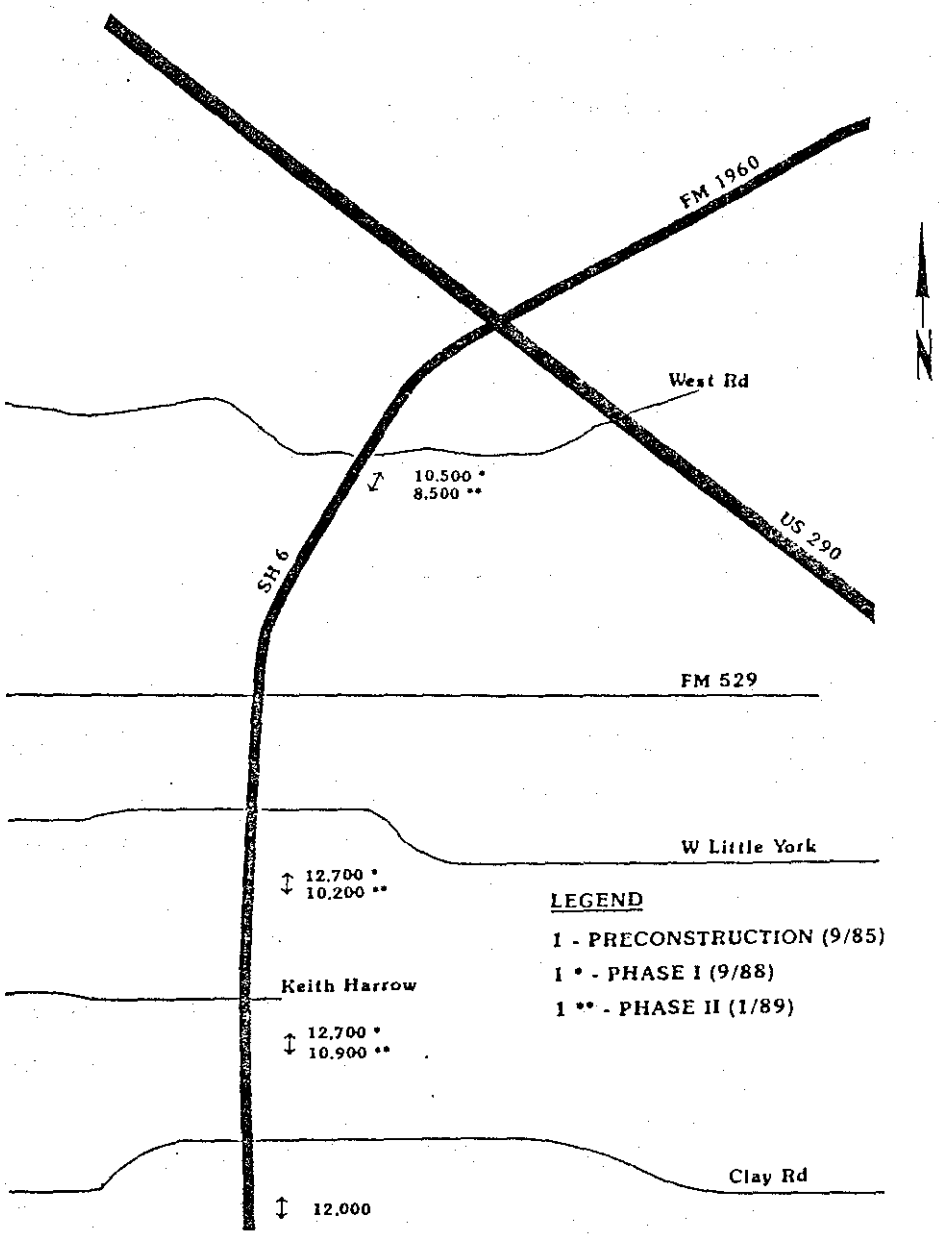

Figure 22. S.H. 6 Evening Peak Period Volumes (3:00 - 7:00 p.m.)

As Table 10 indicates, the average time for northbound travel on S.H. 6 increased by 9% in the morning and evening peak periods. There was no significant effect on northbound travel during the off-peak period. The southbound direction experienced an average increase in time of 9%, 4% and 6% for travel in the morning, evening and off-peak periods, respectively. The conditions for Phase II construction are more complex than for Phase I. As previously described, Phase I consists of overlaying temporary pavement on the southbound shoulder. Phase II is the construction of the northbound travel lanes which introduces more conflicts in the construction zone. Travelers in the area could have been slowed down by this construction activity. The increase in time for travel through the construction corridor may also have been attributed to the narrower lanes associated with Phase II. As shown in Figures 4 and 5, Phase I travel lanes are 10'-9" or 11'-0" and Phase II travel lanes are 10'-0".

Accident Information

Accident data for the S.H. 6 construction zone was obtained in the same manner as that for F.M. 1960. As previously described, the S.H. 6 construction zone only has 155 access driveways compared with the 360 along the F.M. 1960 corridor. The right-of-way constraints are also not as severe along S.H. 6 as they are along F.M. 1960. The retail and commercial developments are built further back from the roadway. These variables create less hazardous construction area conditions than those along F.M. 1960 because there are fewer points of conflict.

As construction on S.H. 6 began in September, 1988, Table 11 compares the accident data from September through December, 1987 with similar data for 1988.

Table 11. State Highway 6 Accidents by Year

Total Accidents, September-December		Difference	% Increase
1987	1988		
84	133	49	58%

As indicated by Table 11, there was a 58% increase in the number of accidents for the four months representing S.H. 6 construction in 1988 from the same four months in 1987. The elimination of the continuous center left-turn lane could have contributed to this increase in accidents. For further investigation, the accidents were divided up into those which occurred at intersections, at driveway access points or at other locations. These are summarized in Table 12.

Table 12. State Highway 6 Accidents by Location

Location	1987 Sept.-Dec.	1988 Sept.-Dec.	Increase	% Increase	% of Total
At Intersection	18	33	15	83%	31%
Intersection Related	17	23	6	35%	12%
Driveway Access	31	44	13	42%	26%
Non-Intersection	18	33	15	83%	31%
Total	84	133	49	58%	100%

Table 12 indicates that the "At Intersection" location experienced an 83% increase in the four months of data available for during construction. Accidents were also summarized by accident type. Table 13 shows this comparison.

Table 13. State Highway 6 Accidents by Type

Type of Accident	1987 Sept.-Dec.	1988 Sept.-Dec.	Increase	% Increase	% of Total
Angle	27	43	16	59%	33%
Rear-End	31	50	19	61%	39%
Sideswipe	4	7	3	75%	6%
Other	22	33	11	50%	22%
Total	84	133	49	58%	100%

As shown in Table 13, the rear-end type accident was the most frequently occurring type for both preconstruction and during construction time frames. The angle and sideswipe types both increased as well. It appears that the construction conditions of no center left-turn lane and adjacent north and southbound travel lanes may have contributed to the increase in accidents. Further examination of accidents during construction will be performed when more data (i.e., 1989) is made available.

Skillman Avenue Traffic Data

As previously discussed, the Dallas project site was not under construction at the time this report was written. Preconstruction data has been collected and Figure 23 illustrates the average weekday volumes for February 1989. Skillman Avenue is currently carrying approximately 27,000 vehicles per day on this section under study. Figures 24 and 25 show the morning and evening peak period volumes collected.

Travel time runs were also performed in February, 1989 to measure preconstruction activity. Table 14 shows the results of the data collected during the three time periods.

Table 14. Skillman Avenue Preconstruction Travel Time

Direction	Average Travel Time During Peak Period (Minutes)		
	Morning Peak	Off-Peak	Evening Peak
Northbound	4.6	5.3	6.2
Southbound	3.9	4.0	4.7

Table 14 indicates that the average travel time for the northbound direction is consistently greater than that for the southbound. This preconstruction traffic data will be compared with construction data in the next interim report. In addition, accident information will be researched and analyzed for comparison.

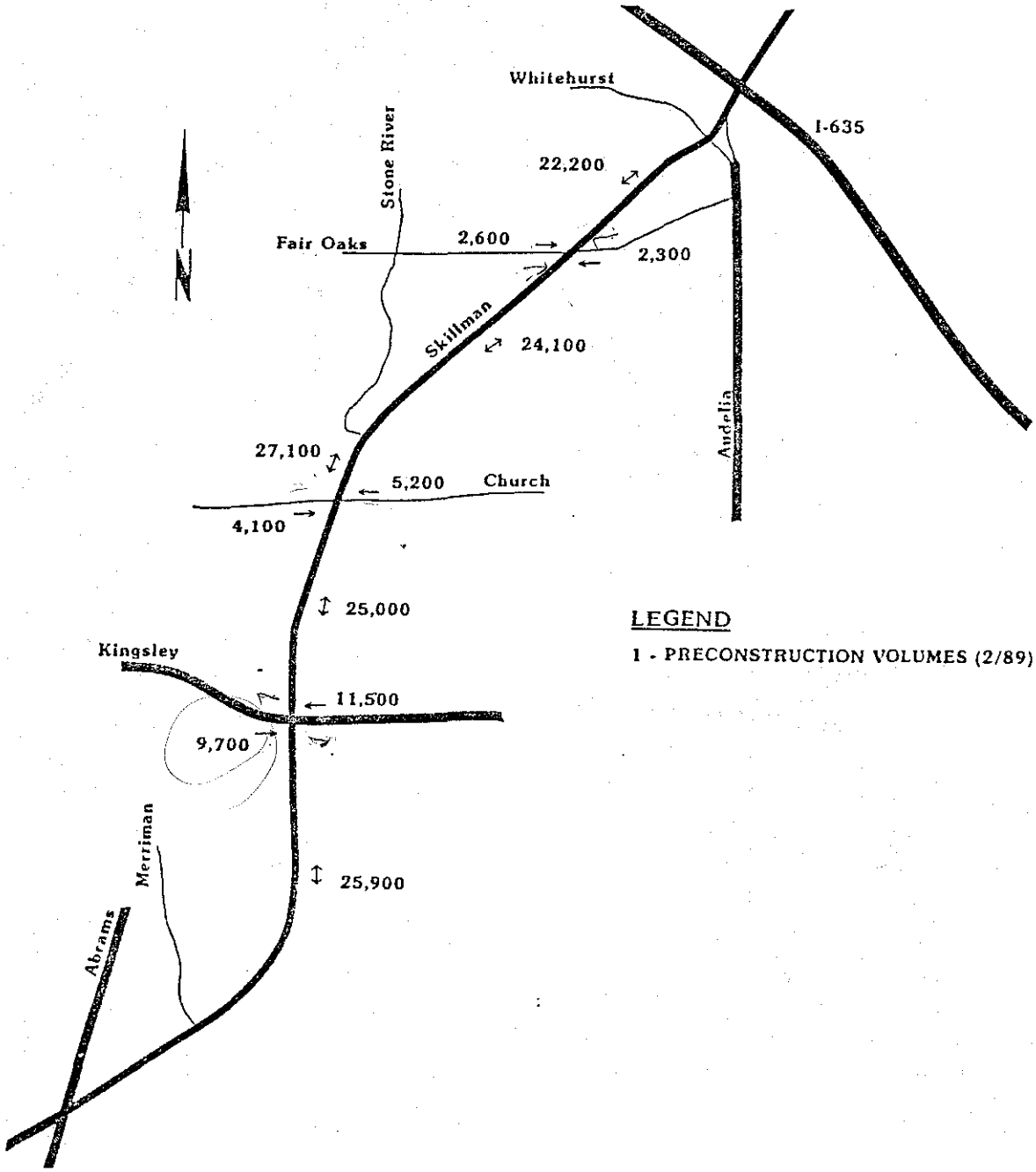

Figure 23. Average Weekday Traffic Volumes, Skillman Avenue

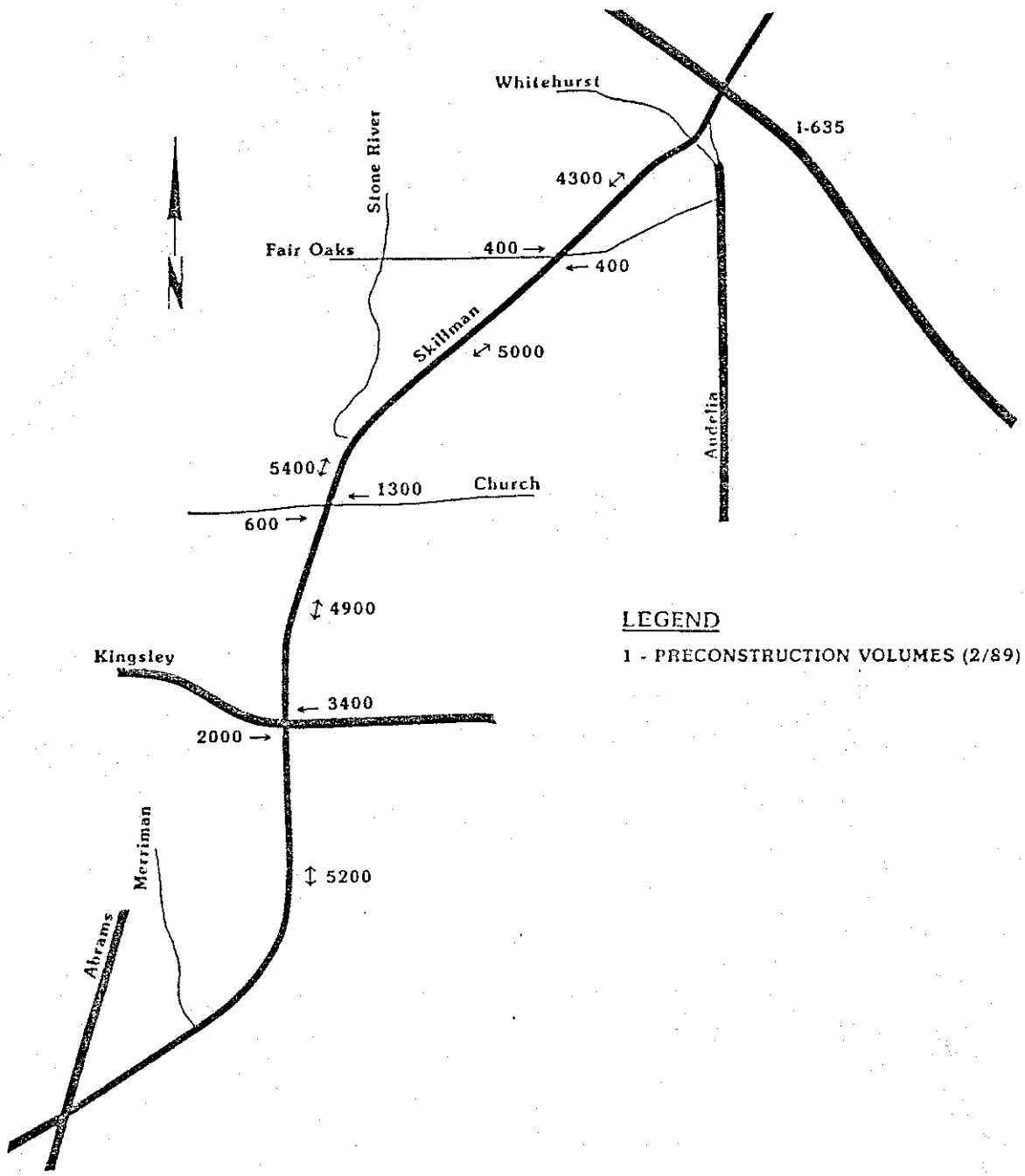

Figure 24. Skillman Avenue Morning Peak Period Volumes (6:00 - 9:00 a.m.)

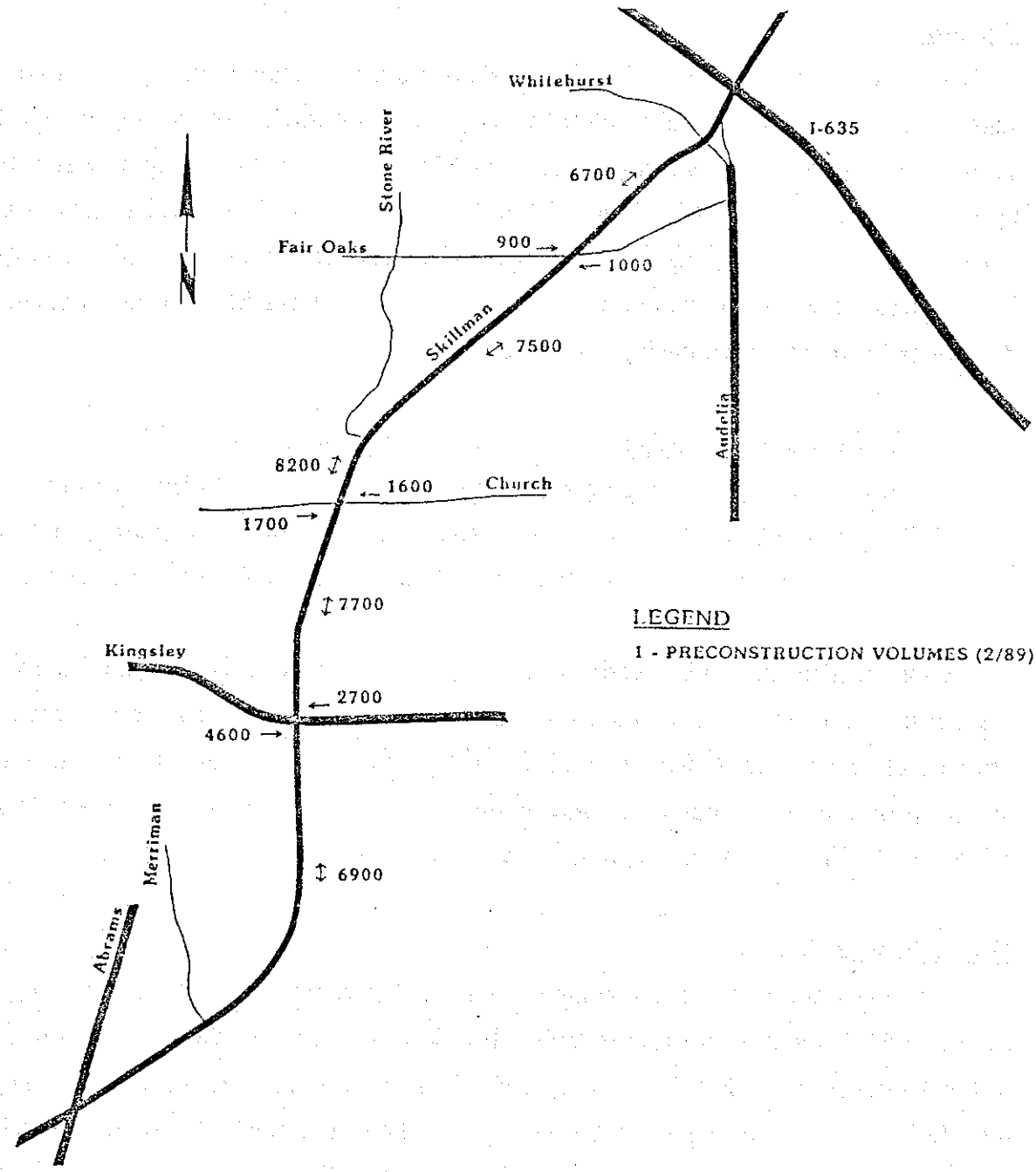

Figure 25. Skillman Avenue Evening Peak Period Volumes (3:00 - 7:00 p.m.)

Motorist Survey

Purpose

Complaints and comments from F.M. 1960 users and retailers in the construction area suggested that the high volume of traffic and high proportion of turning vehicles posed significant problems that warranted study by SDHPT. A previous origin/destination and opinion survey (15) conducted by TTI indicated that further investigation of motorist understanding of the signing used throughout the reconstruction area might be useful in identifying sources of confusion for the motorists along this corridor. A motorist survey was developed to meet the following objectives:

- To ascertain knowledge about work zone signing in general.
- To determine confusing or problematic areas of the F.M. 1960 signing.
- To elicit information from motorists concerning problems with the F.M. 1960 project that may not be related to understanding traffic control devices.

More specifically, three questions were posed: 1) Are motorists having difficulties with the construction area due to confusion and/or the number of signs and traffic control devices, 2) Are motorists having trouble finding destinations within the construction area due to problems with signing, 3) Are primary concerns on the part of F.M. 1960 users related to traffic control and signing, or are other factors more important?

Survey Procedure

Personal interviews were conducted with 205 participants between February 16 and February 21, 1989 at two locations, Willowbrook Mall and the Grant Road Licensing Office of the Department of Public Safety (DPS). Response was strictly on a voluntary basis in the Mall (potential participants were not approached randomly). However, participants at the DPS office were asked to participate in the study. The result was that 115 participants were interviewed at the DPS licensing office and 90 participants were interviewed at Willowbrook Mall.

Survey participants were first asked to respond to questions regarding work zone signs and other forms of traffic control devices that were presented in a booklet of photographs. This set of questions was followed by a series of photographs or signs and scenes from the F.M. 1960 reconstruction project with corresponding questions. The third segment of the interview was a discussion with the participant of their opinions about various aspects of the reconstruction project. A brief set of biographical questions concluded the interview. The interview time averaged approximately 10 minutes. These survey documents are given in **Appendix D -- F.M. 1960 Motorist Survey.**

Results

Sign Comprehension

As predicted from previous research (16), the survey revealed that drivers have some difficulty interpreting both word and symbol messages on signs. This was found to be the case in the motorist survey of F.M. 1960 users. The following paragraphs and figures address the signs and the field placement of signs that were used in the survey and include brief summaries of the responses to the survey questions. The survey questions are in Table 15 and **Appendix D** contains a summary of these questions. The summary includes the question, picture, and responses and percentage of each response.

Road Construction 500 Ft. -- Two-thirds (66.0 percent) of the survey participants correctly interpreted the sign in Figure 26, which is intended to provide advance warning of construction located 500 feet beyond the sign. However, one-fourth (25.2 percent) of the participants incorrectly interpreted the sign as the beginning of a construction area that would continue for 500 feet.

Table 15. Motorist Survey, Traffic Control Devices

1. What does this sign mean?

Advance Flagger Sign
- A. Road construction ahead
- B. Flagger ahead
- C. Guard for school crossing ahead
- D. Not Sure

DO NOT BLOCK INTERSECTION Sign
- A. Leave room for traffic crossing at intersection
- B. If your car stalls, move it out of the intersection
- C. Move through the intersection quickly
- D. Not Sure

NO CENTER LANE Sign
- A. Drive in the center, the lane is not marked
- B. Drive in the right lane only
- C. Be alert for cars stopping to turn left
- D. Not Sure

Field Placement of Lane Reduction Transition Sign
- A. Left-turn lane marker
- B. Left lane ends
- C. Median narrows
- D. Not Sure

Lane Reduction Transition Sign
- A. Median narrows
- B. Right lane ends
- C. Right turn lane marker
- D. Not Sure

Divided Highway Sign
- A. Divided road ahead
- B. Obstacles in the road ahead
- C. Merging traffic ahead
- D. Not Sure

Low Shoulder Sign
- A. Low shoulder
- B. Uneven pavement
- C. Bumpy road
- D. Not Sure

Field Placement of NO CENTER LANE Sign
- A. Drive in the outside lane only
- B. You cannot go straight at the next light
- C. A lane for left turns is not provided
- D. Not Sure

2. What do the orange and white striped signs mean?
- A. Do not turn between these signs
- B. Pay special attention to signs on these posts
- C. Drive to the right of these signs
- D. Not Sure

3. What does the green sign mean?
- A. Crossover here
- B. Crossover at the next signal
- C. Emergency vehicle cross here
- D. Not Sure

4. What do the orange and white posts on the right tell you?
- A. Hazardous area to the right, drive to the left of posts
- B. Shows the right edge of the pavement
- C. Park between these posts
- D. Not Sure

5. What does the second yellow sign mean?
- A. Obstacles in the road ahead
- B. Merging traffic ahead
- C. Divided road ahead
- D. Not Sure

6. Are you permitted to turn left in front of the barrel with the crossover sign?
___ yes ___ no ___ not sure ___ other

7. Are you permitted to turn left behind the barrel with the crossover sign?
___ yes ___ no ___ not sure ___ other

8. Do you think signs like the Auto Tint sign should be allowed in the construction area?
___ yes ___ no ___ not sure ___ other

9. Are you permitted to turn right at this intersection?
___ yes ___ no ___ not sure ___ other

10. Why are these signs different colors?

11. You are driving the pickup, what should you do at this intersection?

12. What is your opinion of these red signs?

Figure 26. Advance Road Construction Sign

Participants viewed the same sign in a photographed segment of F.M. 1960. Within the context of the construction area, the percentage of correct interpretations did not increase. In response to the sign presented in Figure 27, 33 percent of those surveyed said the next 500 feet of roadway are under construction, while 58.3 percent said construction would be encountered 500 feet ahead.

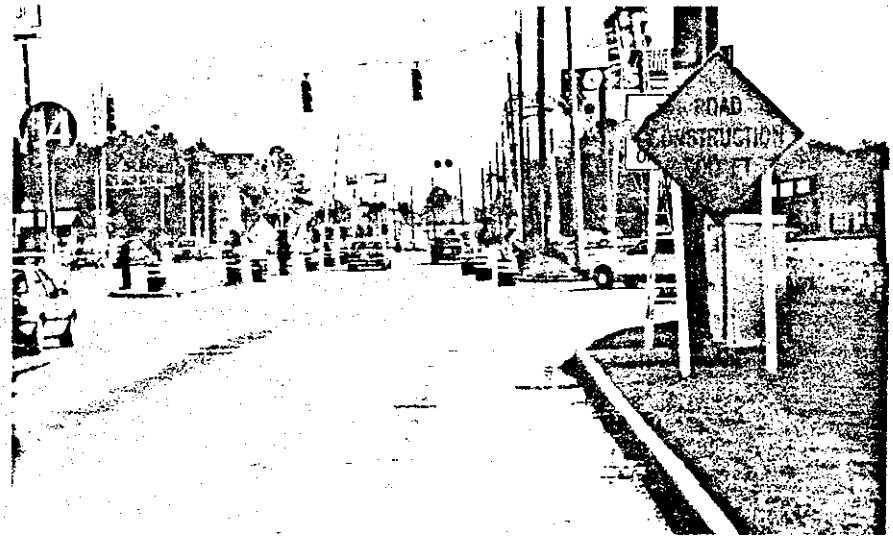

Figure 27. Field Placement of Advance Road Construction Sign

Advance Flagger Symbol Sign -- In contrast to the advance construction word message sign, the **Flagger Ahead** symbol sign was interpreted correctly more often within the construction context presented by photograph. Figures 28 and 29 show the signs as presented to the survey participants. The symbol sign out of context was correctly interpreted by 77.5 percent of the participants. Within context, interpretation increased to 85.1 percent. In response to both questions, those who misinterpreted this sign most often said it indicated road construction ahead.

Figure 28. Advance Flagger Symbol Sign

Figure 29. Field Placement of Advance Flagger Symbol Sign

Low Shoulder Symbol Sign -- The correct interpretation of the symbol sign shown in Figure 30 was very low. The vast majority of drivers (84 percent) thought this sign meant uneven pavement, rather than low shoulder.

Figure 30. Low Shoulder Symbol Sign

Lane Ends Symbol Sign -- 15.7 percent of the participants checked "median narrows" as the meaning of this symbol sign in response to Figure 31 (78.4 percent correctly checked "right lane ends".) In response to the photograph in Figure 32, 9.9 percent thought the sign was a left-turn lane marker. The correct response was given by 79.2 percent of the participants.

Response to Sign Messages

Participants were asked to describe the appropriate driving response to several regulatory and informational signs posted in the construction area. The results showed that for some signs a clear and single message was not interpreted.

No Center Lane and **No Center Turn Lane**, shown in Figures 33 and 34, are used throughout the F.M. 1960 construction area. These signs were confusing to many of the participants. Forty-six percent believed they should drive only in the right lane in response

to the **No Center Lane** sign, and 15 percent thought **No Center Turn Lane** meant "do not turn from the center lane." Only 56.4 percent checked the appropriate response -- "be alert for cars stopping to turn left."

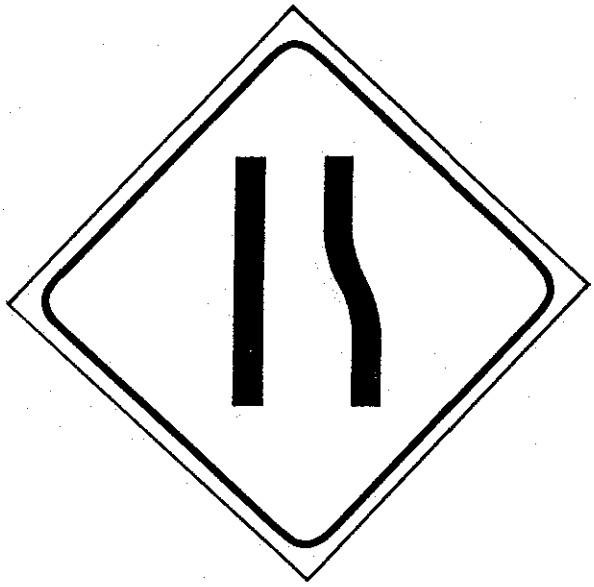

Figure 31. Lane Reduction Transition Symbol Sign

Figure 32. Field Placement of Lane Reduction Transition Symbol Sign

Figure 33. NO CENTER LANE Sign

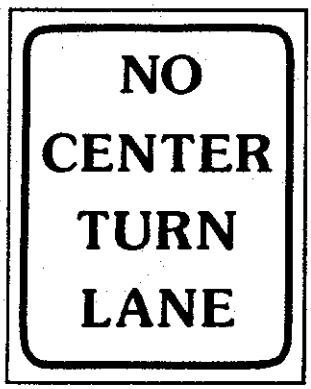

Figure 34. NO CENTER TURN LANE Sign

Green CROSSOVER signs, when posted on a free-standing barrel as shown in Figure 35, do no clearly convey to the motorist where to crossover. Survey participants were asked if it is permissible to crossover before or after the CROSSOVER sign. In response to the situation depicted in Figure 35, 55.2 percent said it was permissible to crossover before the barrel; 38.4 percent said it was not permissible to crossover before the barrel. Eight percent of the participants said they were not sure if they would be permitted to turn after the barrel with the CROSSOVER sign, while 42 percent said they could turn after it, and

Figure 35. Field Placement of CROSSOVER Sign

48 percent said no they could not turn after the CROSSOVER sign. String delineation with flagging between barrels, as shown in Figure 36, simplified the response to the CROSSOVER sign. The string with flagging was used by the contractor to identify those areas with fresh concrete pavement. In this case 82.3 percent of those surveyed said it was not permissible to turn left before the CROSSOVER sign, and 80.2 percent said it was permissible to turn left after the barrel with the CROSSOVER sign. The string and flagging helped the participants to identify the location where turns were permitted.

Figure 36. Field Placement of CROSSOVER Sign with String Delineation

Do Not Block Intersection -- Four response choices were provided for this sign out of context. Response frequencies for each answer were:

- Leave room for traffic crossing at intersection -- 73.5 percent
- If you car stalls, move it out of the intersection -- 9.8 percent
- Move through the intersection quickly -- 15.7 percent

•Not sure -- 1.0 percent

Figure 37 shows the sign as presented in context. Participants were asked what they thought they should do if they were the driver of the pickup truck. In this situation, over 88 percent described in their own words an appropriate driving response. Again, only one percent said they did not know what to do in response to this sign.

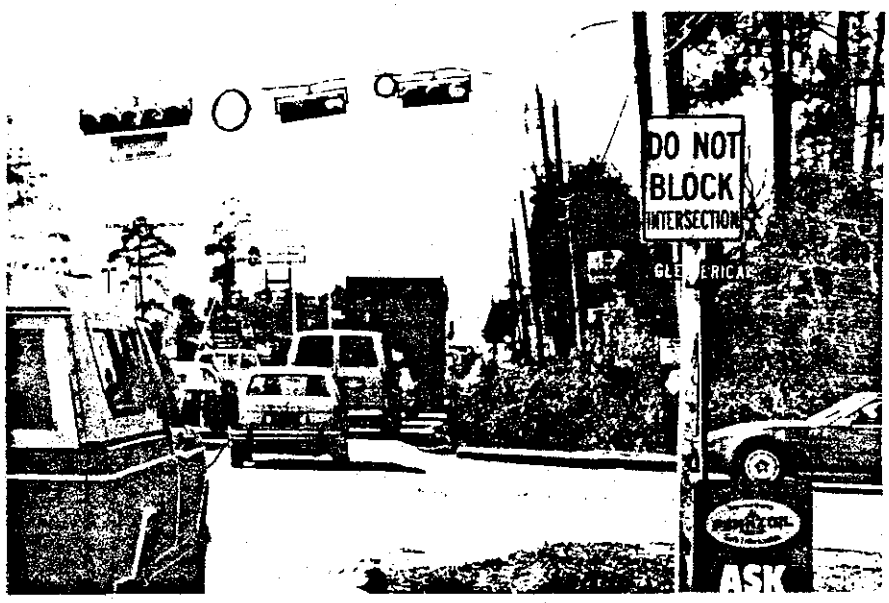

Figure 37. Field Placement of DO NOT BLOCK INTERSECTION Sign

Color Cues

Results from this survey support other research findings (16) that color coding to distinguish construction from other types of signing is not well known by the motoring public. When shown the **Two Way Traffic** symbol sign illustrated in Figure 38, one yellow and one orange, and asked the meaning of the two different colors, over 40 percent said they simply "did not know." Several participants remarked that they did not believe they had ever seen orange signs. A total of 44 percent knew that orange is the color designated for construction signs.

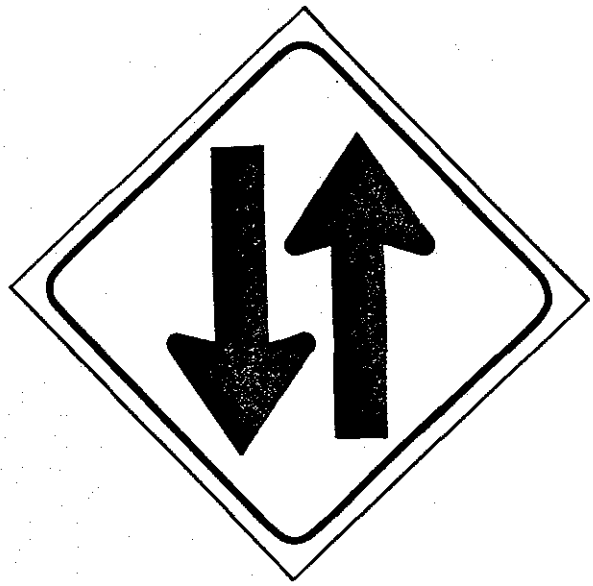

Figure 38. Two-Way Traffic Symbol Sign

For some segments of the construction area, orange and white object markers were used at the pavement edge as shown in Figure 39. Although 70 percent of the participants thought these markers indicated a hazardous area to the right, 26 percent thought they marked the right edge of the pavement. In contrast, solid white markers, shown in Figure 40, were used in the construction area as pavement edge markers. The percent of drivers who recognized these markers as pavement edge markers was 58.3, while 35.9 percent interpreted them as hazard markers.

Figure 39. Field Placement of Construction Object Markers

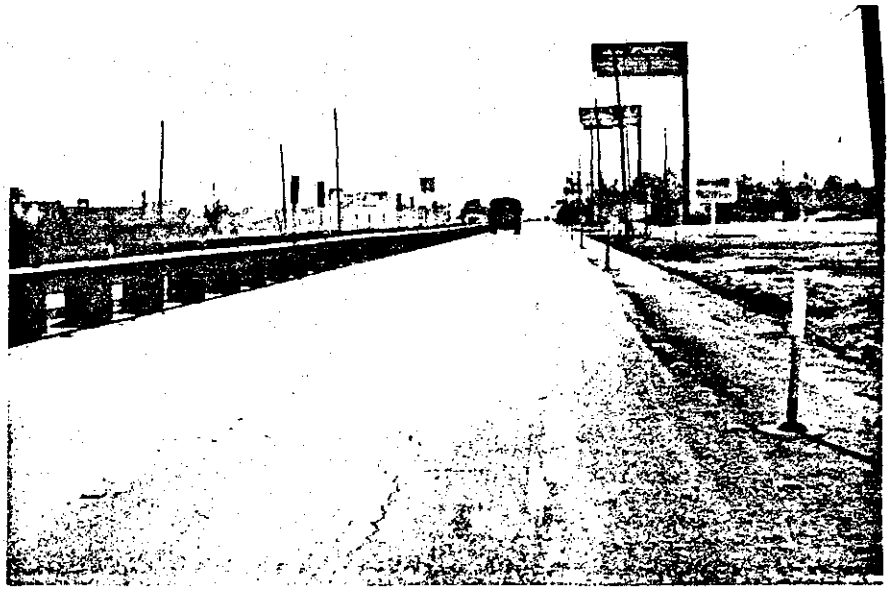

Figure 40. Field Placement of Edge Delineation

Delay

Following the questions about traffic control devices, survey participants were interviewed for their opinions on a variety of F.M. 1960 construction problems using the questions in Table 16. In the first part of these questions, participants were asked to estimate the amount of delay they had experienced as a result of the construction activity. Of those who calculated the delay, in minutes, they had experienced the day of the survey (or on a usual basis), most estimated delay at five (21.5 percent), ten (20.7 percent), 15 (22.2 percent), and 20 minutes (18.5 percent).

Participants were then asked if they traveled on F.M. 1960 during rush hour and if so, how much delay they experienced during these times. Less than half (45.2 percent) of those surveyed used F.M. 1960 during rush hour, and the modal response for estimated delay was 30 minutes (26.8 percent).

Table 16. Motorist Survey, Discussion Questions Summary

1. How much did construction delay you in getting to the mall/driver license station today?
   10 min. -- 20.7%
   15 min. -- 22.2%
   20 min. -- 18.5%

2. Was this delay unreasonable?
   yes -- 33.3%
   no -- 66.0%
   other -- .6%

3a. Do you drive on F.M. 1960 to work or other places during rush hour?
   yes -- 45.2% no -- 54.8%

3b. If yes, how much are you delayed by the construction during rush hour?
   10 min. -- 12.2%
   20 min. -- 17.0%
   30 min. -- 26.8%

3c. Would you say that amount of delay is unreasonable?
   yes -- 46.1% no -- 52.8%
   other -- 1.1%

4. Are you using other routes to get where you want to go, because of the construction on F.M. 1960?
   yes -- 85.7% no -- 13.8%
   other -- .5%

5a. Do you think the benefits of widening this road will be worth the inconvenience now?
   yes -- 90.7% no -- 7.3%
   other -- 2.0%

5b. If no, why not?

6. Do you have trouble finding specific places you want to go because of the construction?
   yes -- 49.5% no -- 50.5%
   other -- 0.0%

7. Are there too many signs, too few signs, or the right amount of signs that give warnings and information about how to drive through the construction area?
   too many -- 9.4% too few -- 13.9%
   right amount -- 73.3% Comments -- 3.5%

8. Are there too many signs, too few signs, or the right amount of signs that give directions to places alongside the construction area? (Retail type signs)
   too many -- 18.4% too few -- 28.9%
   right amount -- 48.8% Comments -- 4.0%

9. Should there be more, less, or about the same number of barrels through the construction area?
   more -- 4.9% less -- 21.7%
   same number -- 70.4% Comments -- 3.0%

10. What is your <u>biggest</u> complaint about the 1960 construction area, if any?
   Construction too slow -- 18.1%
   Delay -- 12.9%
   Signs/Barrels -- 8.8%

11. Do you have any other complaints or comments about the 1960 construction area?
   Turning problems -- 14.9%
   Too much construction at one time -- 11.9%
   Construction too slow -- 10.5%

12. From the list below, what would you say is the biggest problem in the F.M. 1960 construction area?
   12.6% - travel delay
   13.7% - the work has taken too long
   23.2% - the construction area (in miles) is too long
   .5% - signs are confusing
   9.0% - too much traffic
   17.9% - difficult to turn
   1.1% - difficult to find where you're going
   11.6% - hazardous road conditions
   10.5% - general confusion
   ___ - other (please specify) _____

13. Is there anything you would like to add about construction areas in general, or about the State Highway Department in general?
   Compliment to SDHPT -- 18.4%
   Work faster -- 13.8%
   Too many roads under construction -- 9.7%
   Work zones should be shorter -- 9.7%

14. Do you prefer roads to have a continuous left-turn lane marked by painted lines on the pavement, or medians with turn lanes cut out of them?
   continuous left-turn lanes -- 49.5%
   medians -- 50.5%

When asked if they thought the delay they had experienced was unreasonable, the majority said no. In fact, delays of five to twenty minutes during non-rush hour times were not considered unreasonable by two-thirds of the participants. The reported delay during rush hour was not considered unreasonable by 52.8 percent of the participants.

The survey also documented that most drivers avoid driving on F.M. 1960 when possible. Eighty-six percent reported the use of other routes because of the construction.

Turning and Finding Destinations

The second part addressed whether motorists were having difficulty locating or getting to their destinations because of the construction or signing in the construction area. Among other questions, they were asked, "*do you have trouble finding certain places you want to go because of the construction?*" Half (49.5 percent) of the participants said yes to this question and half (50.5 percent) said no.

Subsequently, drivers were asked, "*are there too many, too few, or the right amount of signs that give directions to places alongside the construction area?*" The response given most often (48.8 percent) was that there are the right amount of directional signs for the construction area. However, 28.9 percent said there are too few and 18.4 percent said there are too many.

To optimize the visibility of their businesses and entrances to their businesses, some of the retail owners adjacent to F.M. 1960 posted directional signing. In most cases these signs pictured the business' name, logo, and an arrow as shown in Figure 41. Participants were asked if they favored or opposed this type of signing. A majority (53.5 percent) felt that signs showing directions to retail businesses should be allowed in the construction area. The reasons given for objecting to such signs included that they are distracting (14.9 percent), they are confusing (3.5 percent), they are not official signs (3.5 percent), and they are too small (1.0 percent). Several comments were made by those who favored the signs suggesting that retail owners should be allowed to mitigate the disruptive effect of the construction in terms of visibility and accessibility.

Figure 41. Field Placement of Business Directional Sign

Signs/Messages as Problems

One of the objectives of the survey was to determine the relative importance of signing and the motorist information system as a source of concern for the users of F.M. 1960 during the reconstruction activity. Therefore, survey participants were asked if they believed the signing and channeling devices used were adequate. The responses were fairly positive overall -- 73.3 percent said there was the right amount of warning and directional signing, and 70.4 percent said there were the right number of barrels through the construction area.

Figures 42 and 43 are examples of signs developed by the Houston Northwest Chamber of Commerce. Because these signs seemed to represent an effort to add a certain "lightness" to messages given to motorists, their effect was measured. A majority of those surveyed (66.2 percent) said they like messages on the circular red signs. In general, drivers interpreted them as positive messages. Twenty percent said they did not like them, and 10.8 percent also said they were either distracting or hazardous.

Primary Concerns

When asked to give in their own words their biggest complaint regarding the F.M. 1960 construction area, 10.5 percent of the 171 who responded mentioned signs, barrels, or confusion. "*The construction is too slow*" was given by 18 percent, and 13 percent said the delay in travel time was their biggest complaint.

Participants were asked to select from a list the biggest problem in the construction area. This provided an opportunity for those who did not articulate a personal complaint to identify the biggest problem in general. The most frequently checked problem was regarding the length of the construction area. Percentages of problems ranked as number one were as follows:

23.2% -- The construction area (in miles) is too long.
17.9% -- Difficult to turn.
13.7% -- The work has taken too long.
12.6% -- Travel delay.
11.6% -- Hazardous road conditions.
10.5% -- General confusion.
9.0% -- Too much traffic.
1.1% -- Difficult to find where you're going.
.5% -- Signs are confusing.

Participants were invited to comment freely about construction areas in general or about the SDHPT in general. Responses given most often by the 109 participants who chose to comment were complimentary to the SDHPT, for example, "*they're doing a good job, keep up the good work.*" Positive comments about SDHPT were given by 28.4 percent of those who had a comment to make. Other opinions elicited from this question were: "*they should work faster*" -- 13.7 percent; "*work zones should be shorter*" -- 9.2 percent; and "*there are too many roads under construction*" -- 9.2 percent.

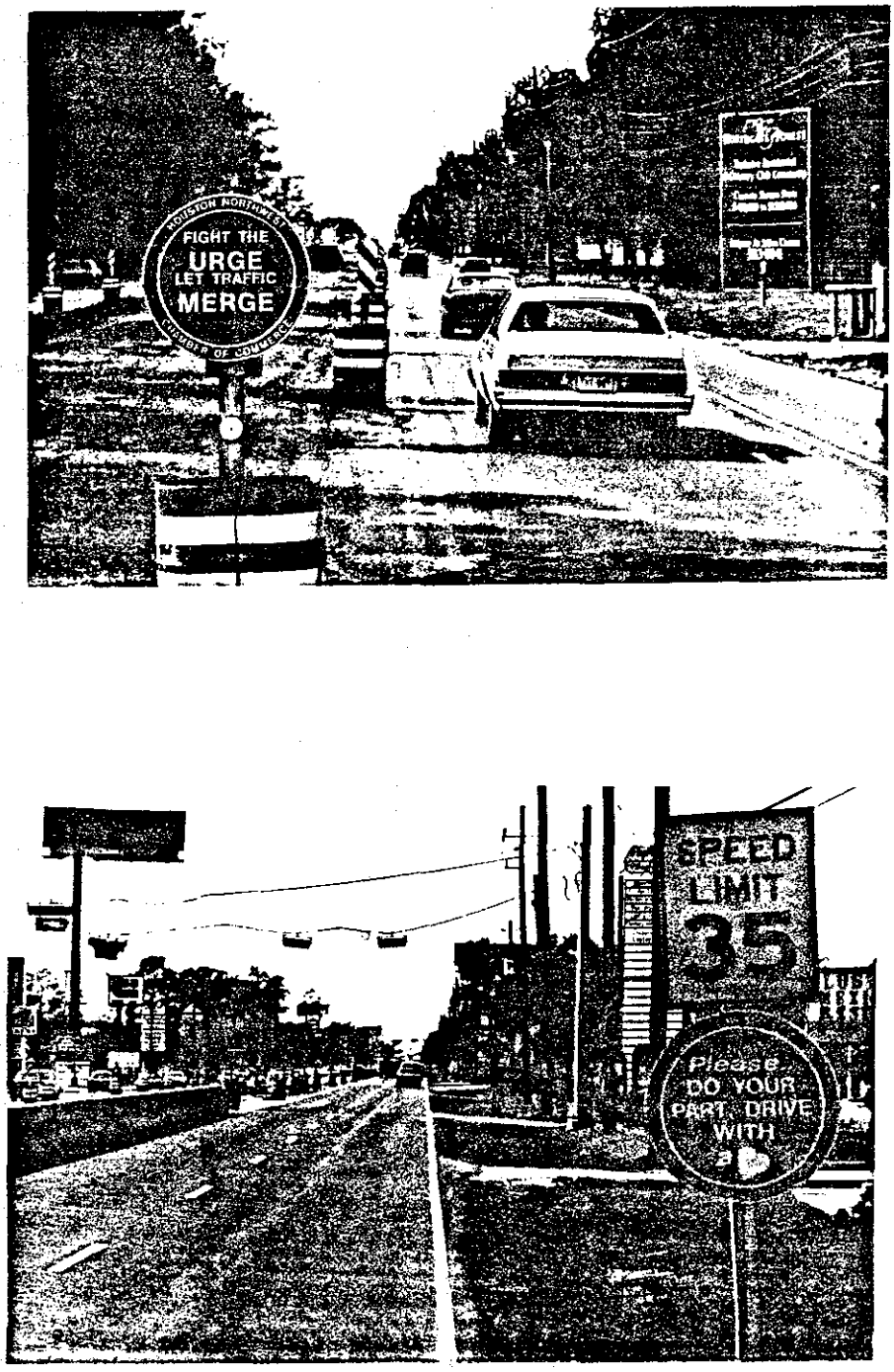

Figure 42. Field Placement of Chamber of Commerce Signs

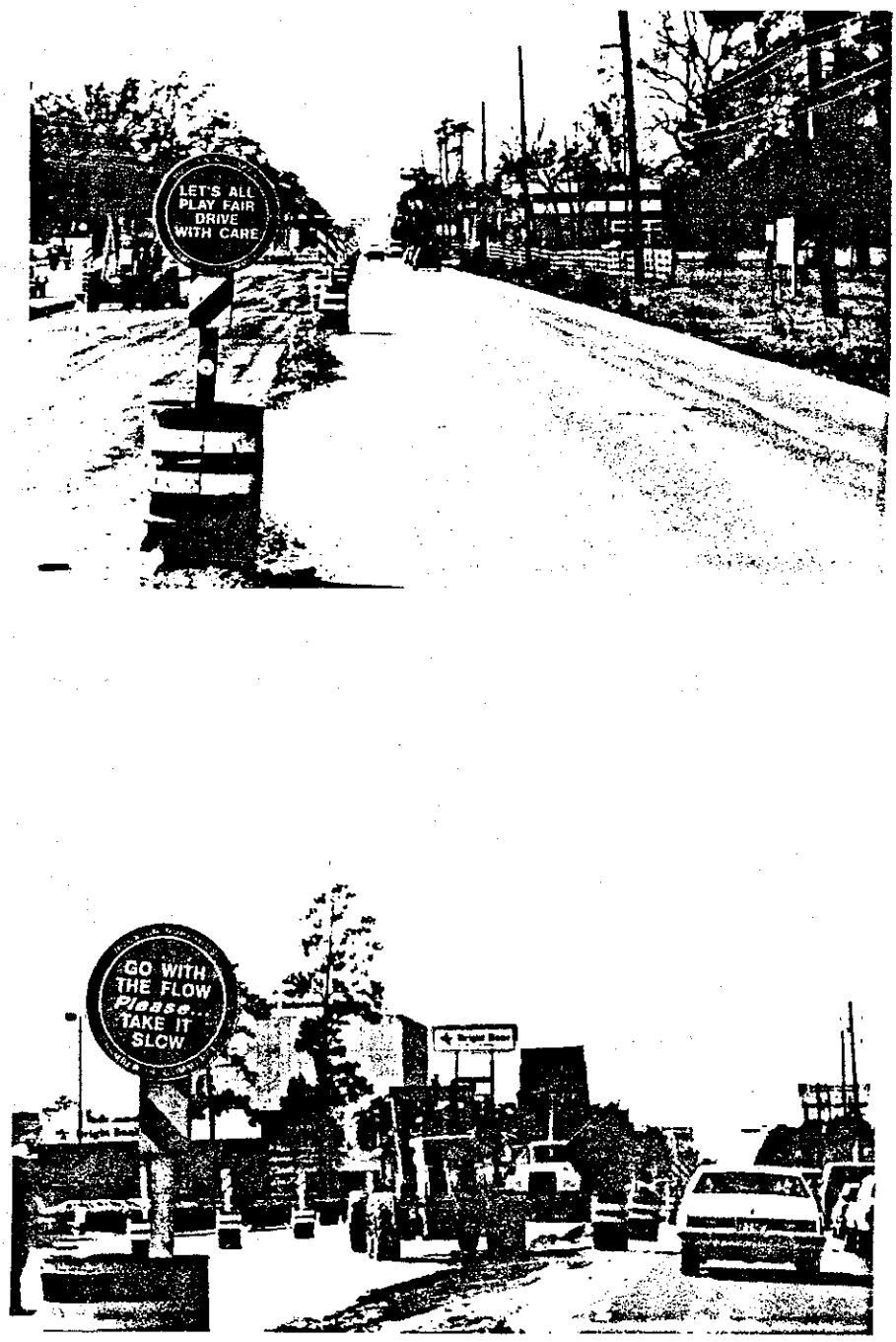

Figure 43. Field Placement of Chamber of Commerce Signs

To add some perspective to the problems experienced by users of F.M. 1960 during the reconstruction phase, the question of benefits to be derived was posed. Specifically, participants were asked, "*do you think the benefits of widening this road will be worth the inconvenience now?*" The overwhelming majority (90.7 percent) said yes. The few who did not think the benefits outweighed the inconveniences tended to have the viewpoint that the reconstruction should not have been initiated at all.

Biographical Results

Biographical questions were asked at the conclusion of the survey in order to evaluate the socio-demographic makeup of the survey participants. A summary of the biographical information is contained in Table 17. The results indicate that the majority of the survey participants were Anglo individuals between the ages of 26 and 55, two-thirds of which have some level of college education. Over three-fourths of the participants traveled on F.M. 1960 at least once a week.

Table 17. Motorist Survey, Biographical Summary

Sex	47.0% Male	53.0% Female		
Race	81.3% Anglo	7.0% Black		
	7.5% Hispanic	4.0%	Other	
Age	15.2% under 25	76.0%	26 - 55	8.8% over 55
Highest level of education received				
	8.9% Less than high school		24.1% High school graduate	
	29.6% Some college		37.4% College graduate	
How many years have you been driving?				
How many years have you lived in Houston?				
What is your zip code?				
How often do you travel on F.M. 1960?				
	42.2% at least once daily		37.3% at least once weekly	
	14.7% at least once monthly		5.9% less than once a month	

Summary and Future Efforts

Study Sites

Three urban arterial work zone sites were selected for study. The sites include F.M. 1960 and S.H. 6 in Houston and Skillman Avenue in Dallas. The F.M. 1960 site is approximately 7 miles long, the S.H. 6 site is approximately 3 miles long, and the Skillman Avenue site is approximately 2.6 miles long. The Traffic Control Plan has been obtained for the two Houston sites and will soon be obtained for the Dallas site. Field documentation of the Traffic Control Plans has been done at the Houston sites. This task has been completed. There are no plans to choose additional sites for study.

Data Collection and Analysis

During the first year of study, various types of data were collected at the F.M. 1960 and S.H. 6 study sites. This data included traffic volumes, travel time comparisons, and accident information. The preliminary findings relative to the work zone areas studied in Houston, Texas are:

- Traffic volumes, both average daily and peak period, have decreased on the roadways under construction.
- Travel time delays have increased.
- Accidents have substantially increased.

From the research prepared thus far, there are several possible causes for the aforementioned traffic characteristics. Some of these are:

- Absence of continuous center left-turn lane. This eliminates the safe refuge area of vehicles wanting to turn left into a drive or from a drive to the arterial.
- Presence of construction barrels. The presence of these barrels and the signing often found on top of the barrels can significantly reduce the available sight distance. The presence of guardfence on these barrels can compound this effect.

- Narrow travel lanes. These increase the probability of sideswipe accidents and make the completion of turning maneuvers more difficult.
- Difference in grade for newly construction roadway versus existing pavement. This results in several difficulties for the motorist. The most severe is a sight distance problem created by the grade differential. The presence of construction barrels and signs intensifies the sight distance problem.
- Adjacent opposite direction travel lanes with no separation barrier. The lack of a buffer in a construction area magnifies the problems associated with the other factors already mentioned.
- Driver diversion to other routes because of construction area. Motorists are finding new routes in order to avoid the difficulties associated with the work zone.

The work zones will continue to be monitored for the remainder of the projects. Additional data will be collected at all three study sites. Further investigation of the data collected may produce other varying traffic behavior characteristics and possible causes. If any are concluded, they will be cited in the second year interim report.

Motorist Survey

The survey of F.M. 1960 users confirmed previously conducted studies (16) that show that all aspects of signing are not fully understood by motorists. Most signs were correctly interpreted by 70 to 80 percent of the survey participants. Interpretation of signs shown in the field showed a slight improvement. Signs which appear more confusing to the survey participants include the Advance Construction sign, the NO CENTER LANE sign, and the NO CENTER TURN LANE sign.

However, traffic control device interpretation is not a primary source of concern for users of F.M. 1960. More important construction issues involve the length of the project, problems associated with turning, and travel delay. The length of the project (in time) was the most often cited personal complaint about the construction, while the length (in miles) was the most often checked from a list of problems.

The survey focused on problems that might have been encountered by users of F.M. 1960 during the construction activity. Yet, in spite of the construction difficulties identified in the survey, 91 percent of the drivers believed the long term benefits will outweigh the short term inconveniences. In general, the survey participants indicated a tolerance for construction and its related problems, and have positive attitudes toward the SDHPT.

SECTION 5
CONCLUSIONS AND STUDY CONTINUATION

This three-year research study has been undertaken in order to develop improved guidelines for use with urban arterial work zones. These guidelines are needed because there is a lack of documentation for developing traffic control plans for urban arterials. The guidelines will address the impacts of such factors as signing, vehicle volumes, traffic signals, property access, and turning movements on the effectiveness of work zones in highly developed urban areas. They will lead to improved worker and driver safety, improved traffic operations in advance of and through work zones, and reduced risk of tort liability at work zones across the state. These improved guidelines are likely to see immediate implementation by both SDHPT and municipal agencies.

The primary emphasis during the first year of the study has been to collect information which will provide insight for developing guidelines for urban arterial work zones. The information which was collected during the first year includes findings of previous research, results from surveys of traffic personnel and motorists, and information from arterial work zones, including traffic control plans and field data.

A thorough analysis of the data collected during the first year has not begun. However, preliminary analysis of some data has led to some early conclusions about the need for improved guidelines and problems encountered in the work zones. Some of the early conclusions include:

- There is significantly less research material available about urban arterial work zones than there is about work zones on other highway facilities.
- A typical assertion in the research material addressing urban arterial work zones is the need for improved MUTCD guidelines addressing this topic.
- Traffic professionals at local agencies in Texas also indicate a need to expand the MUTCD to include guidelines for work zones in urban areas.

- There is variation among local agencies in the significance attached to work zone control. This may be due to the lack of detailed guidelines for urban areas.
- The study sites selected for data collection represent typical construction locations in heavily developed urban areas. The two major metropolitan areas in Texas are represented.
- The collected data indicates that traffic volumes have decreased in the construction area, travel time has increased, and accidents have increased.
- Sufficient data has not been collected to definitively explain the decreases in traffic performance. Possible causes include:
  * Absence of continuous left-turn lane.
  * Presence of construction barrels.
  * Narrow travel lanes.
  * No separation between traffic flowing in opposite directions.
  * Differences in grade between adjacent pavements.
- Motorist surveys in the vicinity of the study sites support previous research that indicates signing is not fully understood by motorists.
- The motorist survey indicated greater concern for other construction problems than for work zone signing.
- Survey participants indicated positive support for SDHPT.

Although the first year of this study concentrated on the collection of data and information about urban arterial work zones, the study methodology and analysis procedures were also formulated. The study methodology and analysis procedures will be utilized in the second and third years of the study in order to develop the desired guidelines. In addition, they will be refined and improved during the remaining portions of the study as the need dictates.

The methodology used to develop the guidelines will concentrate on analyzing the collected data to evaluate the effectiveness and safety of various traffic control strategies. The effectiveness and safety will be determined based on comparisons of the field data collected at the three sites and from survey results. Data to be included in the comparisons may include traffic volumes, turning movements, geometric features (such as sight distance

and grade differentials), traffic control device placement, accidents and accident locations, photographs, video, and motorists' opinions. Analysis procedures may include statistical analysis, cost/benefit analysis, and safety analysis.

The methodology will also evaluate the conditions which affect the use of various traffic control measures. Such factors as motorist recognition, accidents, accident locations, and traffic volumes will be analyzed. The differences between the traffic control plan and actual field placement of traffic control devices will also be analyzed. Finally, the relationship between accident locations and work zone traffic control (both design and actual field implementation) will be investigated.

This research study will continue for two more years. During this time, efforts to collect and analyze data will continue, in order to develop the desired guidelines for urban arterial work zones. The second year of the study will concentrate on continuing collection of field data and the refinement of the study methodology and analysis procedures. During this period, an interim analysis and evaluation will be conducted. A second interim report will be prepared at the end of the year. Data collection will continue in the third year and the final guidelines will be developed. These will be described in an interim report.

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APPENDIX A

TRAFFIC CONTROL PLAN

FM 1960

HOUSTON, TEXAS

PHASE I

CONSTRUCTION SCHEDULE

JANUARY 1988 - MARCH 1988

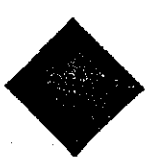
PLAN LEGEND

WORK ZONE

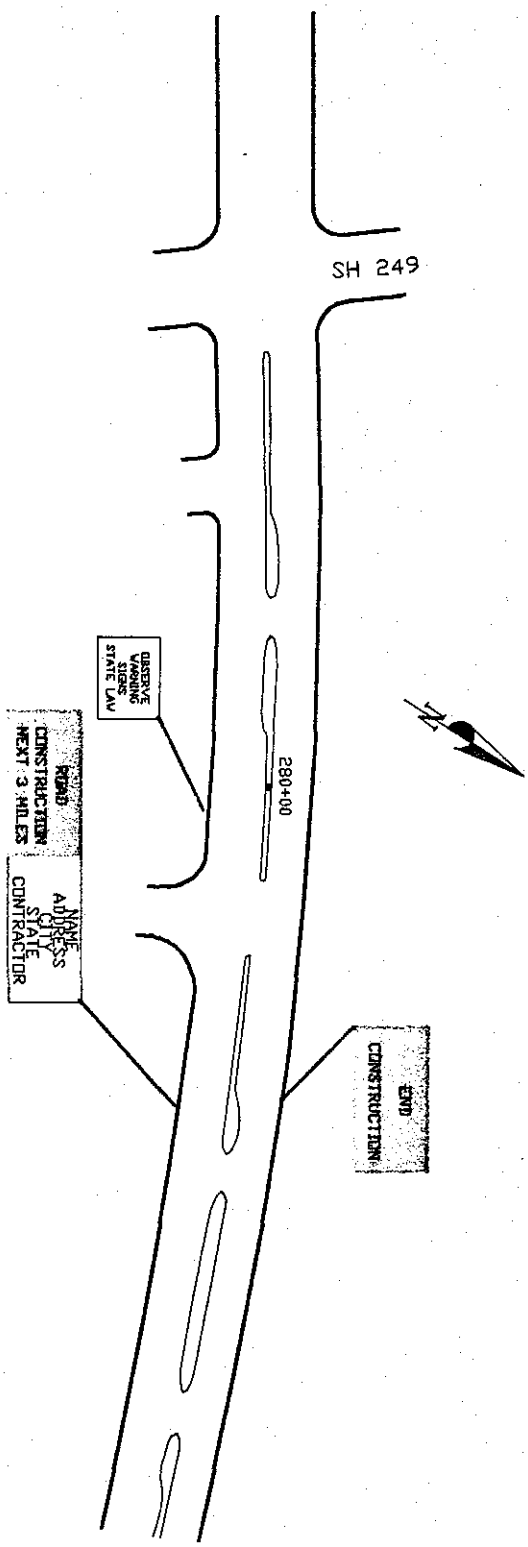
XXX + XX STATION NUMBERS

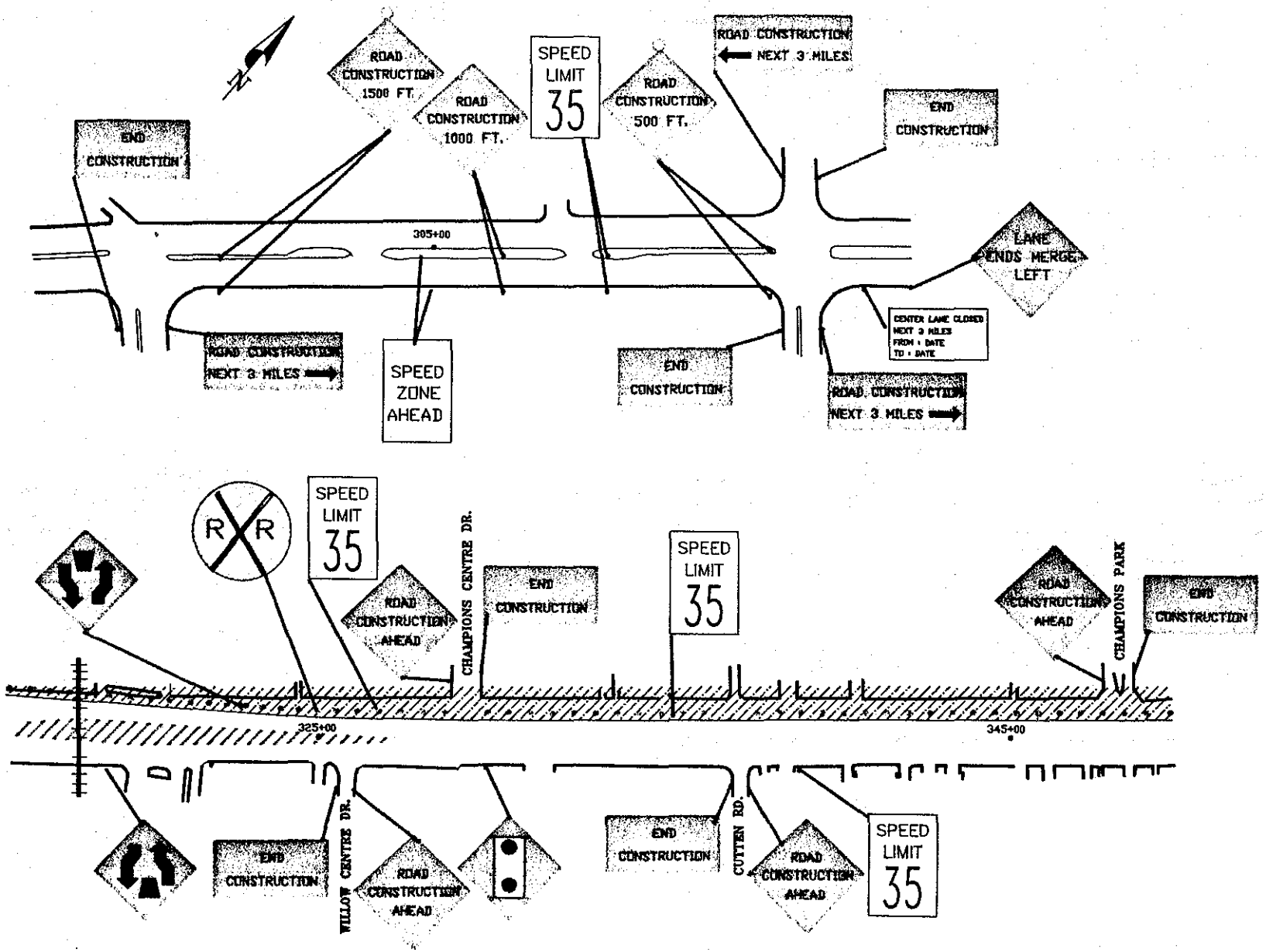
● ● ● ● BARRELLS (ORANGE)

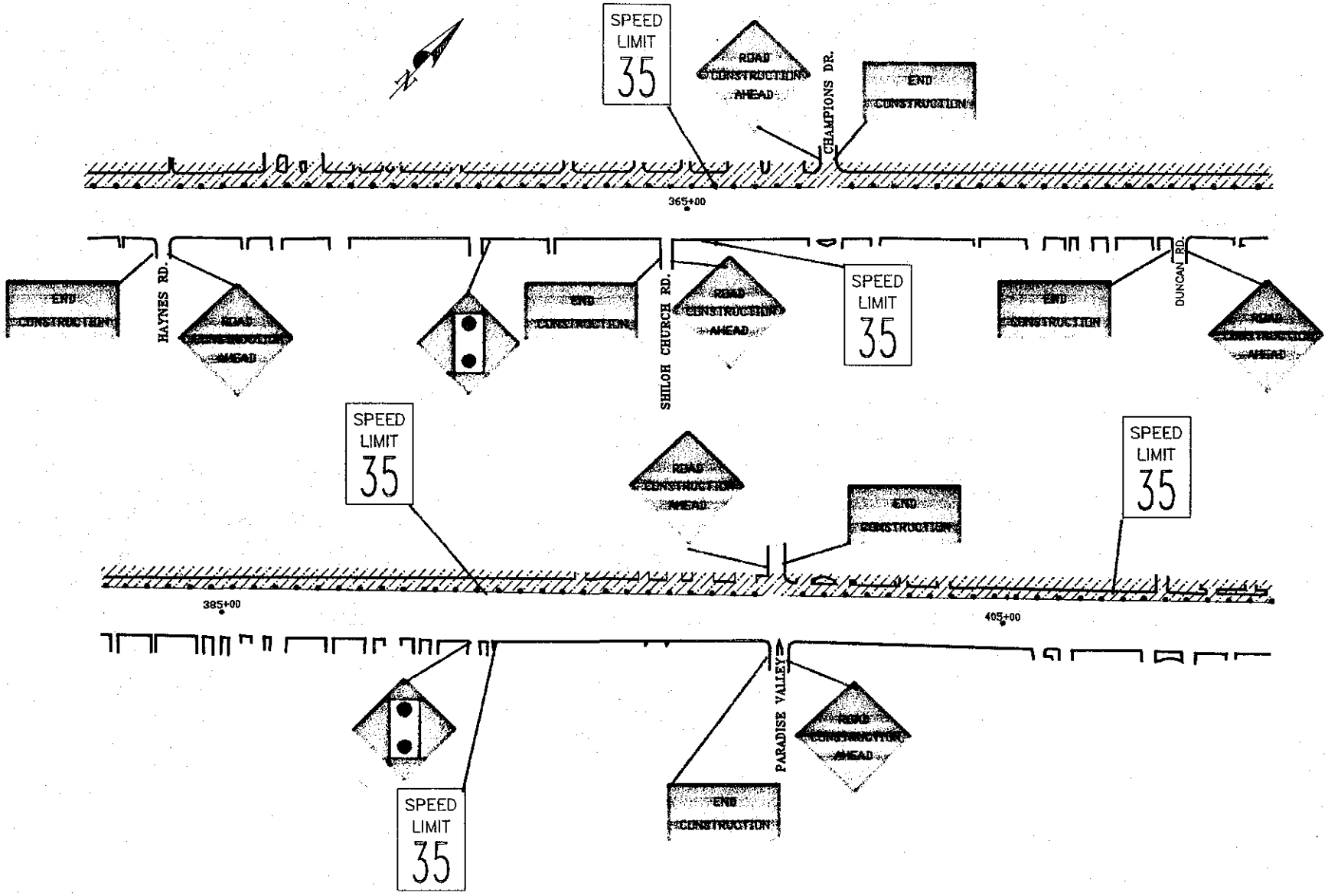
O FLASHING WARNING LIGHTS (YELLOW)

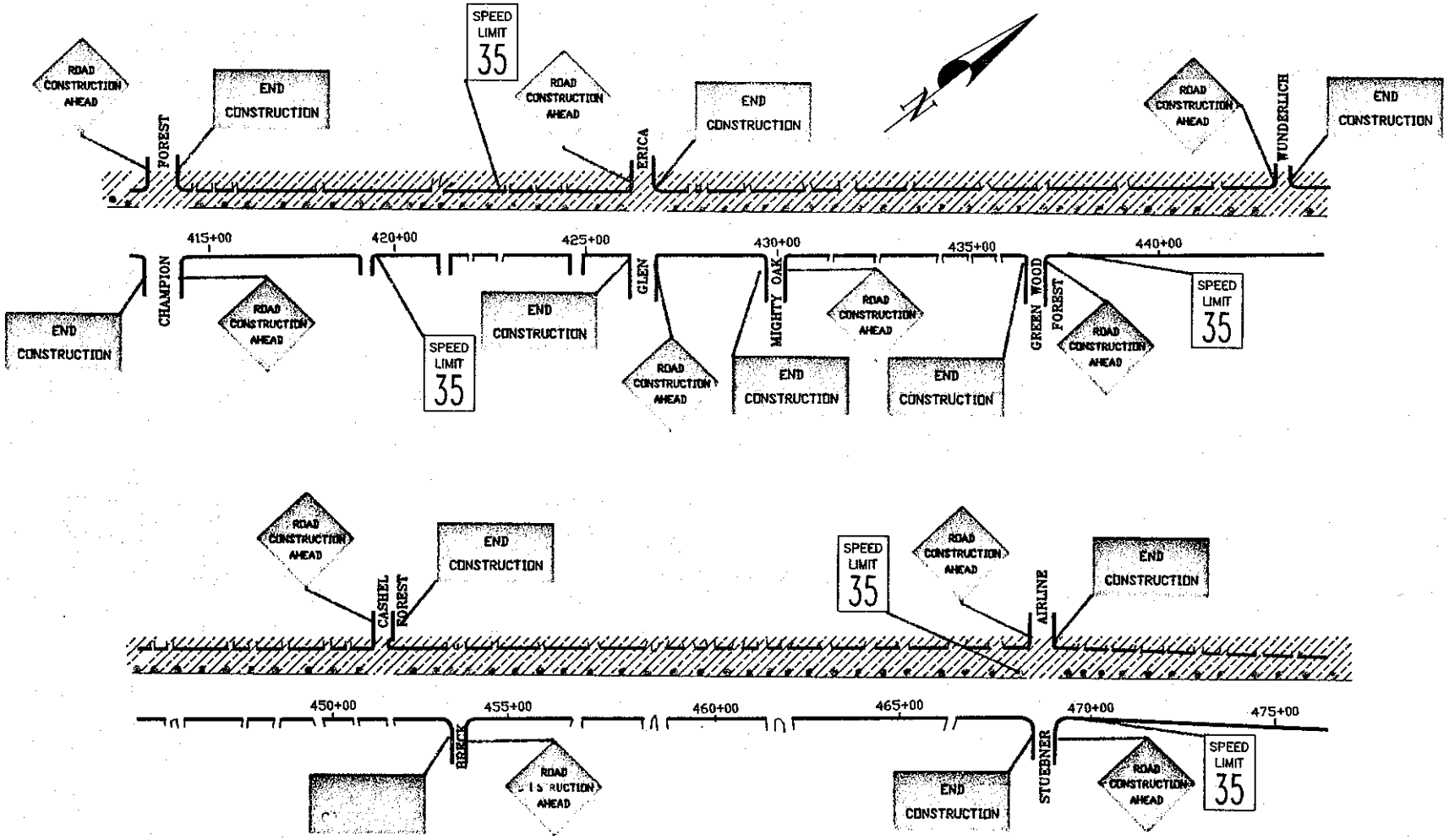


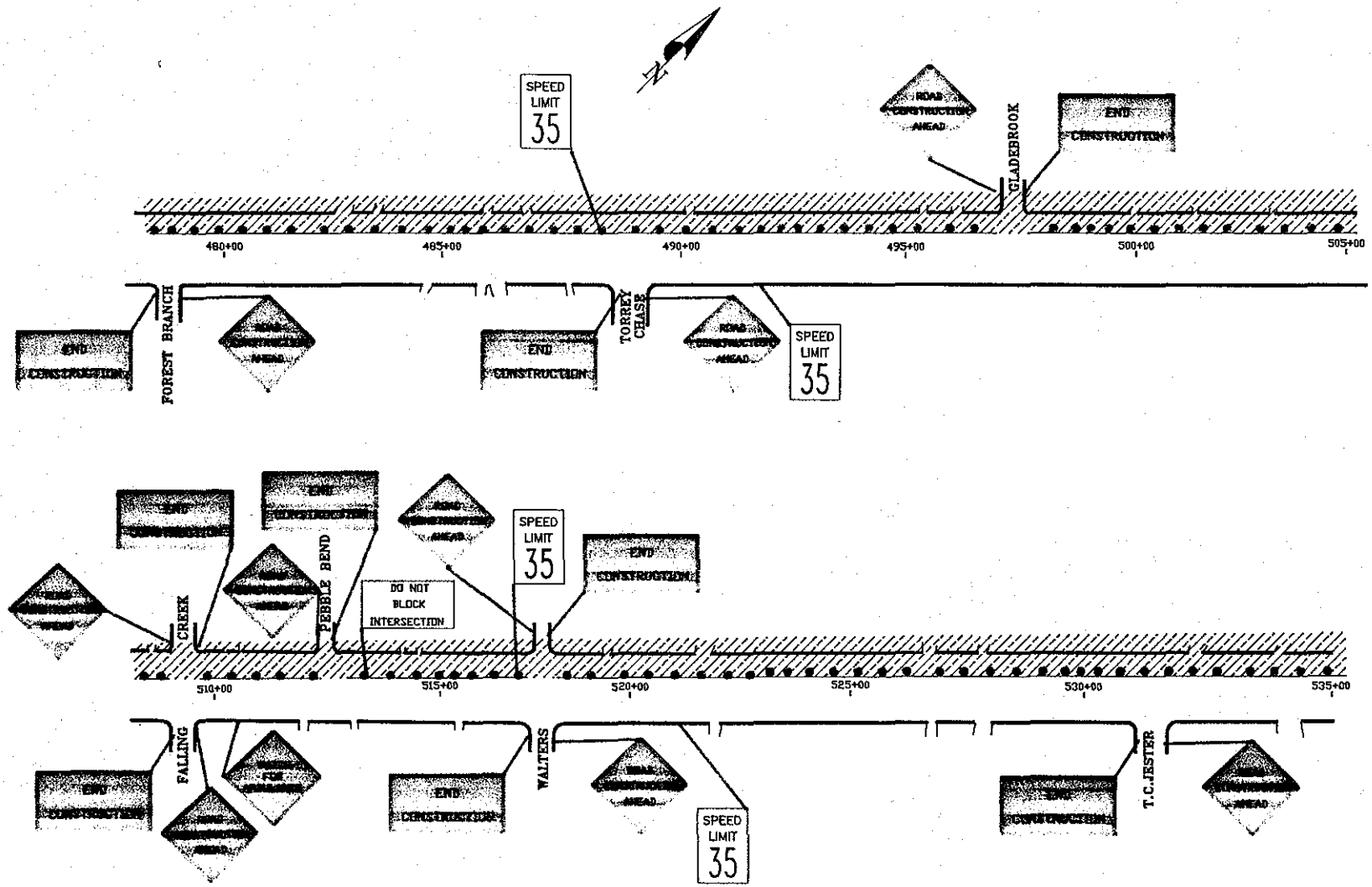
CONSTRUCTION WARNING SIGNS (BLACK ON ORANGE)

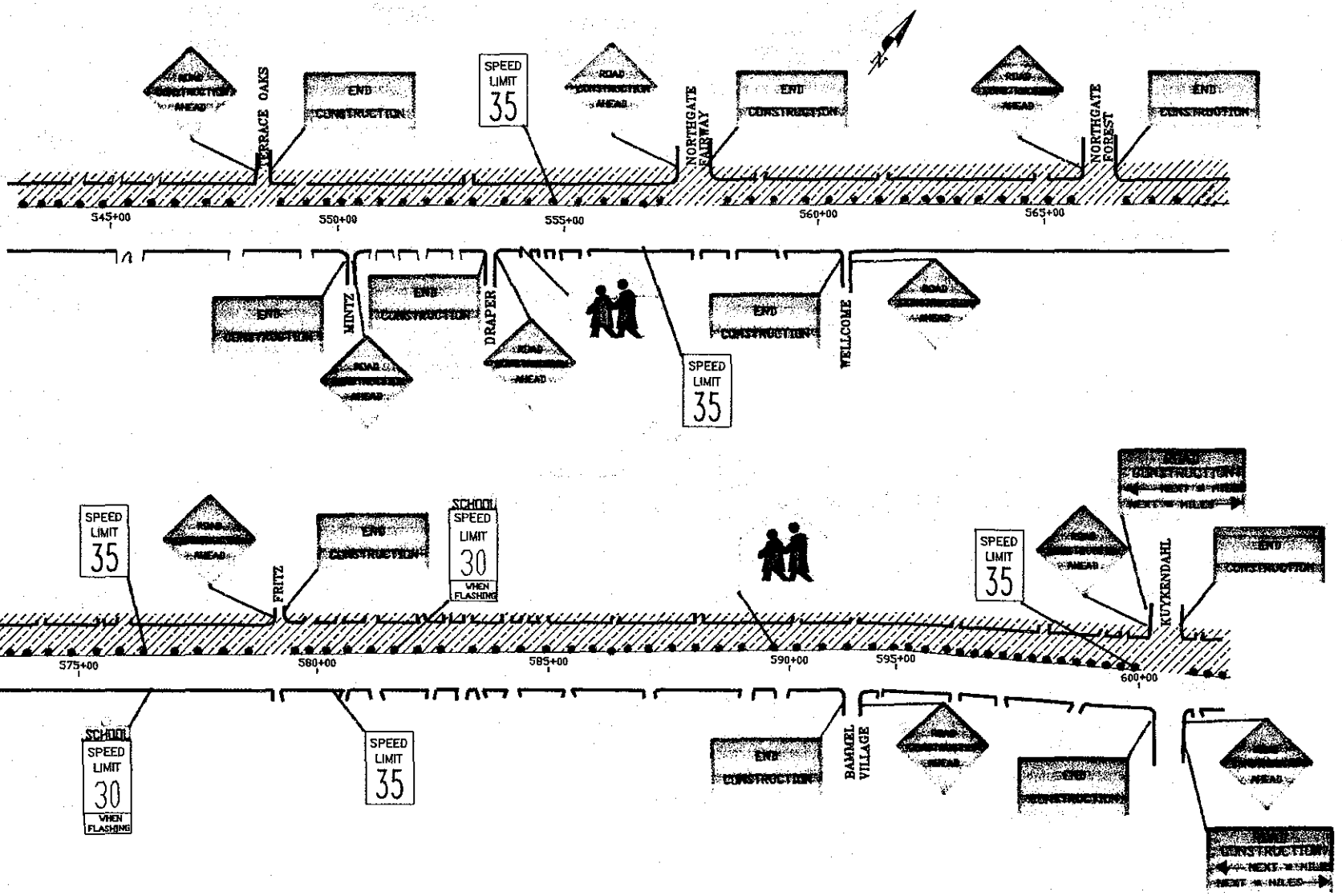

SH 249
280+00
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION NEXT 3 MILES
NAME
ADDRESS
CITY
STATE
CONTRACTOR
END CONSTRUCTION

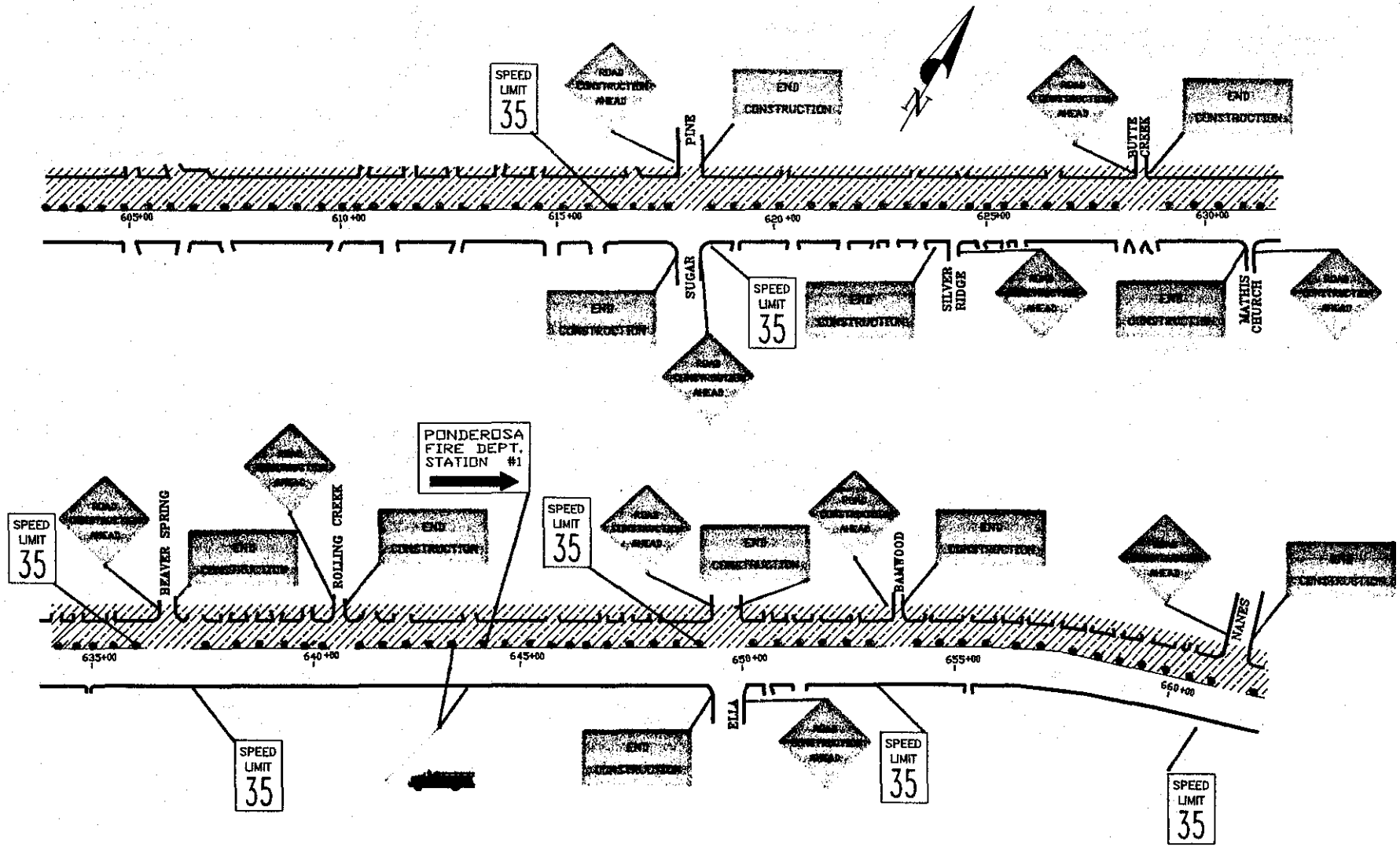

ROAD CONSTRUCTION 1500 FT.
ROAD CONSTRUCTION 1000 FT.
SPEED LIMIT 35
ROAD CONSTRUCTION 500 FT.
ROAD CONSTRUCTION NEXT 3 MILES
END CONSTRUCTION
END CONSTRUCTION
305+00
LANE ENDS MERGE LEFT
CENTER LANE CLOSED NEXT 3 MILES FROM : DATE TO : DATE
ROAD CONSTRUCTION NEXT 3 MILES
SPEED ZONE AHEAD
END CONSTRUCTION
ROAD CONSTRUCTION NEXT 3 MILES
R R
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
CHAMPIONS CENTRE DR.
END CONSTRUCTION
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
CHAMPIONS PARK
END CONSTRUCTION
325+00
345+00
END CONSTRUCTION
WILLOW CENTRE DR.
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
CUTTEN RD.
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35

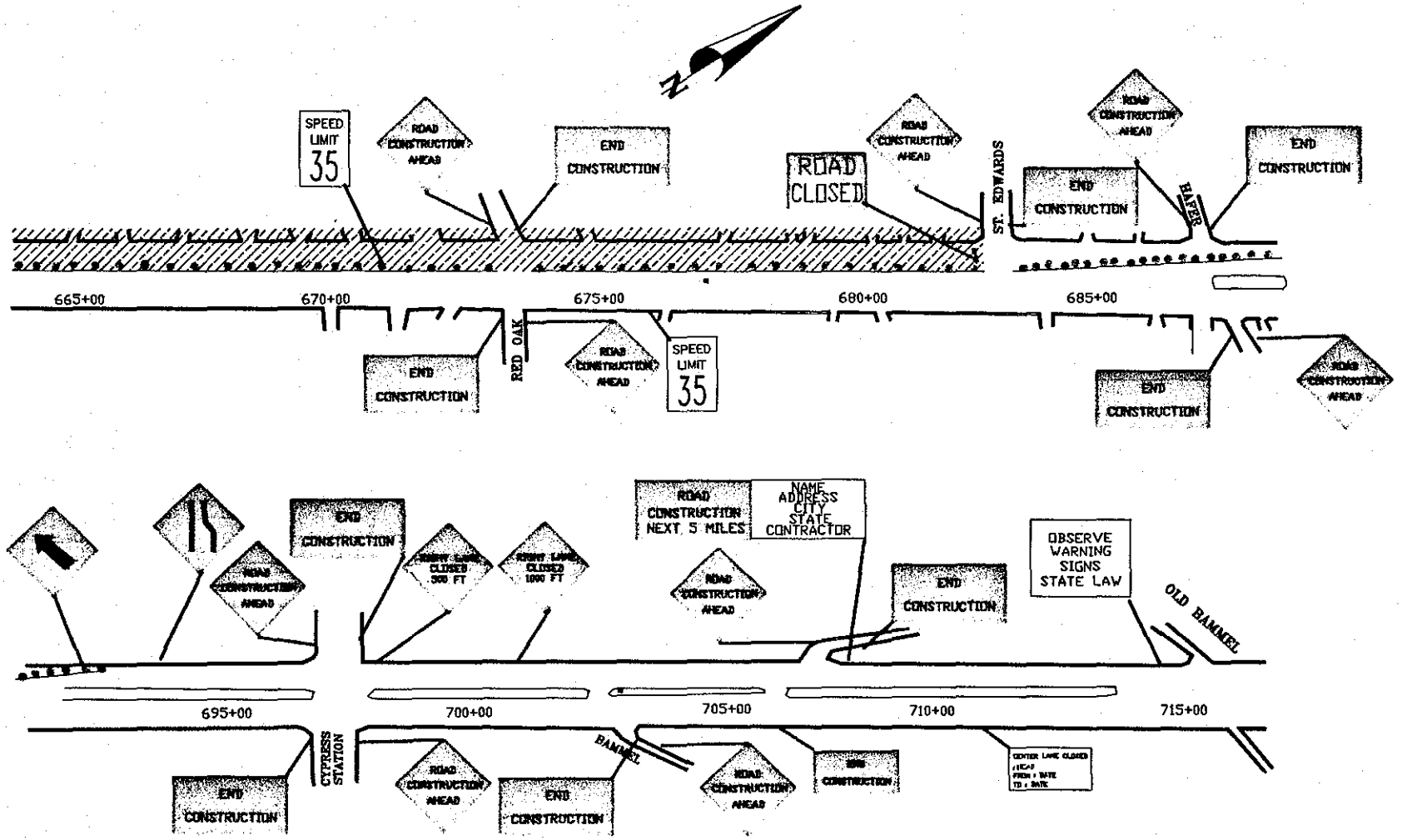

SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
CHAMPIONS DR.
365+00
HAYNES RD.
SHILOH CHURCH RD.
DUNCAN RD.
SPEED LIMIT 35
385+00
405+00
PARADISE VALLEY


ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
SPEED LIMIT 35
FOREST
ERICA
WUNDERLICH
415+00
420+00
425+00
430+00
435+00
440+00
CHAMPION
GLEN
MIGHTY OAK
GREEN WOOD
FOREST
CASHEL FOREST
AIRLINE
450+00
455+00
460+00
465+00
470+00
475+00
BRECK
STUEBNER


SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
GLADEBROOK
480+00
485+00
490+00
495+00
500+00
505+00
END CONSTRUCTION
FOREST BRANCH
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
TORREY CHASE
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
END CONSTRUCTION
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
END CONSTRUCTION
CREEK
PEBBLE BEND
DO NOT BLOCK INTERSECTION
510+00
515+00
520+00
525+00
530+00
535+00
END CONSTRUCTION
FALLING
FOR
END CONSTRUCTION
WALTERS
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
END CONSTRUCTION
T.C.JESTER
ROAD CONSTRUCTION AHEAD


ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
TERRACE OAKS
SPEED LIMIT 35
NORTHGATE FAIRWAY
NORTHGATE FOREST
545+00
550+00
555+00
560+00
565+00
MINTZ
DRAPER
WELLCOME
SPEED LIMIT 35
SCHOOL SPEED LIMIT 30 WHEN FLASHING
FRITZ
575+00
580+00
585+00
590+00
595+00
600+00
KUYKENDAHL
BAMMEL VILLAGE
NEXT 4 MILES


SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
PINE
BUTTE CREEK
605+00
610+00
615+00
620+00
625+00
630+00
SUGAR
SILVER RIDGE
MATHIS CHURCH
PONDEROSA FIRE DEPT. STATION #1
BEAVER SPRING
ROLLING CREEK
BAMWOOD
NANES
635+00
640+00
645+00
650+00
655+00
660+00
ELLA

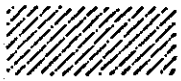

N
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
ROAD CLOSED
ST. EDWARDS
HAFER
665+00
670+00
675+00
680+00
685+00
RED OAK
SPEED LIMIT 35
NAME ADDRESS CITY STATE CONTRACTOR
ROAD CONSTRUCTION NEXT 5 MILES
OBSERVE WARNING SIGNS STATE LAW
OLD HAMMEL
695+00
700+00
705+00
710+00
715+00
CYPRESS STATION
HAMMEL

PHASE II

CONSTRUCTION SCHEDULE

MARCH 1988 - JANUARY 1989

PLAN LEGEND



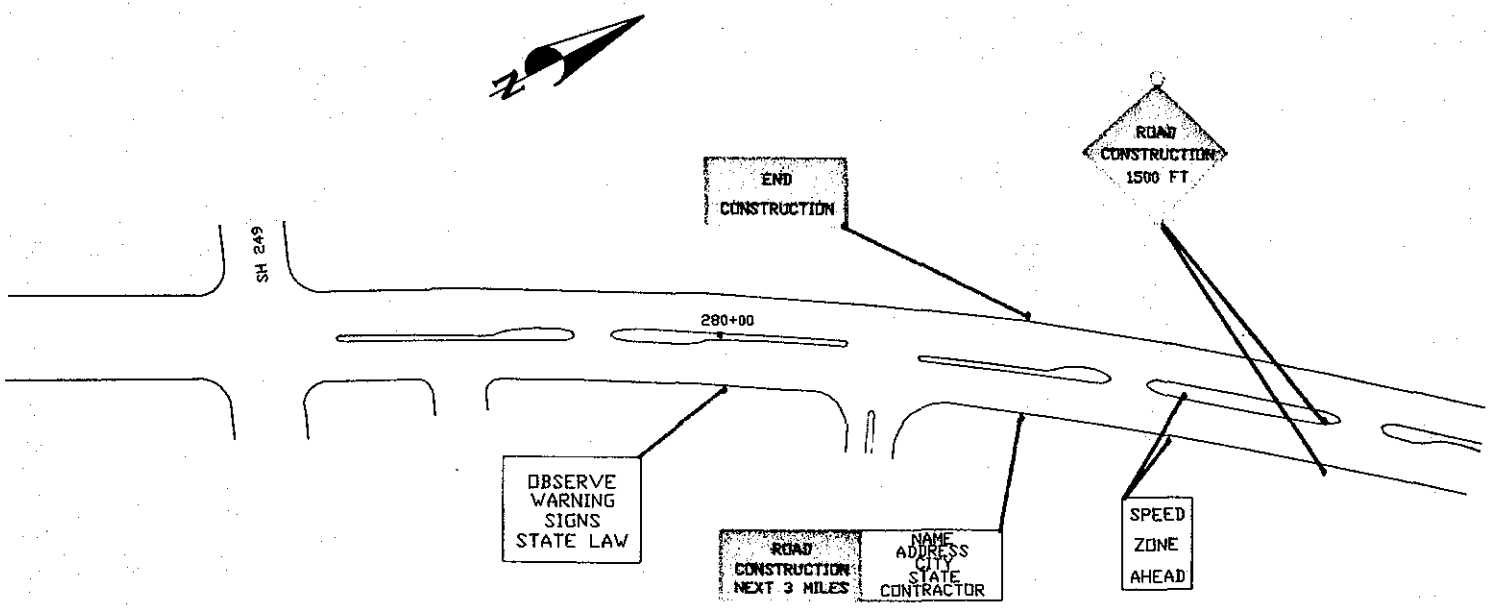
WORK ZONE

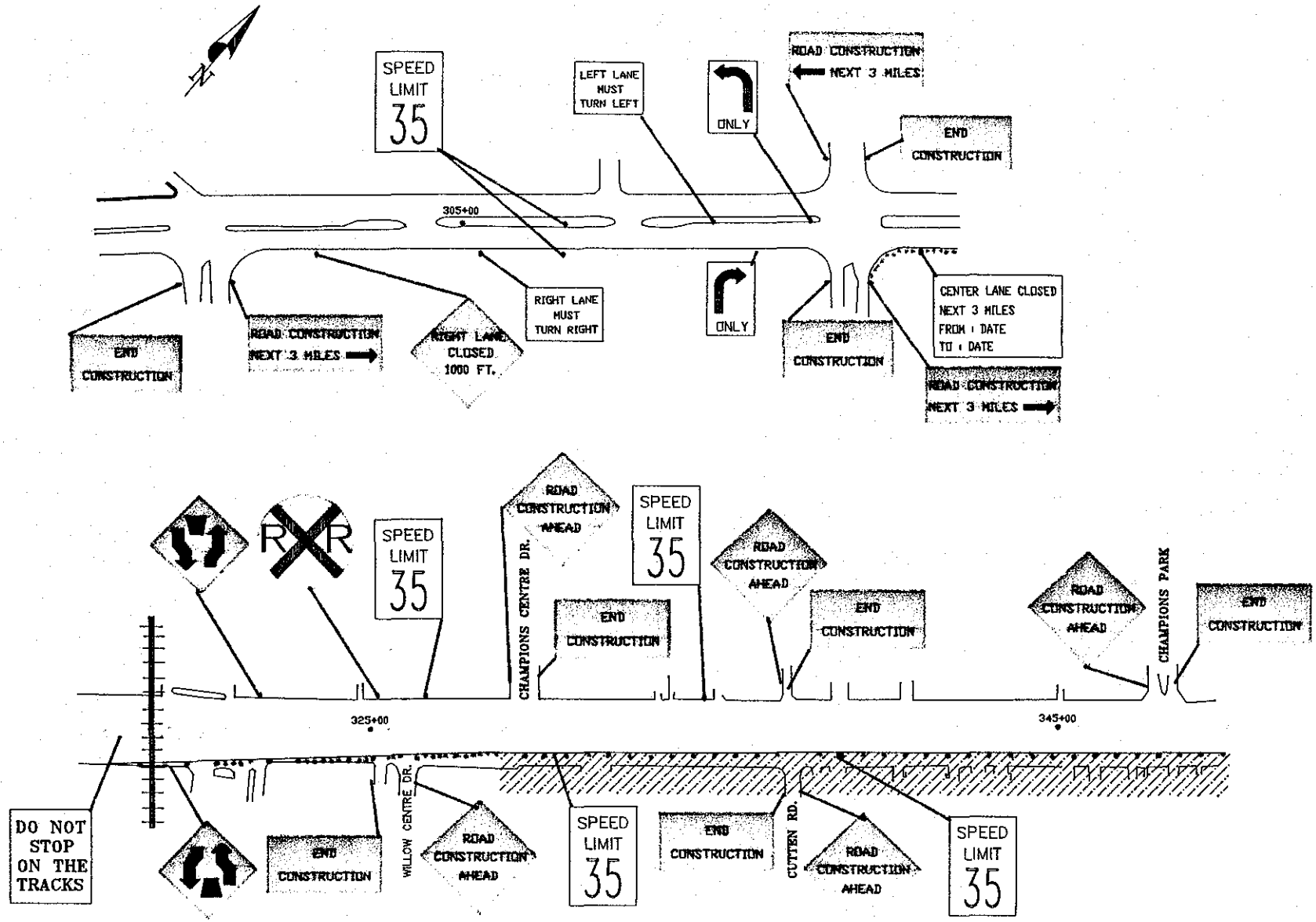
XXX + XX STATION NUMBERS

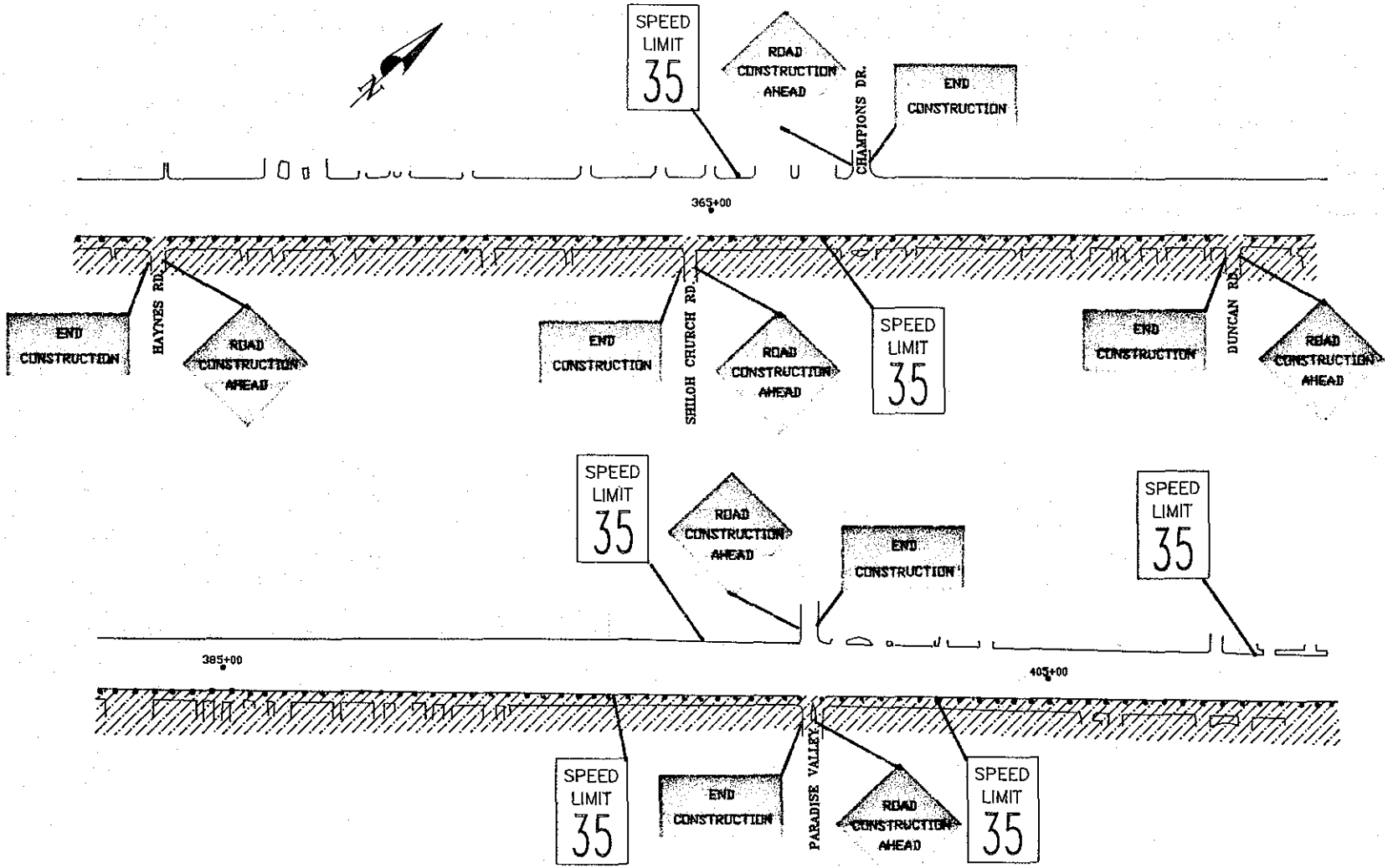
BARRELLS (ORANGE)

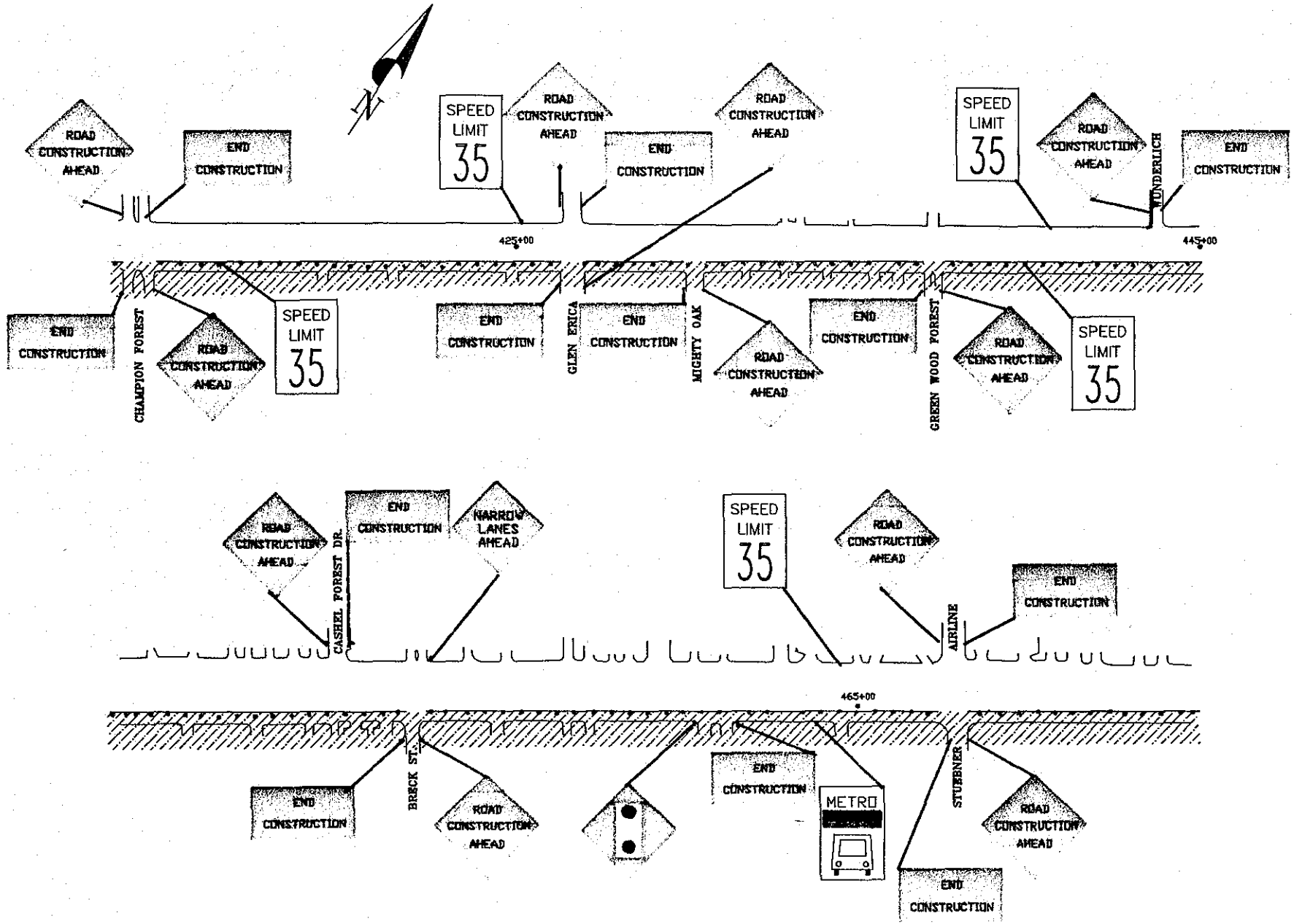
FLASHING WARNING LIGHTS (YELLOW)

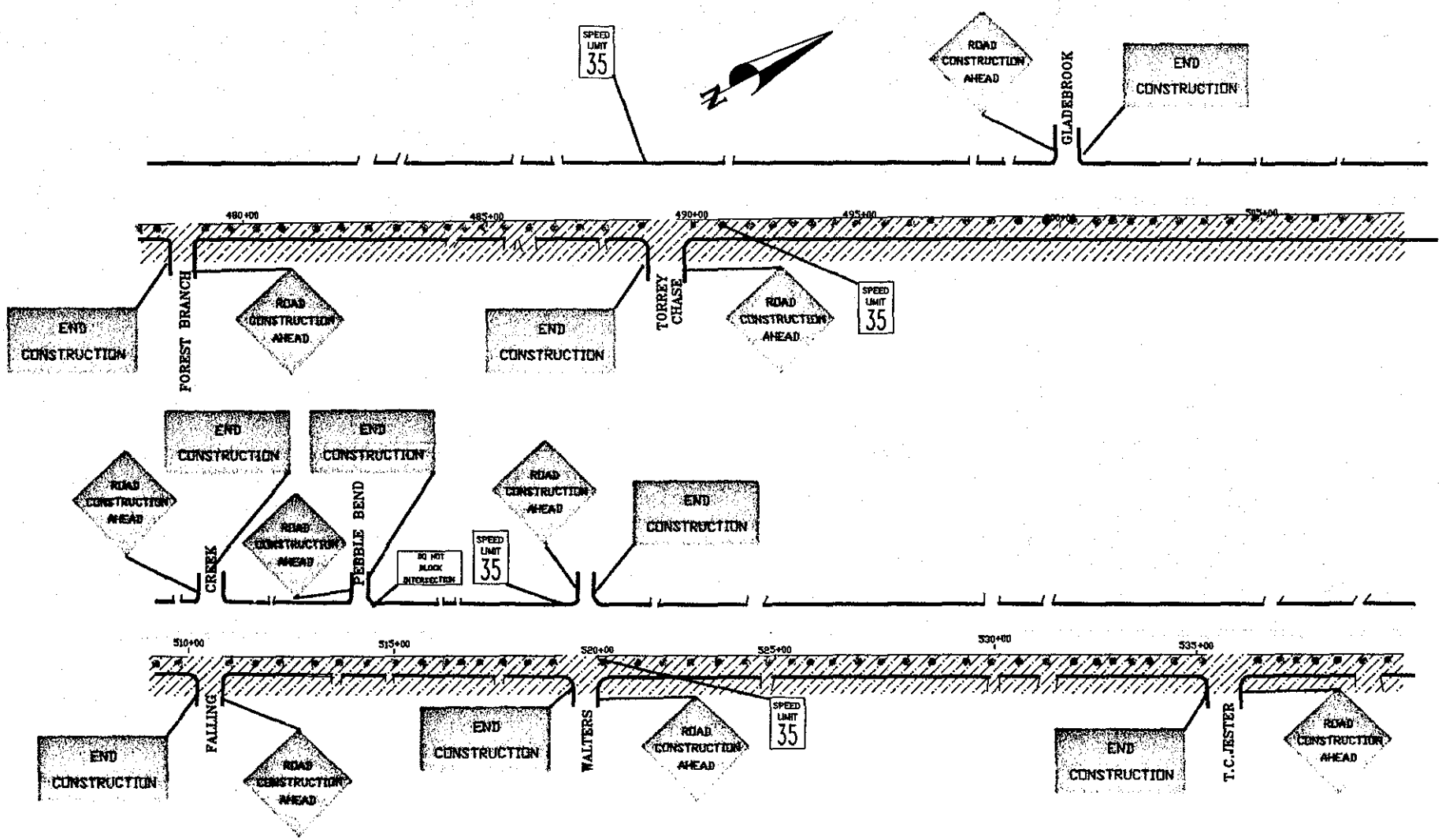
CONSTRUCTION WARNING SIGNS (BLACK ON ORANGE)

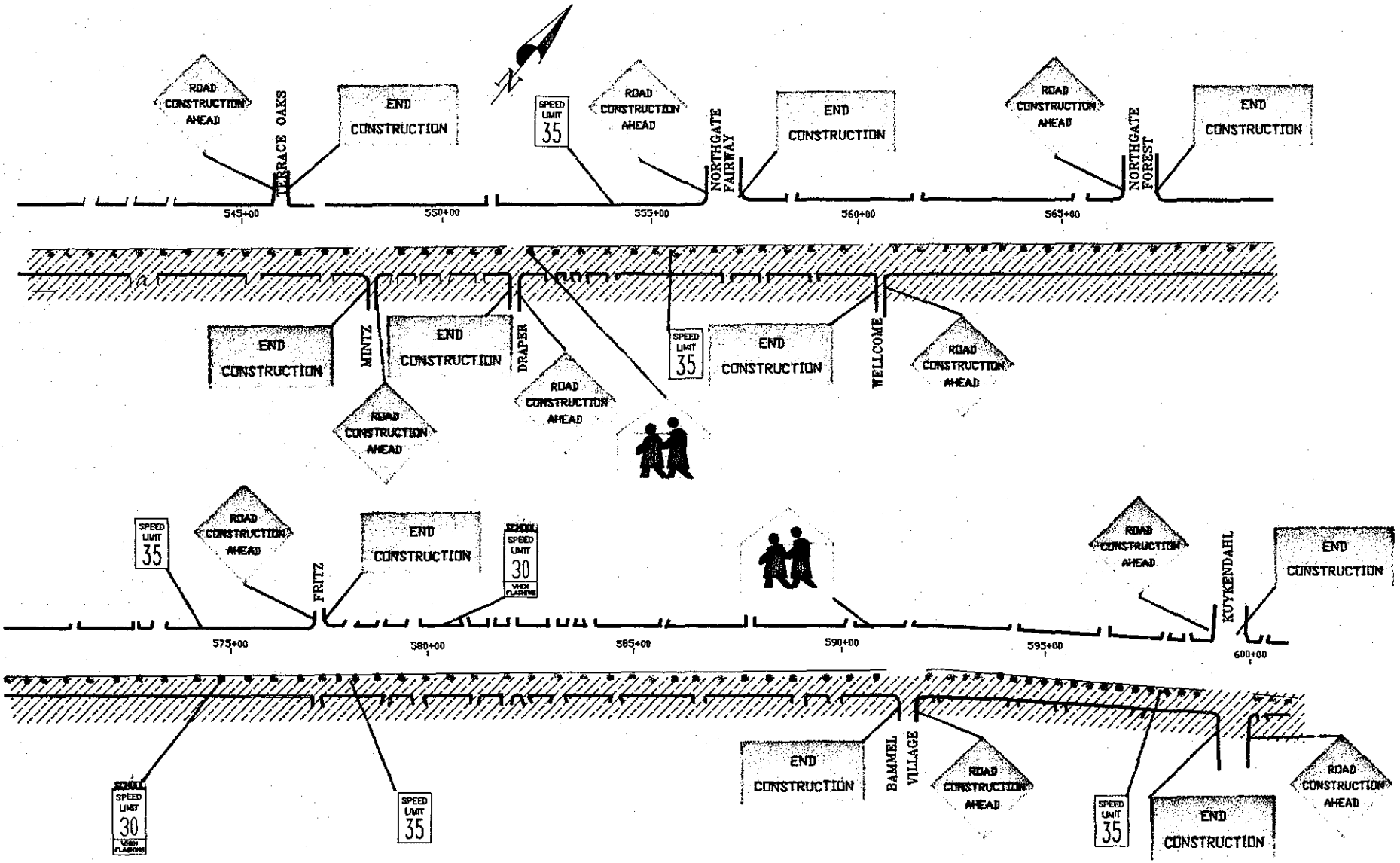

N
ROAD CONSTRUCTION 1500 FT
END CONSTRUCTION
SH 249
280+00
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION NEXT 3 MILES
NAME ADDRESS CITY STATE CONTRACTOR
SPEED ZONE AHEAD

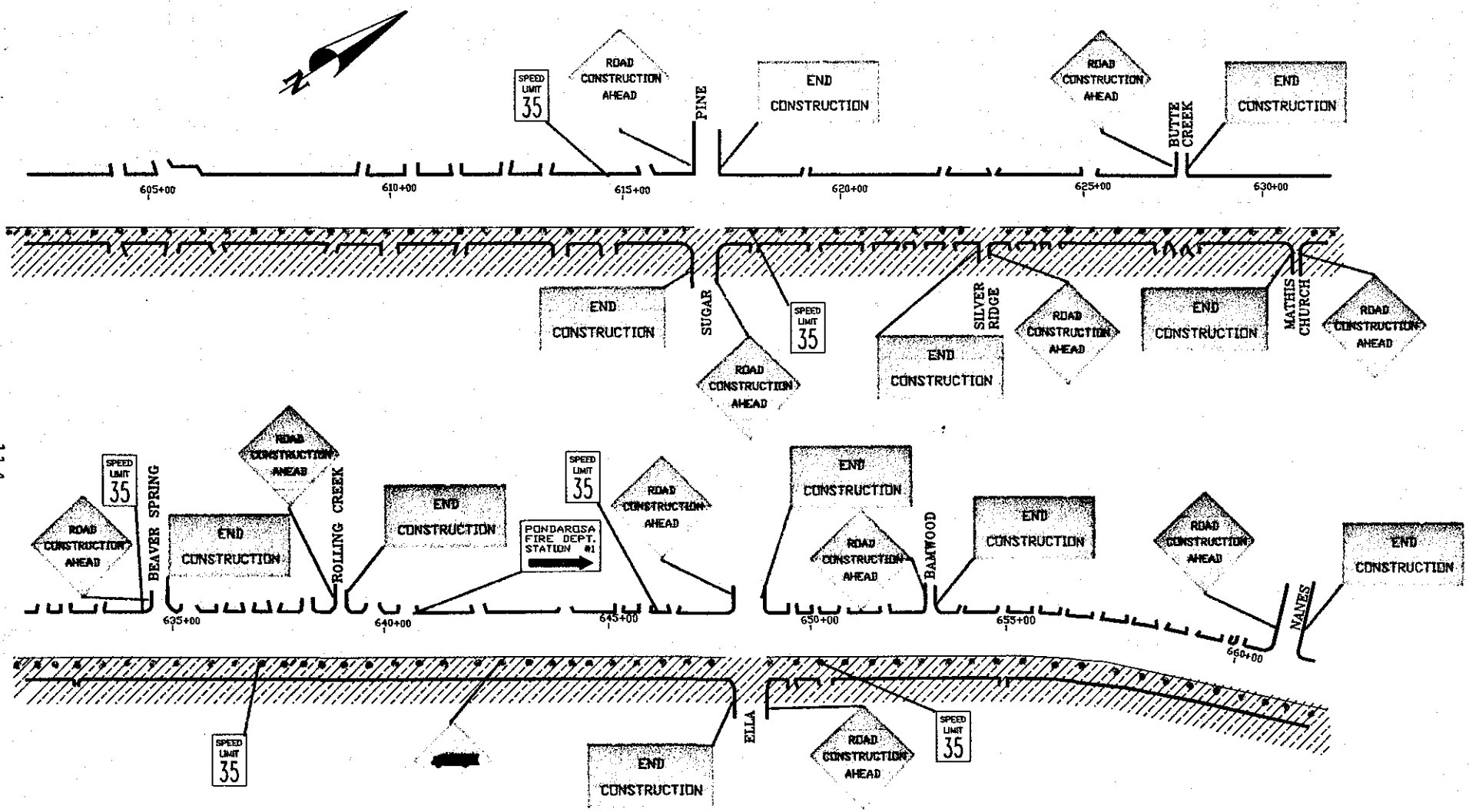

SPEED LIMIT 35
LEFT LANE MUST TURN LEFT
ONLY
ROAD CONSTRUCTION NEXT 3 MILES
END CONSTRUCTION
305+00
RIGHT LANE MUST TURN RIGHT
ONLY
END CONSTRUCTION
ROAD CONSTRUCTION NEXT 3 MILES
RIGHT LANE CLOSED 1000 FT.
ROAD CONSTRUCTION NEXT 3 MILES
CENTER LANE CLOSED NEXT 3 MILES FROM : DATE TO : DATE
R X R
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
CHAMPIONS CENTRE DR.
END CONSTRUCTION
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
CHAMPIONS PARK
END CONSTRUCTION
325+00
345+00
DO NOT STOP ON THE TRACKS
END CONSTRUCTION
WILLOW CENTRE DR.
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
END CONSTRUCTION
CUTTEN RD.
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35

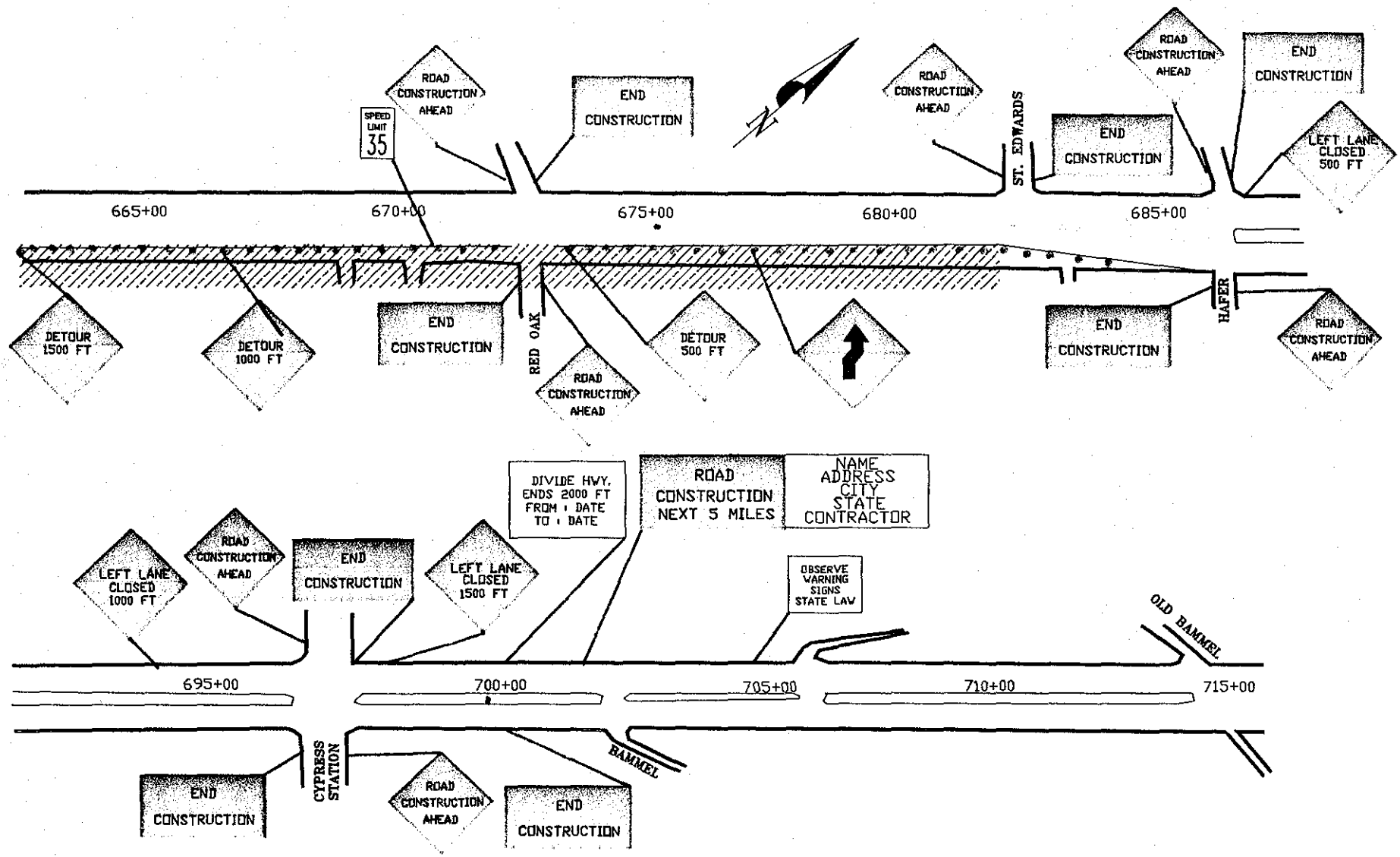

SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
CHAMPIONS DR.
365+00
END CONSTRUCTION
HAYNES RD.
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
SHILOH CHURCH RD.
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
END CONSTRUCTION
DUNCAN RD.
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
SPEED LIMIT 35
385+00
405+00
SPEED LIMIT 35
END CONSTRUCTION
PARADISE VALLEY
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35


ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
WUNDERLICH
END CONSTRUCTION
425+00
445+00
END CONSTRUCTION
CHAMPION FOREST
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
END CONSTRUCTION
GLEN ERICA
END CONSTRUCTION
MIGHTY OAK
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
GREEN WOOD FOREST
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
CASHEL FOREST DR.
END CONSTRUCTION
NARROW LANES AHEAD
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
AIRLINE
END CONSTRUCTION
465+00
END CONSTRUCTION
BRICK ST.
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
METRO
STUBBNER
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION


SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
GLADEBROOK
END CONSTRUCTION
480+00
485+00
490+00
495+00
500+00
505+00
END CONSTRUCTION
FOREST BRANCH
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
TORREY CHASE
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
END CONSTRUCTION
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
CREEK
ROAD CONSTRUCTION AHEAD
PEBBLE BEND
DO NOT BLOCK INTERSECTION
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
510+00
515+00
520+00
525+00
530+00
535+00
END CONSTRUCTION
FALLING
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
WALTERS
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
END CONSTRUCTION
T.C.JESTER
ROAD CONSTRUCTION AHEAD


ROAD CONSTRUCTION AHEAD
TERRACE OAKS
END CONSTRUCTION
SPEED LIMIT 35
NORTHGATE FAIRWAY
NORTHGATE FOREST
545+00
550+00
555+00
560+00
565+00
MINTZ
DRAPER
WELLCOME
SPEED LIMIT 30
VIEW FLASHING
FRITZ
575+00
580+00
585+00
590+00
595+00
600+00
KUYKENDAHL
BAMMEL VILLAGE


SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
PINE
END CONSTRUCTION
BUTTE CREEK
605+00
610+00
615+00
620+00
625+00
630+00
SUGAR
SILVER RIDGE
MATHIS CHURCH
BEAVER SPRING
ROLLING CREEK
PONDEROSA FIRE DEPT. STATION #1
BAMWOOD
NAVES
ELLA
635+00
640+00
645+00
650+00
655+00
660+00


ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
ST. EDWARDS
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
LEFT LANE CLOSED 500 FT
665+00
670+00
675+00
680+00
685+00
DETOUR 1500 FT
DETOUR 1000 FT
END CONSTRUCTION
RED OAK
ROAD CONSTRUCTION AHEAD
DETOUR 500 FT
END CONSTRUCTION
HAFER
ROAD CONSTRUCTION AHEAD
DIVIDE HWY. ENDS 2000 FT FROM ↓ DATE TO ↓ DATE
ROAD CONSTRUCTION NEXT 5 MILES
NAME ADDRESS CITY STATE CONTRACTOR
LEFT LANE CLOSED 1000 FT
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
LEFT LANE CLOSED 1500 FT
OBSERVE WARNING SIGNS STATE LAW
OLD BAMMEL
695+00
700+00
705+00
710+00
715+00
CYPRESS STATION
BAMMEL
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION

PHASE III

CONSTRUCTION SCHEDULE

JANUARY 1989 - APRIL 1989

PLAN LEGEND

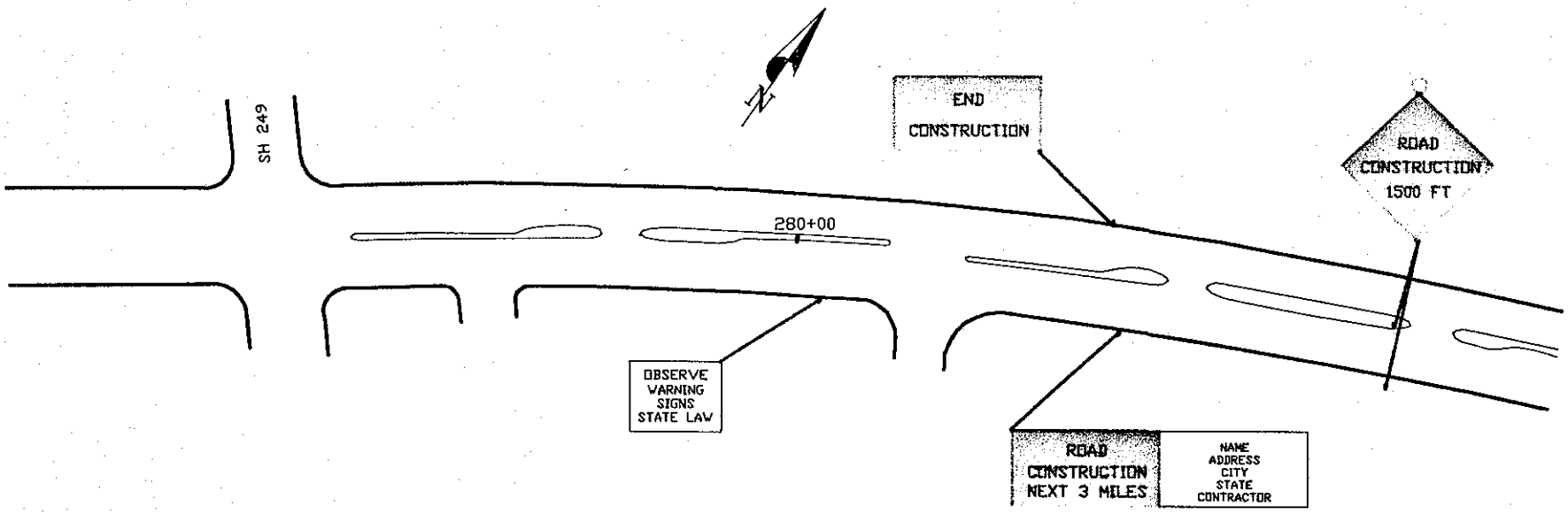
WORK ZONE

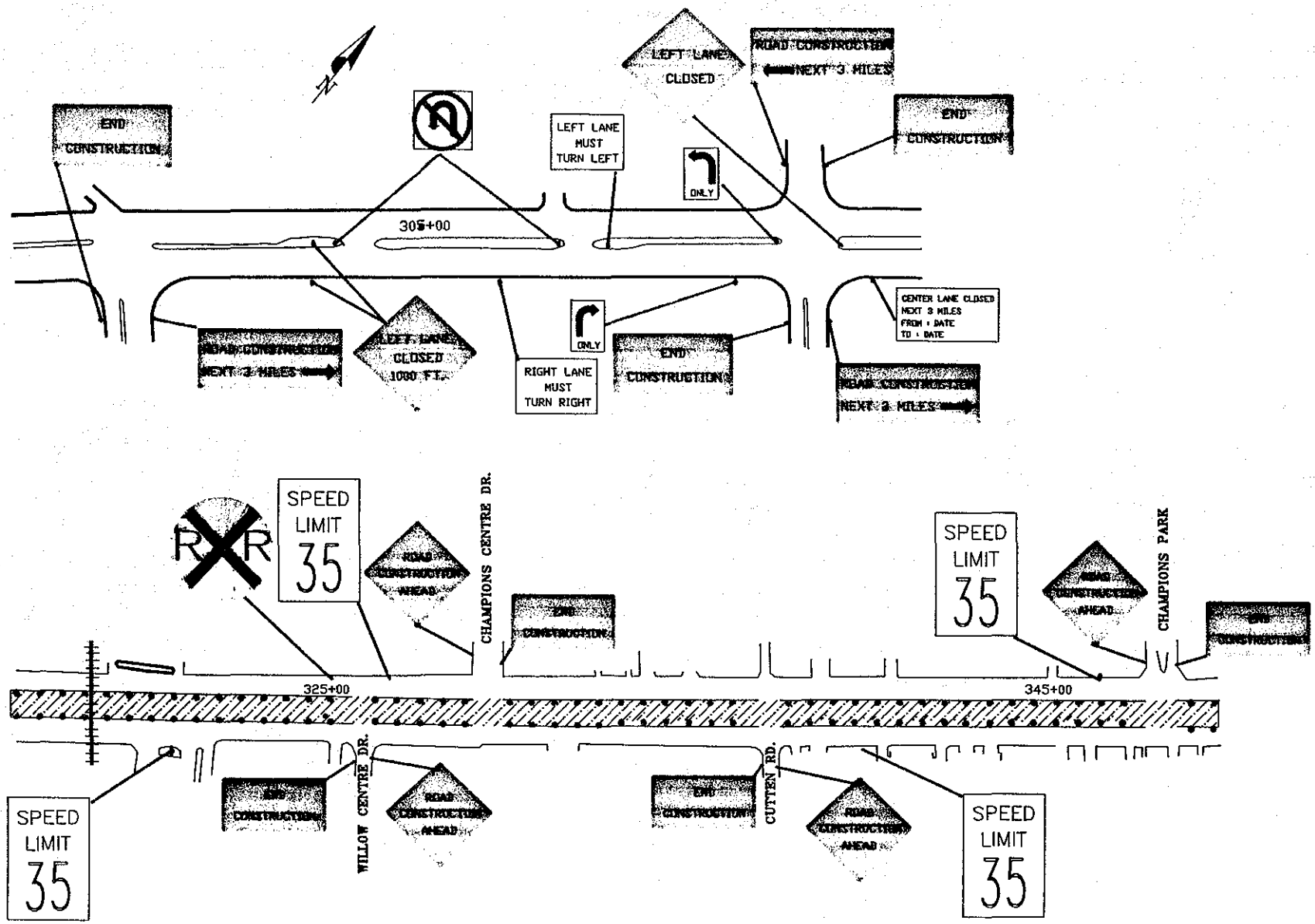
XXX + XX STATION NUMBERS

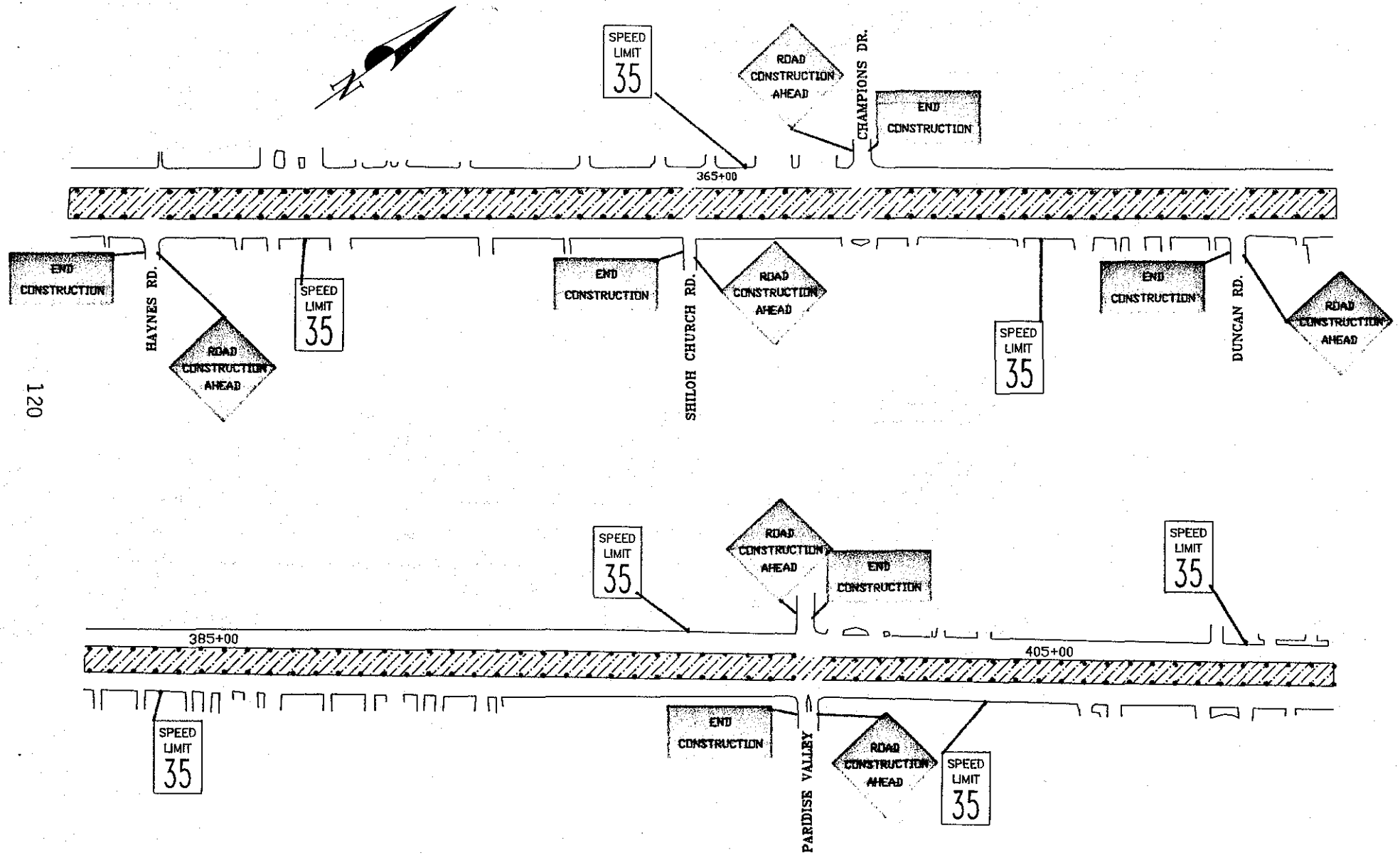
● ● ● ● BARRELLS (ORANGE)

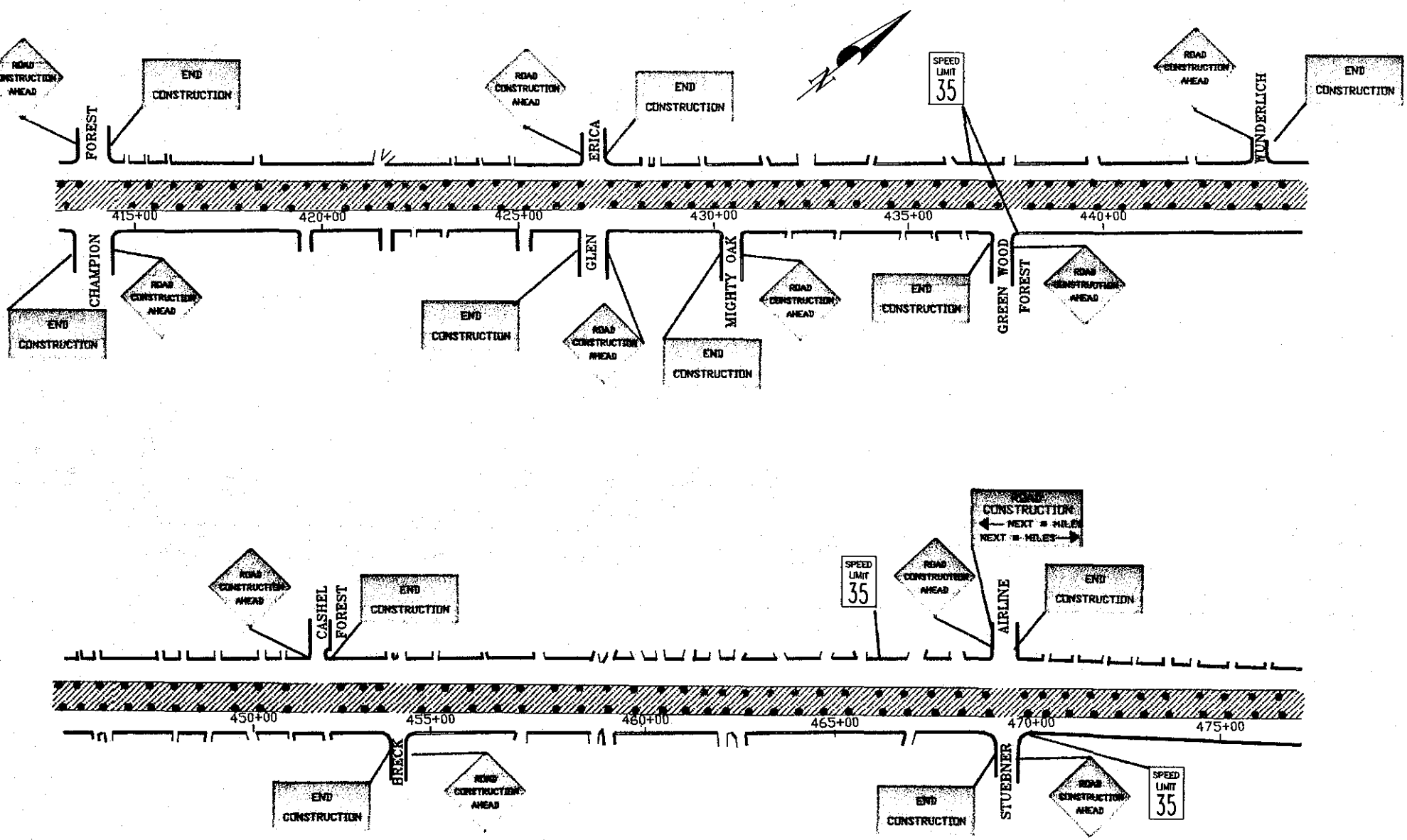
O FLASHING WARNING LIGHTS (YELLOW)

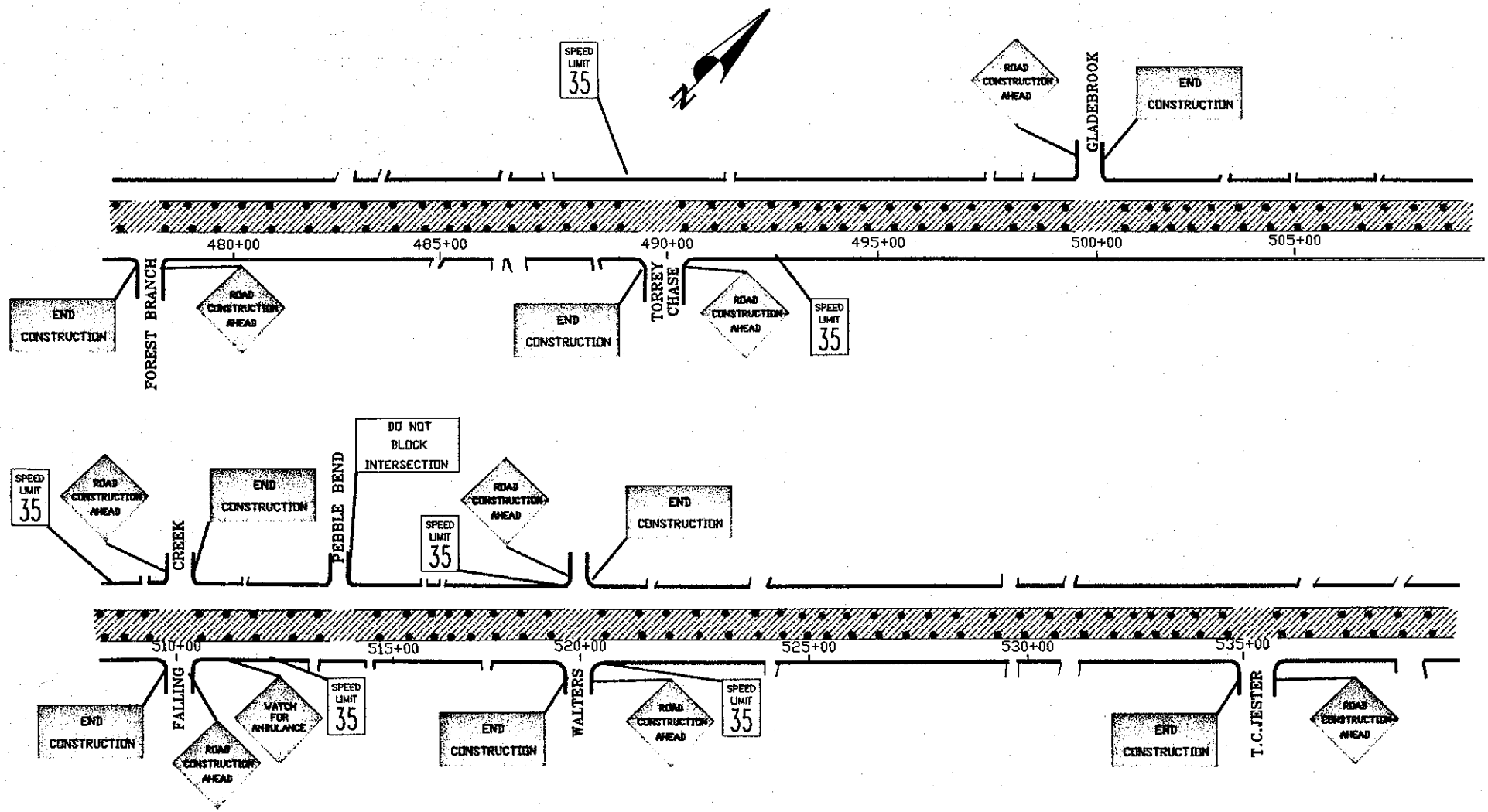
CONSTRUCTION WARNING SIGNS (BLACK ON ORANGE)

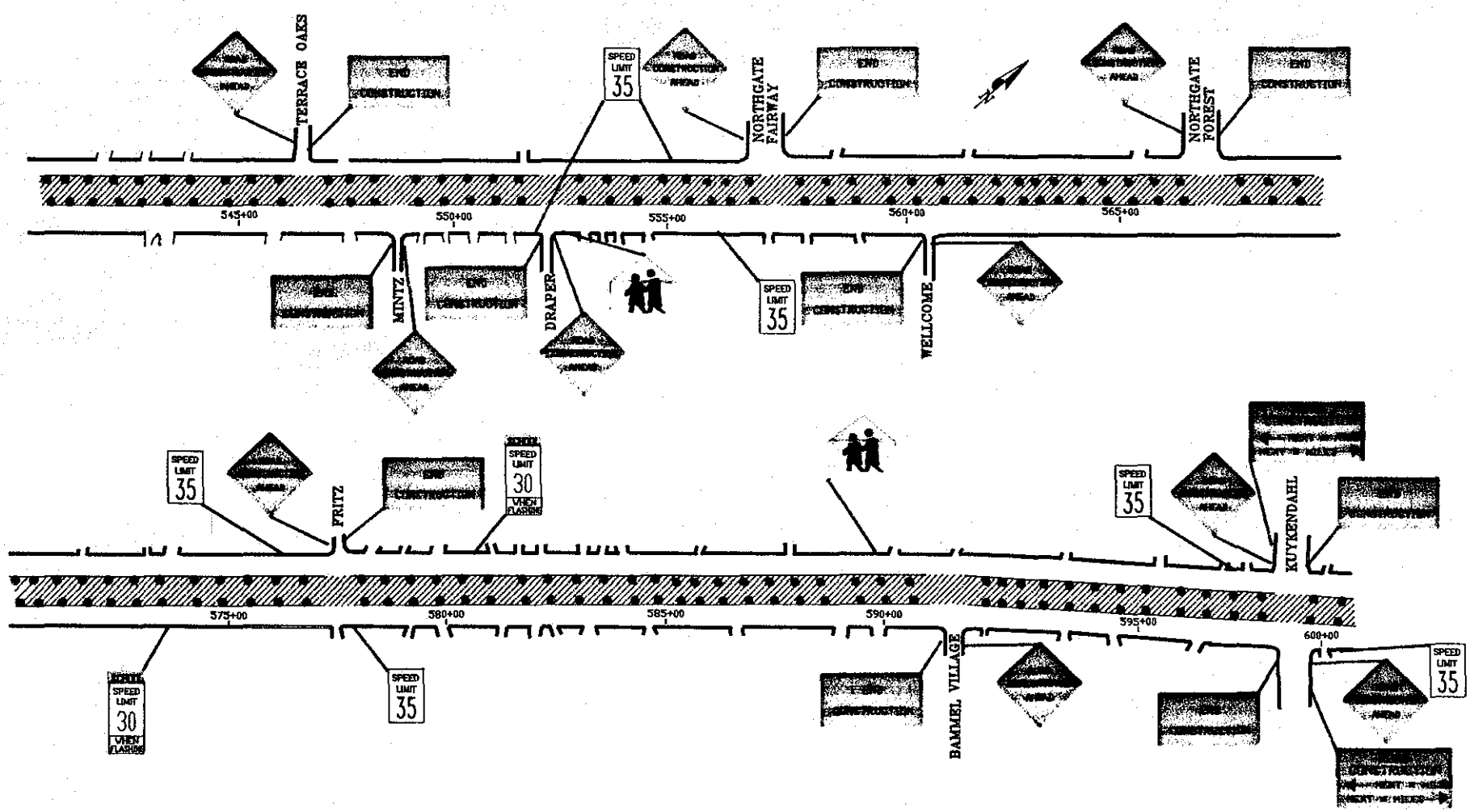

SH 249
END
CONSTRUCTION
ROAD
CONSTRUCTION
1500 FT
280+00
OBSERVE
WARNING
SIGNS
STATE LAW
ROAD
CONSTRUCTION
NEXT 3 MILES
NAME
ADDRESS
CITY
STATE
CONTRACTOR

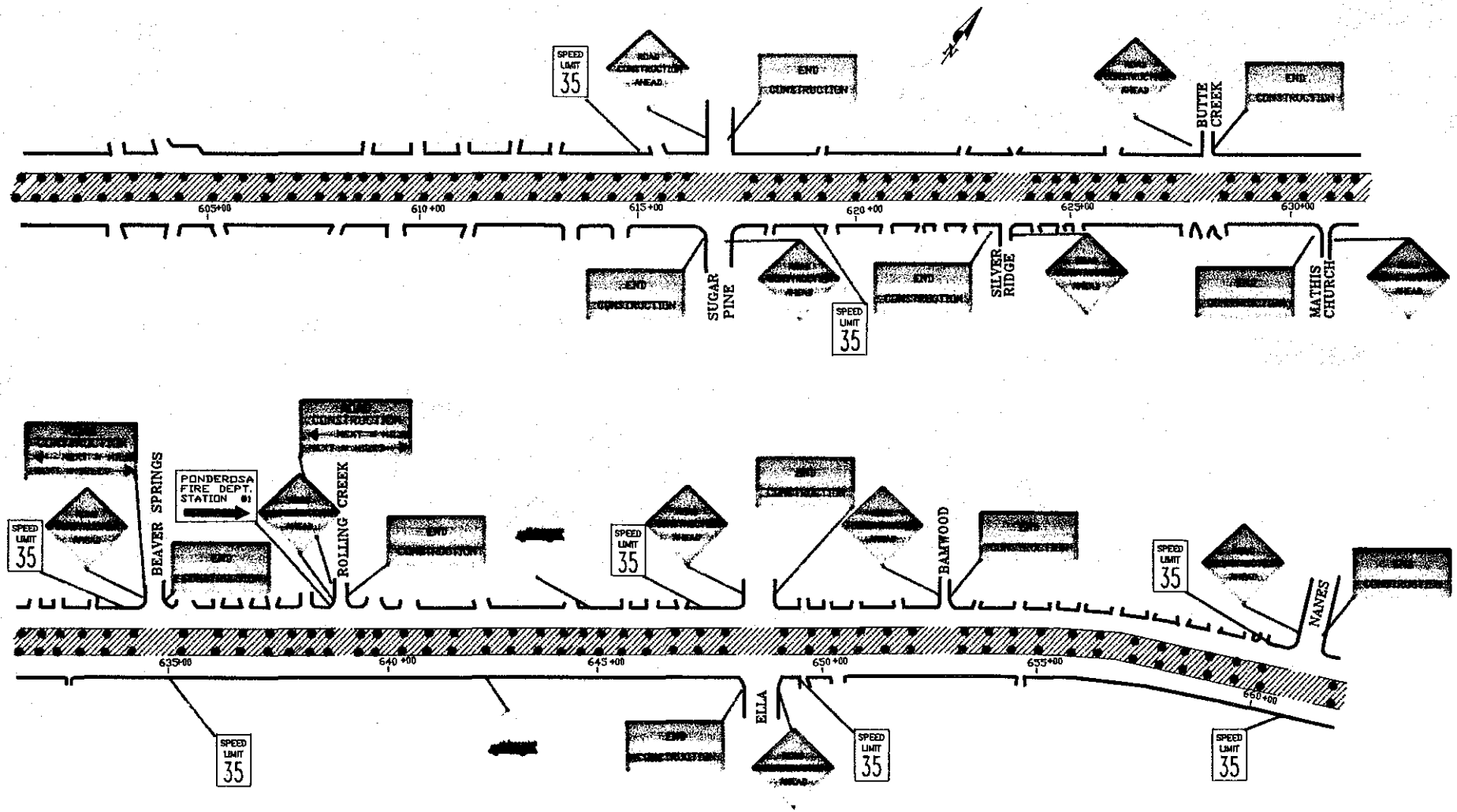

END CONSTRUCTION
LEFT LANE CLOSED
ROAD CONSTRUCTION
NEXT 3 MILES
END CONSTRUCTION
LEFT LANE MUST TURN LEFT
ONLY
305+00
CENTER LANE CLOSED
NEXT 3 MILES
FROM = DATE
TO = DATE
ROAD CONSTRUCTION
NEXT 3 MILES
LEFT LANE CLOSED 1000 FT.
RIGHT LANE MUST TURN RIGHT
ONLY
END CONSTRUCTION
ROAD CONSTRUCTION
NEXT 3 MILES
R R
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
CHAMPIONS CENTRE DR.
END CONSTRUCTION
325+00
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
CHAMPIONS PARK
END CONSTRUCTION
345+00
SPEED LIMIT 35
END CONSTRUCTION
WILLOW CENTRE DR.
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
CUTTEN RD.
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35

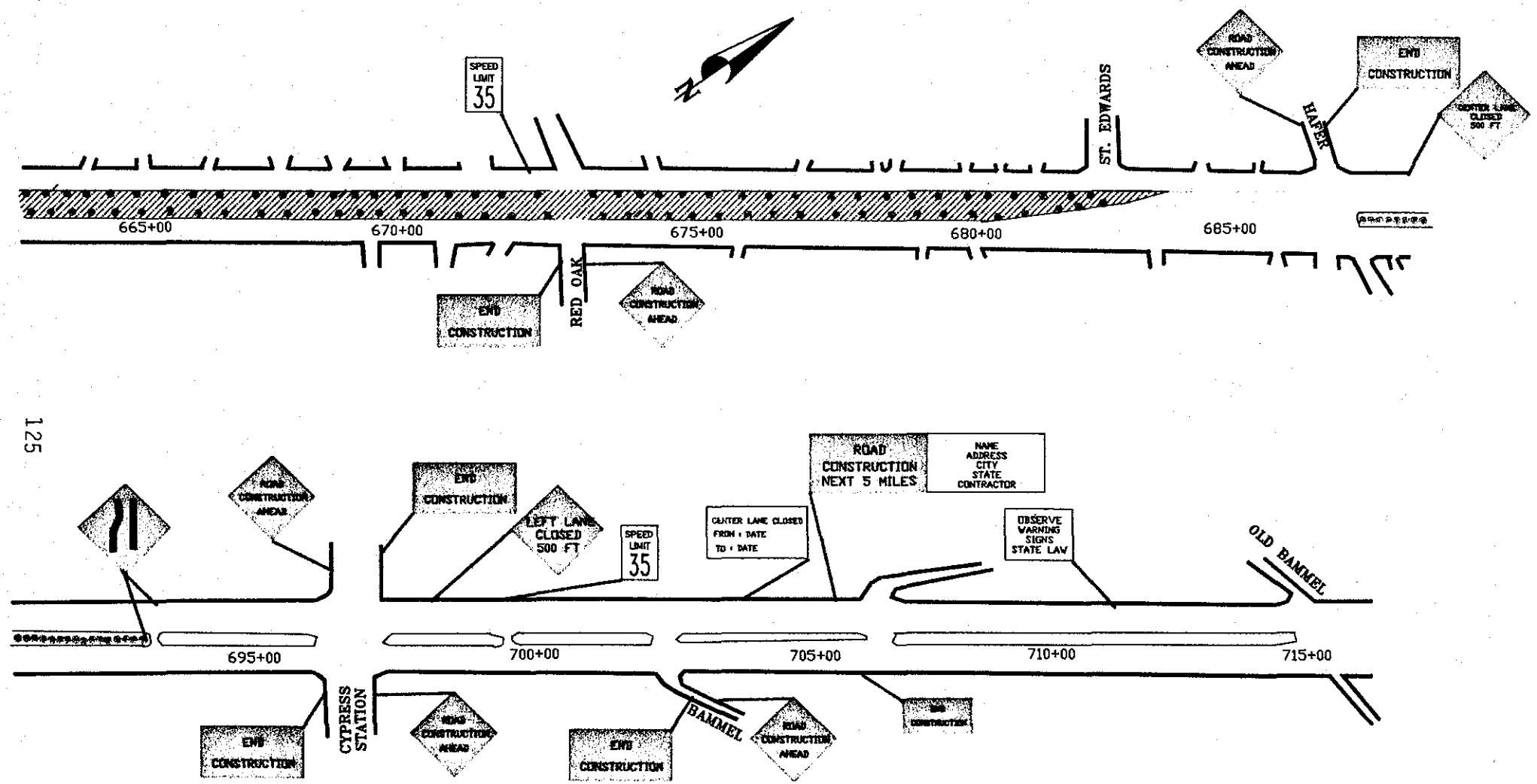

SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
CHAMPIONS DR.
END CONSTRUCTION
365+00
END CONSTRUCTION
HAYNES RD.
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
END CONSTRUCTION
SHILOH CHURCH RD.
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
END CONSTRUCTION
DUNCAN RD.
ROAD CONSTRUCTION AHEAD
120
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
SPEED LIMIT 35
385+00
405+00
SPEED LIMIT 35
END CONSTRUCTION
PARIDISE VALLEY
ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35


ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
FOREST
ERICA
SPEED LIMIT 35
WUNDERLICH
415+00
420+00
425+00
430+00
435+00
440+00
CHAMPION
GLEN
MIGHTY OAK
GREEN WOOD
FOREST
CASHEL FOREST
AIRLINE
450+00
455+00
460+00
465+00
470+00
475+00
BRECK
STUEBNER


SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
GLADEBROOK
480+00
485+00
490+00
495+00
500+00
505+00
FOREST BRANCH
TORREY CHASE
SPEED LIMIT 35
DO NOT BLOCK INTERSECTION
PEBBLE BEND
CREEK
510+00
515+00
520+00
525+00
530+00
535+00
FALLING
WATCH FOR AMBULANCE
WALTERS
T.C.JESTER


TERRACE OAKS
END CONSTRUCTION
SPEED LIMIT 35
NORTHGATE FAIRWAY
NORTHGATE FOREST
545+00
550+00
555+00
560+00
565+00
MINTZ
DRAPER
WELLCOME
FRITZ
SPEED LIMIT 30 WHEN FLASHING
575+00
580+00
585+00
590+00
595+00
600+00
KUYKENDAHL
BAMMEL VILLAGE


SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
BUTTE CREEK
605+00
610+00
615+00
620+00
625+00
630+00
SUGAR PINE
SILVER RIDGE
MATHIS CHURCH
PONDEROSA FIRE DEPT. STATION #1
BEAVER SPRINGS
ROLLING CREEK
BAMWOOD
NANES
635+00
640+00
645+00
650+00
655+00
660+00
ELLA


SPEED LIMIT 35
ST. EDWARDS
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
HAFER
665+00
670+00
675+00
680+00
685+00
END CONSTRUCTION
RED OAK
ROAD CONSTRUCTION AHEAD
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
LEFT LANE CLOSED 500 FT
SPEED LIMIT 35
CENTER LANE CLOSED FROM + DATE TO + DATE
ROAD CONSTRUCTION NEXT 5 MILES
NAME ADDRESS CITY STATE CONTRACTOR
OBSERVE WARNING SIGNS STATE LAW
OLD BAMMEL
695+00
700+00
705+00
710+00
715+00
END CONSTRUCTION
CYPRESS STATION
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
BAMMEL
ROAD CONSTRUCTION AHEAD

PHASE IV

CONSTRUCTION SCHEDULE

APRIL 1989 - NOVEMBER 1989 *

* TENTATIVE END DATE

PLAN LEGEND

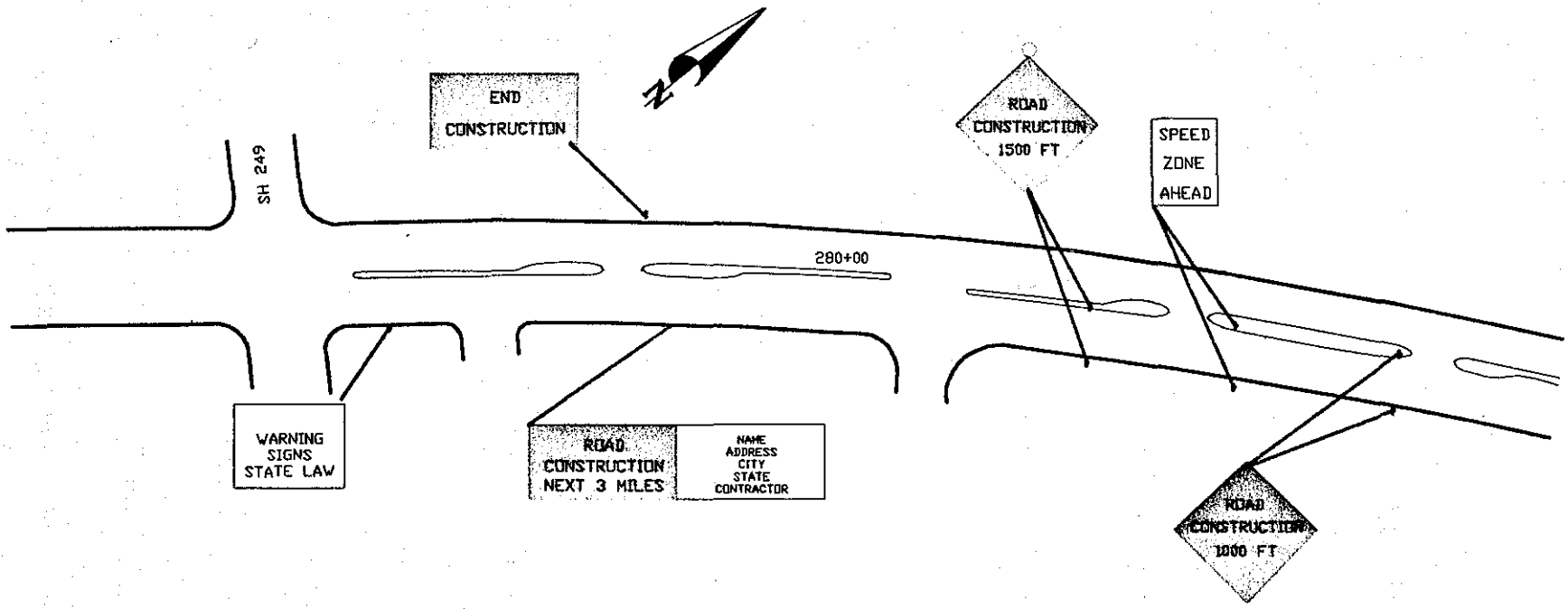
WORK ZONE

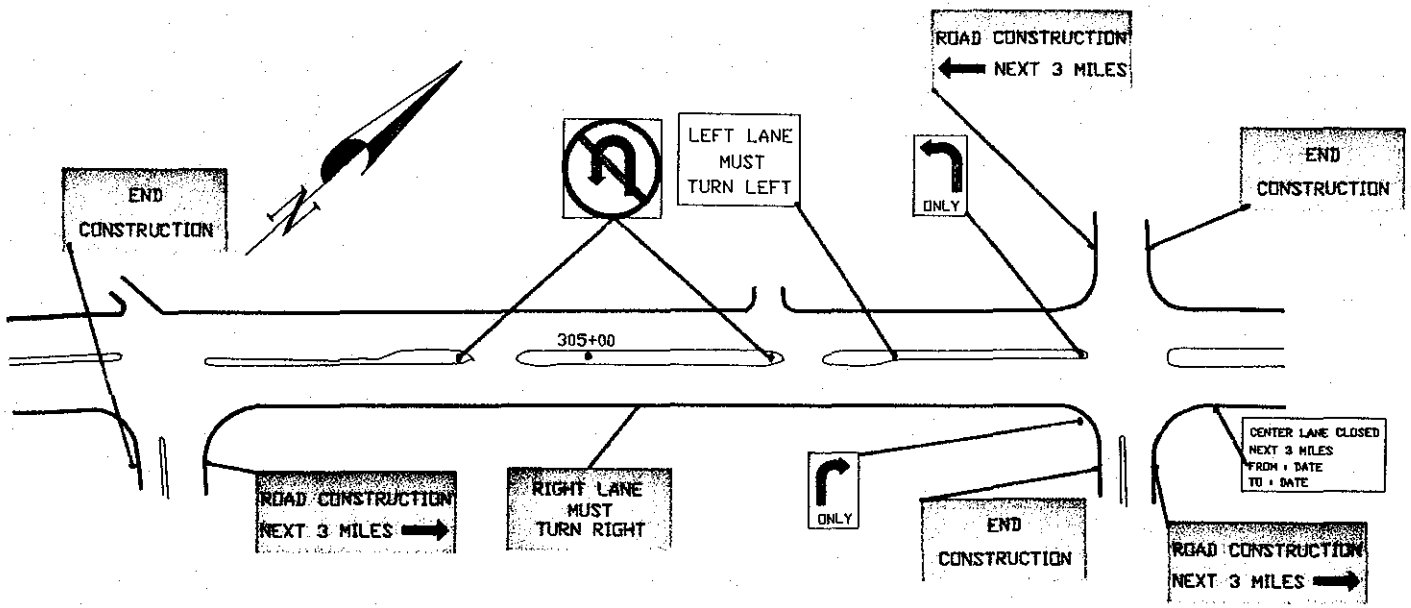
XXX + XX STATION NUMBERS

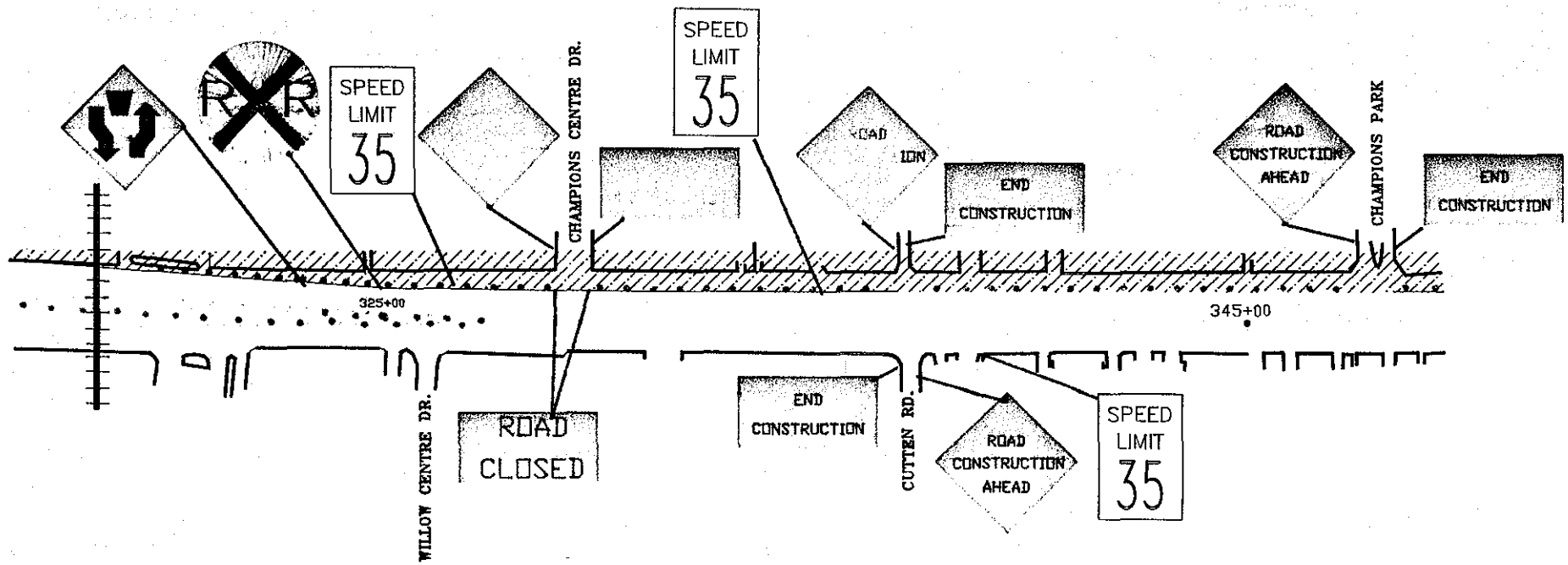
● ● ● ● BARRELLS (ORANGE)

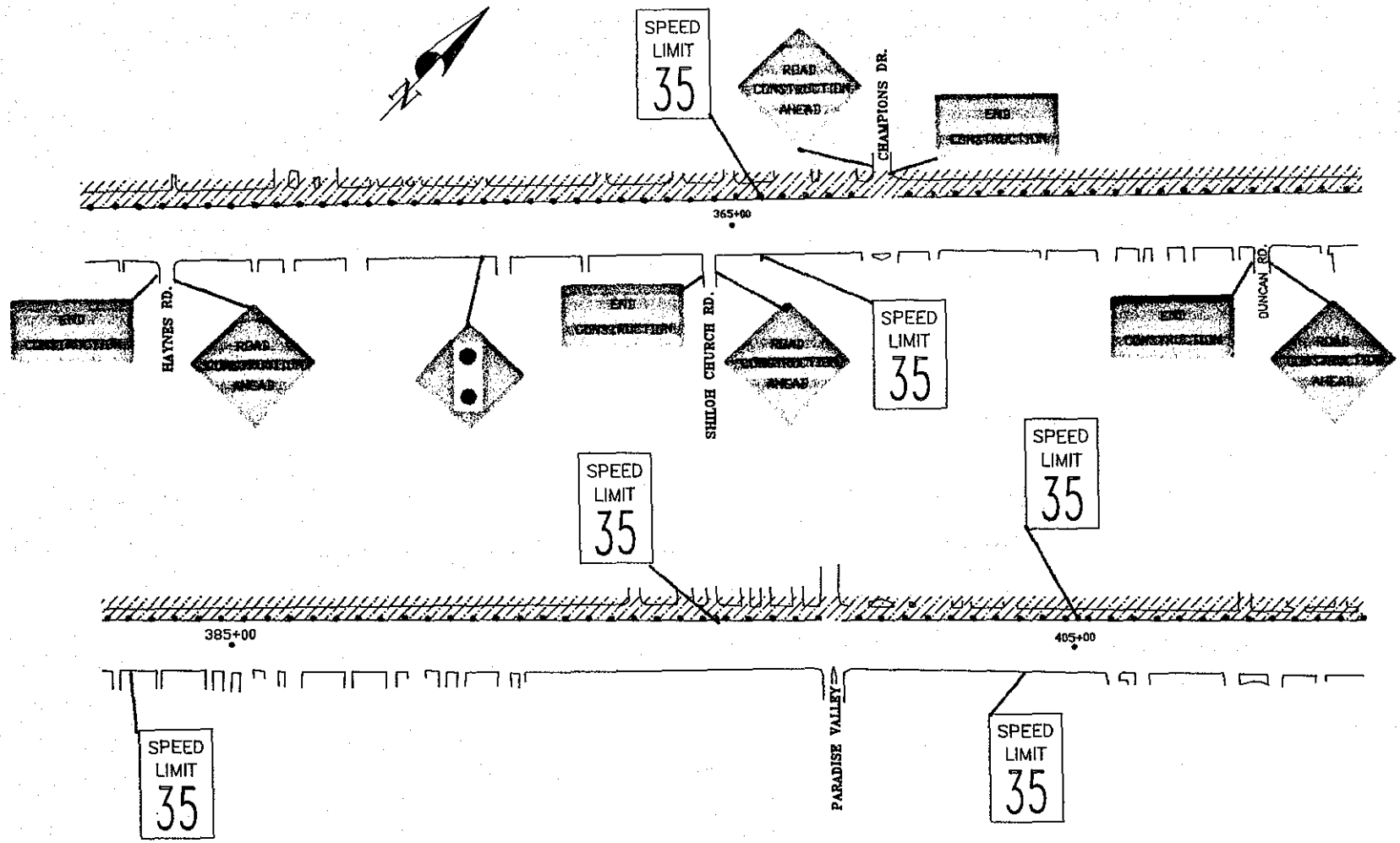
O FLASHING WARNING LIGHTS (YELLOW)

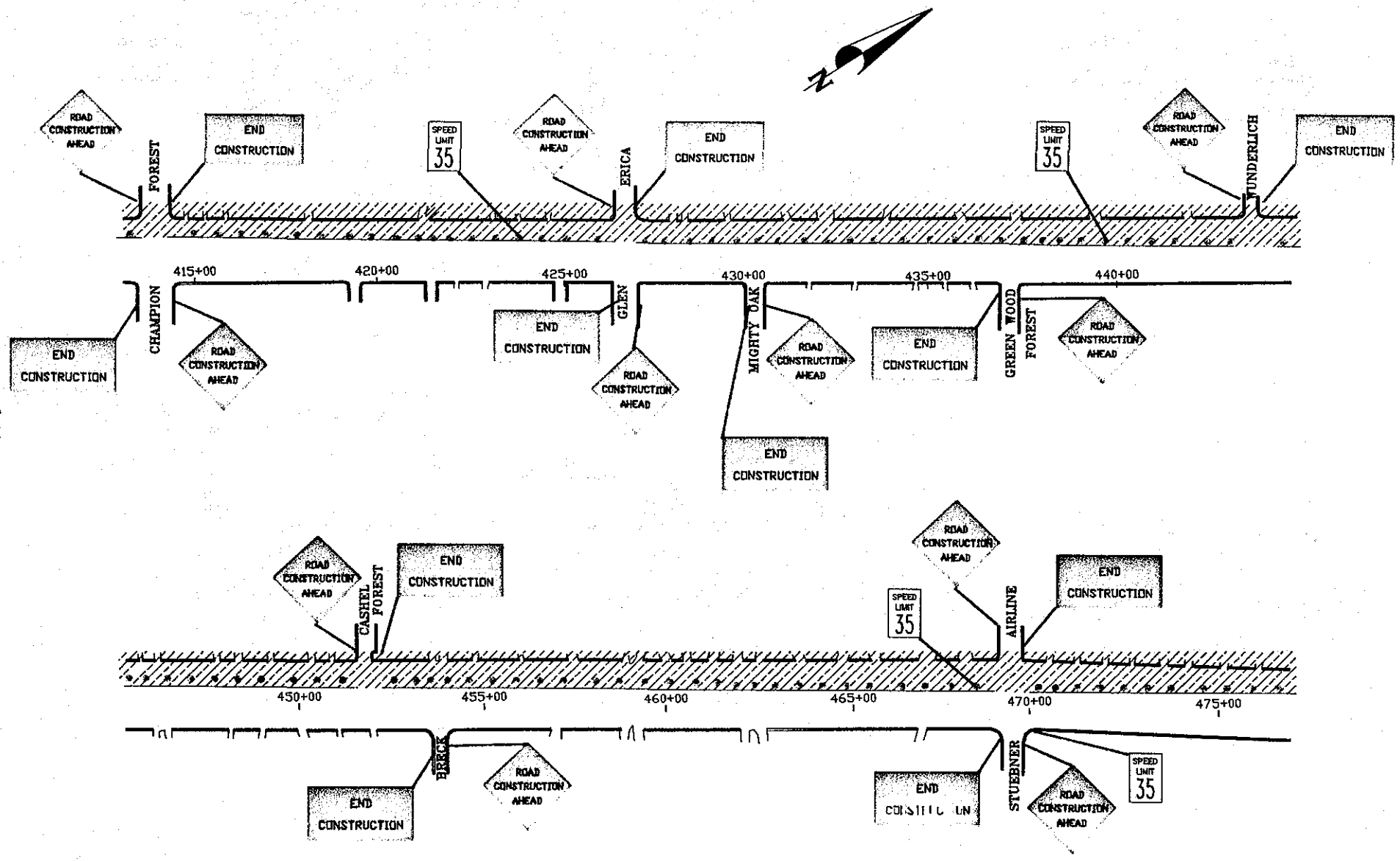
CONSTRUCTION WARNING SIGNS (BLACK ON ORANGE)

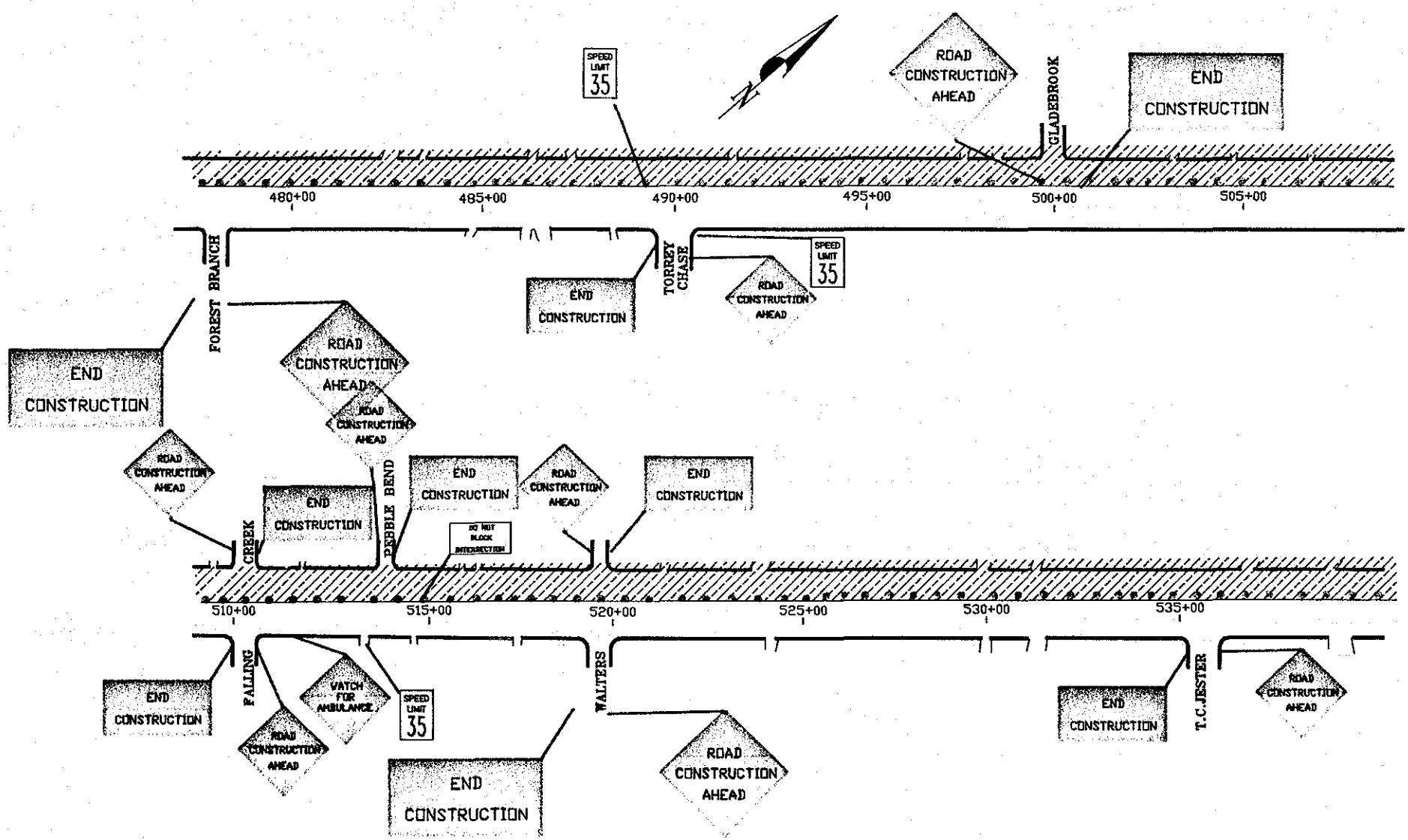

END
CONSTRUCTION
SH 249
280+00
ROAD
CONSTRUCTION
1500 FT
SPEED
ZONE
AHEAD
WARNING
SIGNS
STATE LAW
ROAD
CONSTRUCTION
NEXT 3 MILES
NAME
ADDRESS
CITY
STATE
CONTRACTOR
ROAD
CONSTRUCTION
1000 FT

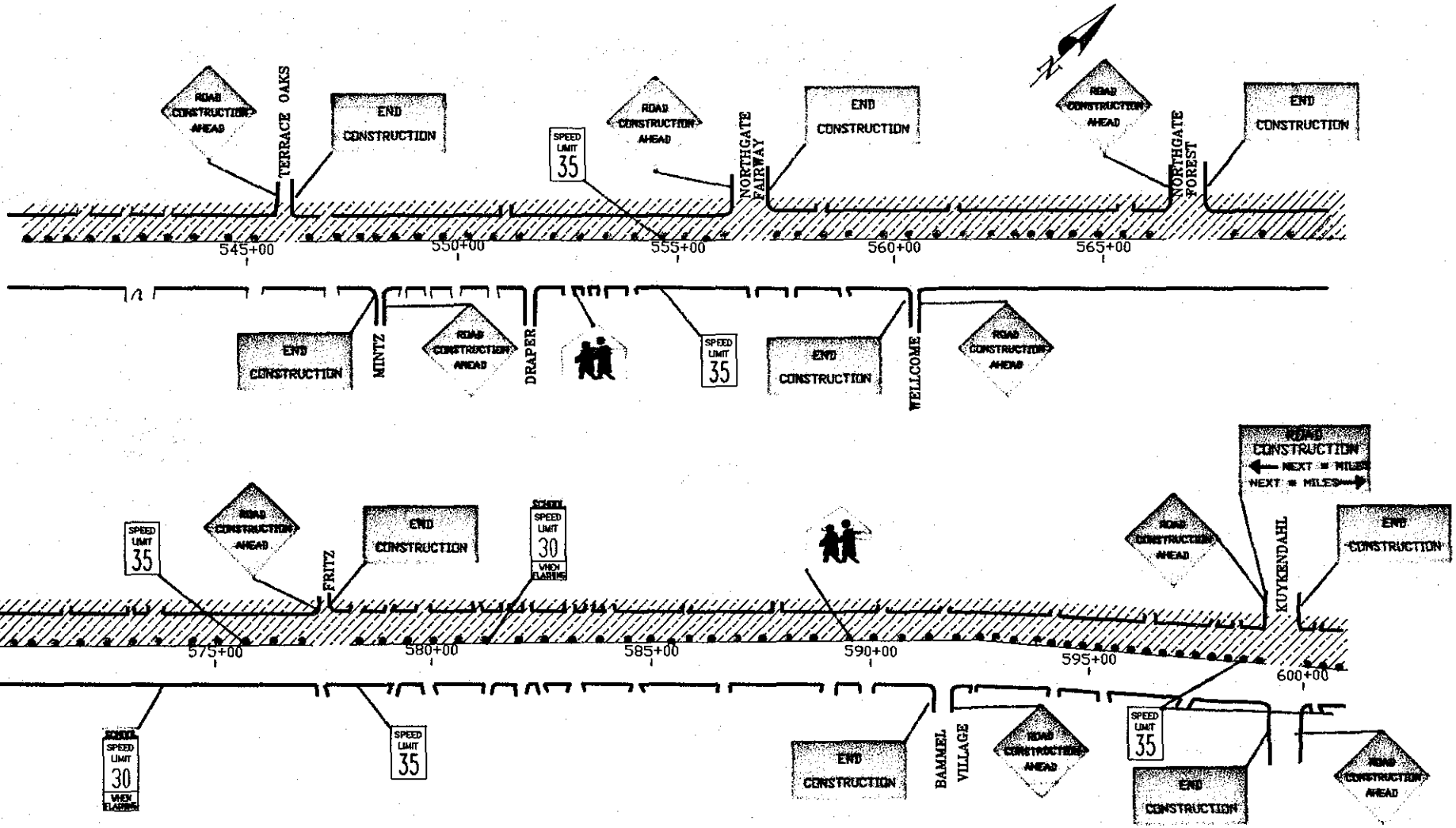

ROAD CONSTRUCTION
NEXT 3 MILES
END
CONSTRUCTION
LEFT LANE
MUST
TURN LEFT
ONLY
END
CONSTRUCTION
305+00
ROAD CONSTRUCTION
NEXT 3 MILES
RIGHT LANE
MUST
TURN RIGHT
ONLY
END
CONSTRUCTION
CENTER LANE CLOSED
NEXT 3 MILES
FROM : DATE
TO : DATE
ROAD CONSTRUCTION
NEXT 3 MILES

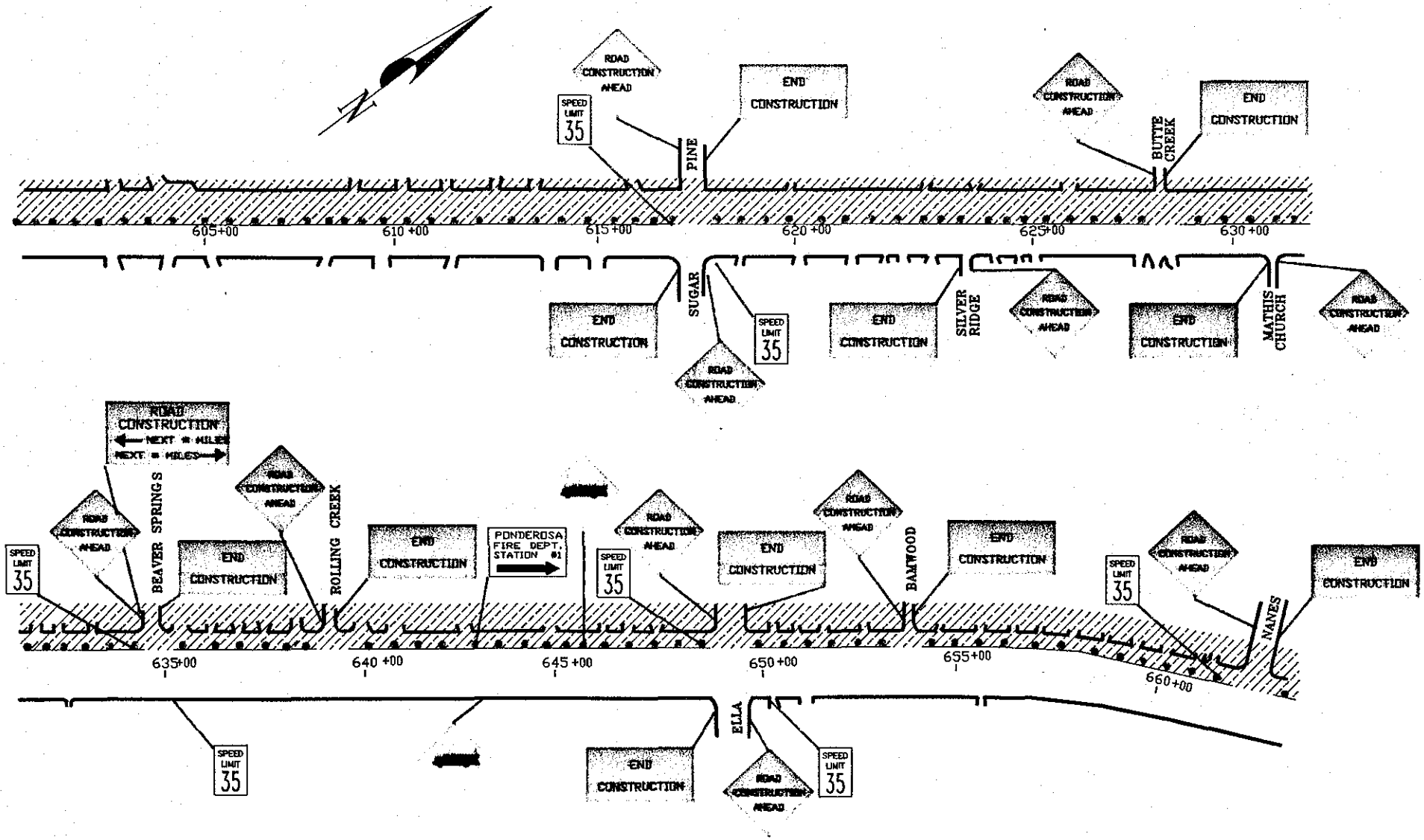

SPEED
LIMIT
35
CHAMPIONS CENTRE DR.
SPEED
LIMIT
35
END
CONSTRUCTION
ROAD
CONSTRUCTION
AHEAD
CHAMPIONS PARK
END
CONSTRUCTION
325+00
345+00
WILLOW CENTRE DR.
ROAD
CLOSED
END
CONSTRUCTION
CUTTEN RD.
ROAD
CONSTRUCTION
AHEAD
SPEED
LIMIT
35

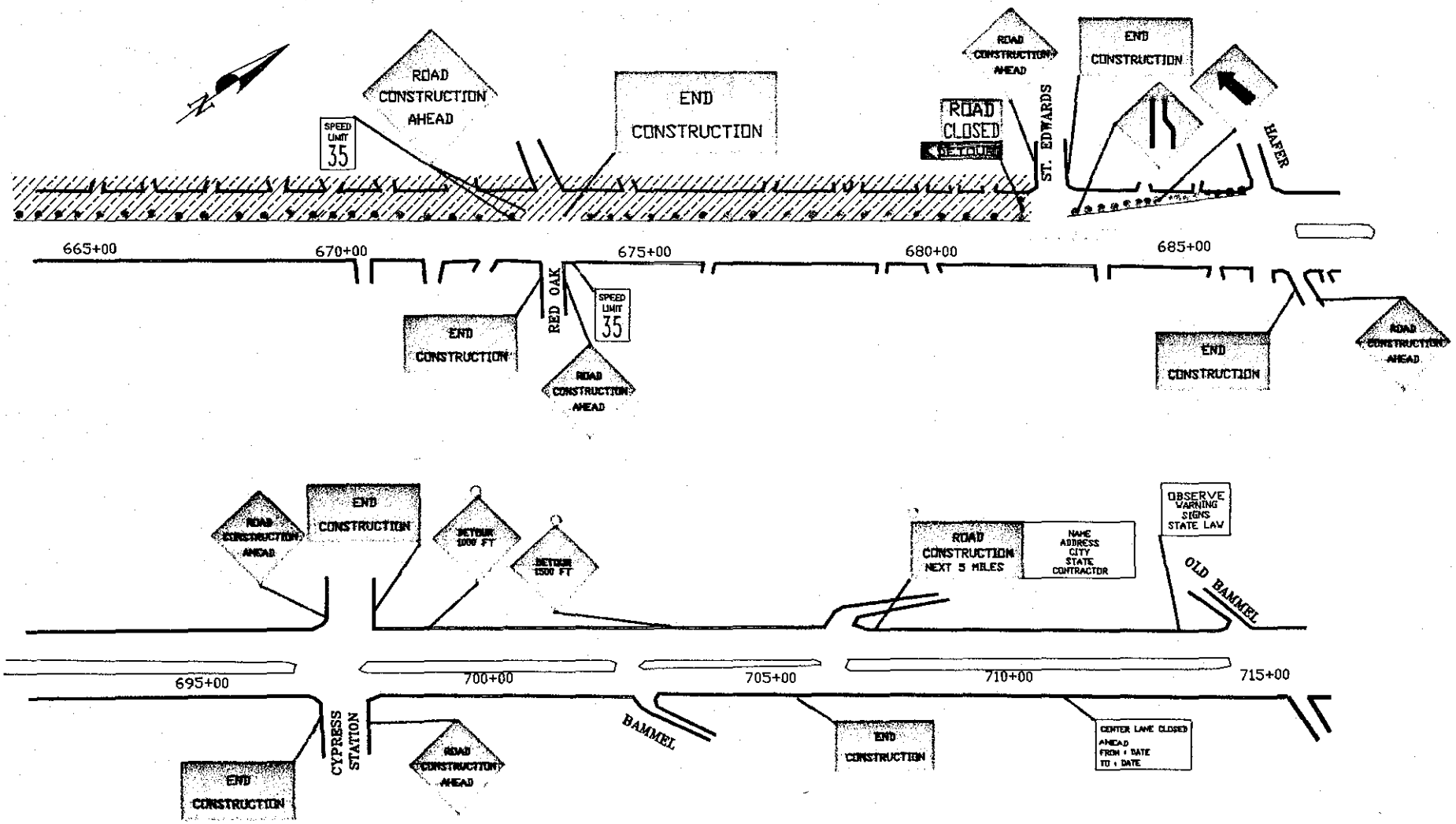

SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
CHAMPIONS DR.
365+00
HAYNES RD.
SHILOH CHURCH RD.
SPEED LIMIT 35
DUNCAN RD.
SPEED LIMIT 35
SPEED LIMIT 35
385+00
405+00
SPEED LIMIT 35
PARADISE VALLEY
SPEED LIMIT 35


ROAD CONSTRUCTION AHEAD
FOREST
END CONSTRUCTION
SPEED LIMIT 35
ERICA
SUNDERLICH
415+00
420+00
425+00
430+00
435+00
440+00
CHAMPION
GLEN
MIGHTY OAK
GREEN WOOD
CASHEL
AIRLINE
450+00
455+00
460+00
465+00
470+00
475+00
BRECK
STUEBNER


SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
GLADEBROOK
END CONSTRUCTION
480+00
485+00
490+00
495+00
500+00
505+00
FOREST BRANCH
END CONSTRUCTION
TORREY CHASE
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
ROAD CONSTRUCTION AHEAD
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
CREEK
END CONSTRUCTION
PEBBLE BEND
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
DO NOT BLOCK INTERSECTION
510+00
515+00
520+00
525+00
530+00
535+00
END CONSTRUCTION
FALLING
WATCH FOR AMBULANCE
SPEED LIMIT 35
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
WALTERS
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
T.C.JESTER
ROAD CONSTRUCTION AHEAD


ROAD CONSTRUCTION AHEAD
TERRACE OAKS
END CONSTRUCTION
SPEED LIMIT 35
NORTHGATE FAIRWAY
NORTHGATE FOREST
545+00
550+00
555+00
560+00
565+00
MINTZ
DRAPER
WELLCOME
SPEED LIMIT 30
WHEN FLASHING
FRITZ
SCHOOL
575+00
580+00
585+00
590+00
595+00
600+00
KUYKENDAHL
BAMMEL VILLAGE


ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
END CONSTRUCTION
PINE
BUTTE CREEK
605+00
610 +00
615+00
620 +00
625+00
630 +00
SUGAR
SILVER RIDGE
MATHIS CHURCH
ROAD CONSTRUCTION
NEXT = MILES
NEXT = MILES
BEAVER SPRINGS
ROLLING CREEK
PONDEROSA FIRE DEPT. STATION #1
BAMWOOD
NANES
635+00
640 +00
645 +00
650 +00
655+00
660+00
ELLA


ROAD CONSTRUCTION AHEAD
SPEED LIMIT 35
END CONSTRUCTION
ROAD CLOSED
DETOUR
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
ST. EDWARDS
HAFER
665+00
670+00
675+00
680+00
685+00
RED OAK
SPEED LIMIT 35
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
DETOUR 1000 FT
DETOUR 1500 FT
ROAD CONSTRUCTION NEXT 5 MILES
NAME ADDRESS CITY STATE CONTRACTOR
OBSERVE WARNING SIGNS STATE LAW
OLD BAMMEL
695+00
700+00
705+00
710+00
715+00
CYPRESS STATION
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
BAMMEL
END CONSTRUCTION
CENTER LANE CLOSED AHEAD FROM = DATE TO = DATE

APPENDIX B

TRAFFIC CONTROL PLAN

STATE HIGHWAY 6

HOUSTON, TEXAS

PHASE I

CONSTRUCTION SCHEDULE

SEGMENT I	**SEPTEMBER 1988 - OCTOBER 1988**
SEGMENT II	**SEPTEMBER 1988 - DECEMBER 1988**
SEGMENT III	**SEPTEMBER 1988 - MARCH 1989**

PLAN LEGEND

WORK ZONE

XXX + XX STATION NUMBERS

● ● ● ● BARRELLS (ORANGE)

○ FLASHING WARNING LIGHTS (YELLOW)

CONSTRUCTION WARNING SIGNS (BLACK ON ORANGE)

OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
ROAD CONSTRUCTION 1000 FT
ROAD CONSTRUCTION 500 FT
20+00
25+00
30+00
35+00
40+00
45+00
50+00
HEMPSTEAD
POINT SIX CIRCLE DR.
NAME
ADDRESS
CITY
STATE
CONTRACTOR
55+00
60+00
65+00
70+00
75+00
80+00
85+00
90+00
PEBBLE LAKE WEST
HUFFMEISTER
POINT NORTHWEST

OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
95+00
100+00
105+00
110+00
115+00
120+00
125+00
FOREST TRAILS
WILLOW RIVER
GLEN CHASE
CHERRY PARK
LOGENBAUGH
RIDGE PARK
SUGAR RIDGE
135+00
140+00
145+00
150+00
155+00
160+00
165+00
170+00

OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
175+00
180+00
185+00
190+00
195+00
200+00
205+00
F.M. 529
ROAD CONSTRUCTION AHEAD
OBSERVE WARNING SIGNS STATE LAW
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
KINGFIELD
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
WEST LITTLE YORK
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
GOODMAN
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
TIMBER CREEK PLACE
210+00
215+00
220+00
225+00
230+00
235+00
240+00
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
OBSERVE WARNING SIGNS STATE LAW

OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
TIMBER CREEK PLACE LANE
END
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
ADDICKS SATSUMA
END
250+00
255+00
260+00
265+00
270+00
275+00
280+00
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
KEITH HARROW
END
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
RIPPLING WATER
END
285+00
290+00
295+00
300+00
305+00
310+00
ROAD CONSTRUCTION AHEAD
OBSERVE WARNING SIGNS STATE LAW
LOCH KATHRINE
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
ROYAL MILE
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD

OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
OBSERVE WARNING SIGNS STATE LAW
CAIRNWAY
NORTH ASAPENGLEN
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION NEXT 5.1 MILES
NAME
ADDRESS
CITY
STATE
CONTRACTOR
ROAD CONSTRUCTION 500 FT
ROAD CONSTRUCTION 1000 FT
ROAD CONSTRUCTION 1500 FT
OBSERVE WARNING SIGNS STATE LAW
325+00
330+00
335+00
340+00
345+00
CLAY
CLAY CREEK
ROAD CONSTRUCTION AHEAD
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
OBSERVE WARNING SIGNS STATE LAW

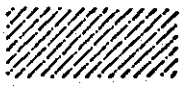
PHASE II

CONSTRUCTION SCHEDULE

SEGMENT I	**OCTOBER 1988 - AUGUST 1989 ***
SEGMENT II	**DECEMBER 1988 - OCTOBER 1989 ***
SEGMENT III	**MARCH 1989 - NOVEMBER 1989 ***

*** TENTATIVE END DATE**

PLAN LEGEND



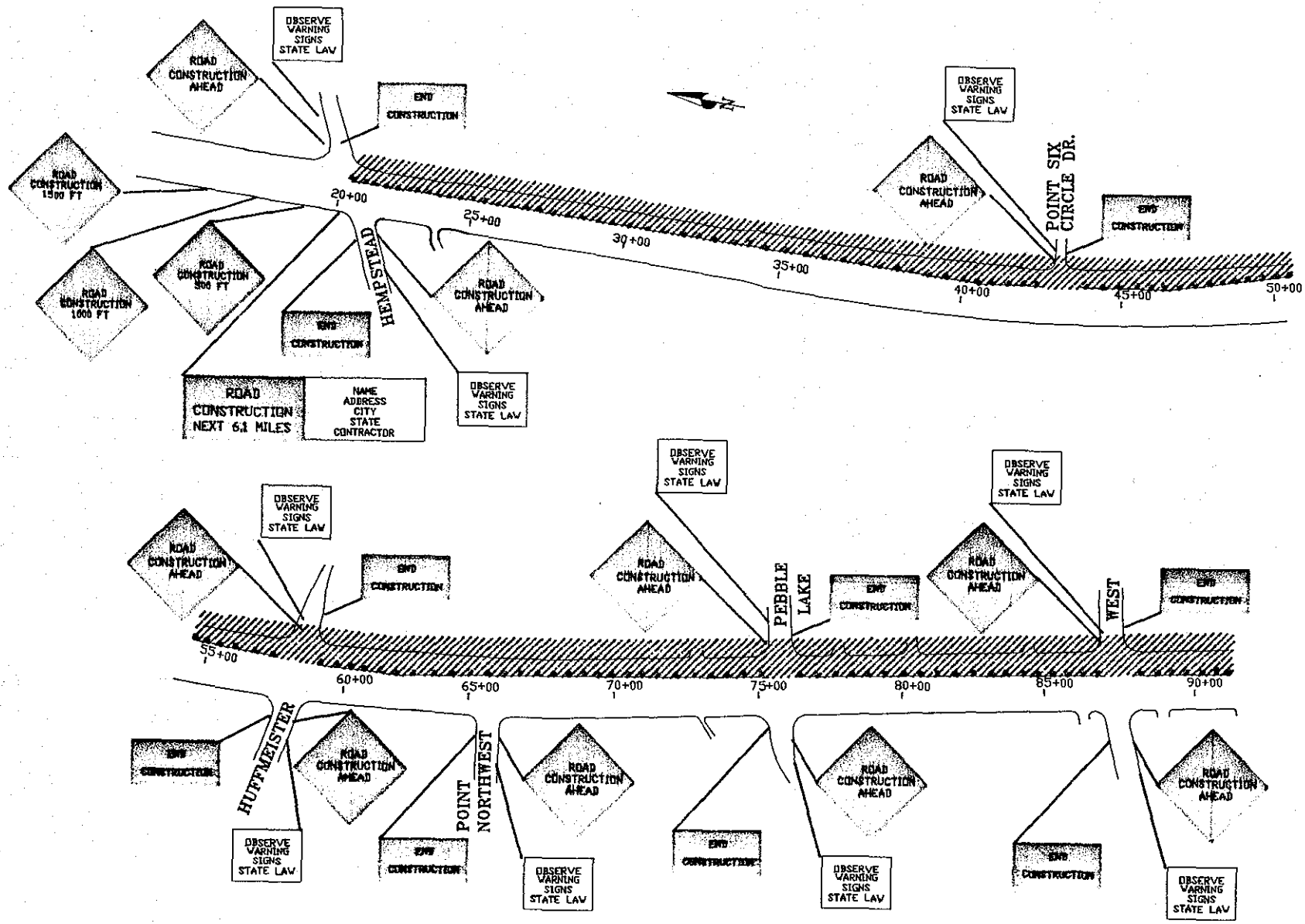
WORK ZONE

XXX + XX STATION NUMBERS

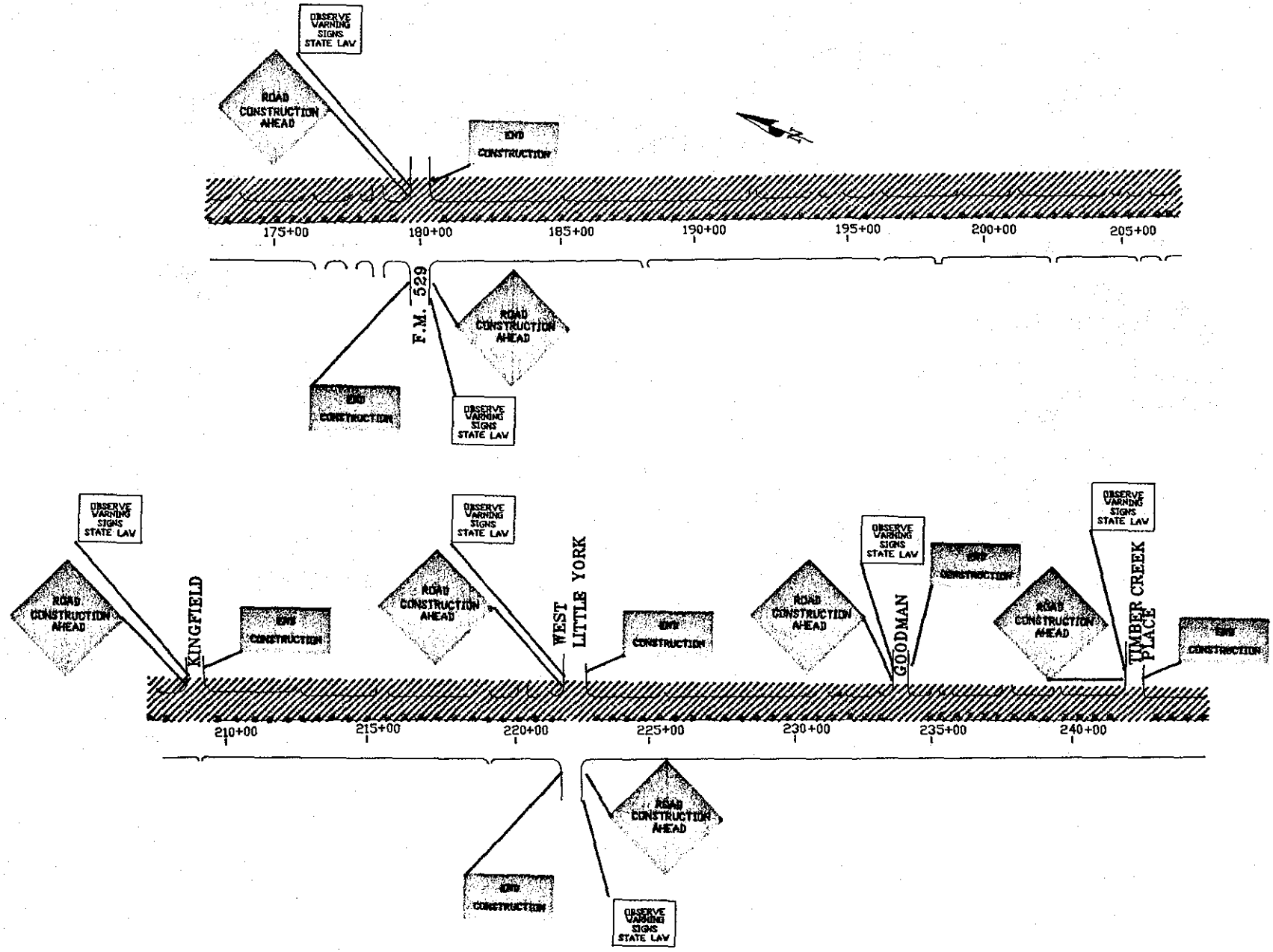
● ● ● ● BARRELLS (ORANGE)

○ FLASHING WARNING LIGHTS (YELLOW)

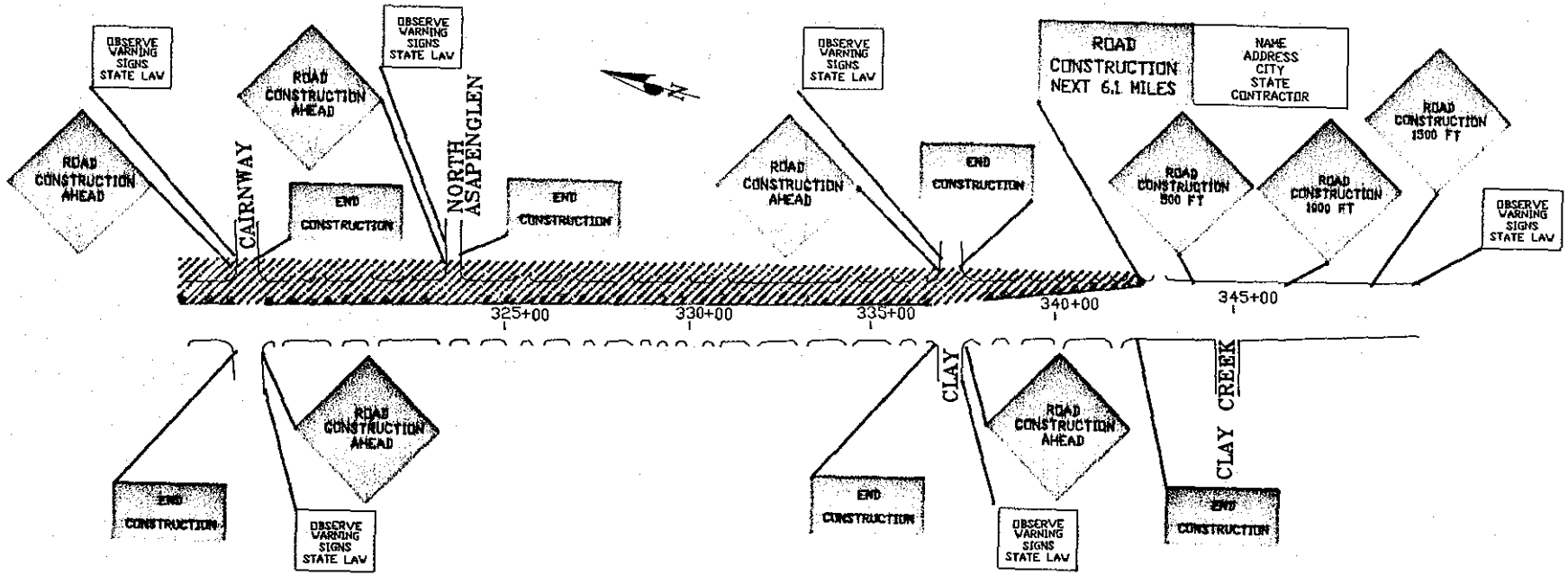
CONSTRUCTION WARNING SIGNS (BLACK ON ORANGE)


ROAD CONSTRUCTION AHEAD
OBSERVE WARNING SIGNS STATE LAW
END CONSTRUCTION
ROAD CONSTRUCTION 1500 FT
ROAD CONSTRUCTION 1000 FT
ROAD CONSTRUCTION 500 FT
ROAD CONSTRUCTION NEXT 6.1 MILES
NAME ADDRESS CITY STATE CONTRACTOR
HEMPSTEAD
POINT SIX CIRCLE DR.
PEBBLE LAKE
WEST
HUFFMEISTER
POINT NORTHWEST
20+00
25+00
30+00
35+00
40+00
45+00
50+00
55+00
60+00
65+00
70+00
75+00
80+00
85+00
90+00

OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
95+00
100+00
105+00
110+00
115+00
120+00
125+00
FOREST TRAILS
WILLOW RIVER
GLENCHASE
CHERRY PARK
LOGENBAUGH
RIDGE PARK
SUGAR RIDGE
135+00
140+00
145+00
150+00
155+00
160+00
165+00
170+00


OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
175+00
180+00
185+00
190+00
195+00
200+00
205+00
F.M. 529
210+00
215+00
220+00
225+00
230+00
235+00
240+00
KINGFIELD
WEST LITTLE YORK
GOODMAN
TIMBER CREEK PLACE

OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
TIMBER CREEK PLACE LANE
END CONSTRUCTION
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
ADDICKS SATSUMA
END CONSTRUCTION
250+00
255+00
260+00
265+00
270+00
275+00
280+00
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
KEITH HARROW
OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
RIPPLING WATER
END CONSTRUCTION
285+00
290+00
295+00
300+00
305+00
310+00
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
OBSERVE WARNING SIGNS STATE LAW
END CONSTRUCTION
LOCH KATHRINE
ROAD CONSTRUCTION AHEAD
OBSERVE WARNING SIGNS STATE LAW
END CONSTRUCTION
ROYAL MILE
ROAD CONSTRUCTION AHEAD
OBSERVE WARNING SIGNS STATE LAW


OBSERVE WARNING SIGNS STATE LAW
ROAD CONSTRUCTION AHEAD
CAIRNWAY
ROAD CONSTRUCTION AHEAD
OBSERVE WARNING SIGNS STATE LAW
END CONSTRUCTION
NORTH ASAPENGLEN
END CONSTRUCTION
N
OBSERVE WARNING SIGNS STATE LAV
ROAD CONSTRUCTION AHEAD
END CONSTRUCTION
ROAD CONSTRUCTION NEXT 6.1 MILES
NAME ADDRESS CITY STATE CONTRACTOR
ROAD CONSTRUCTION 500 FT
ROAD CONSTRUCTION 1000 FT
ROAD CONSTRUCTION 1500 FT
OBSERVE WARNING SIGNS STATE LAV
325+00
330+00
335+00
340+00
345+00
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
OBSERVE WARNING SIGNS STATE LAV
CLAY
END CONSTRUCTION
ROAD CONSTRUCTION AHEAD
OBSERVE WARNING SIGNS STATE LAV
CLAY CREEK
END CONSTRUCTION

APPENDIX C

SKILLMAN AVENUE

DALLAS, TEXAS

PRE-CONSTRUCTION
BASE ROADWAY CONDITIONS

CONSTRUCTION SCHEDULE

PROPOSED START DATE

SEPTEMBER 1989

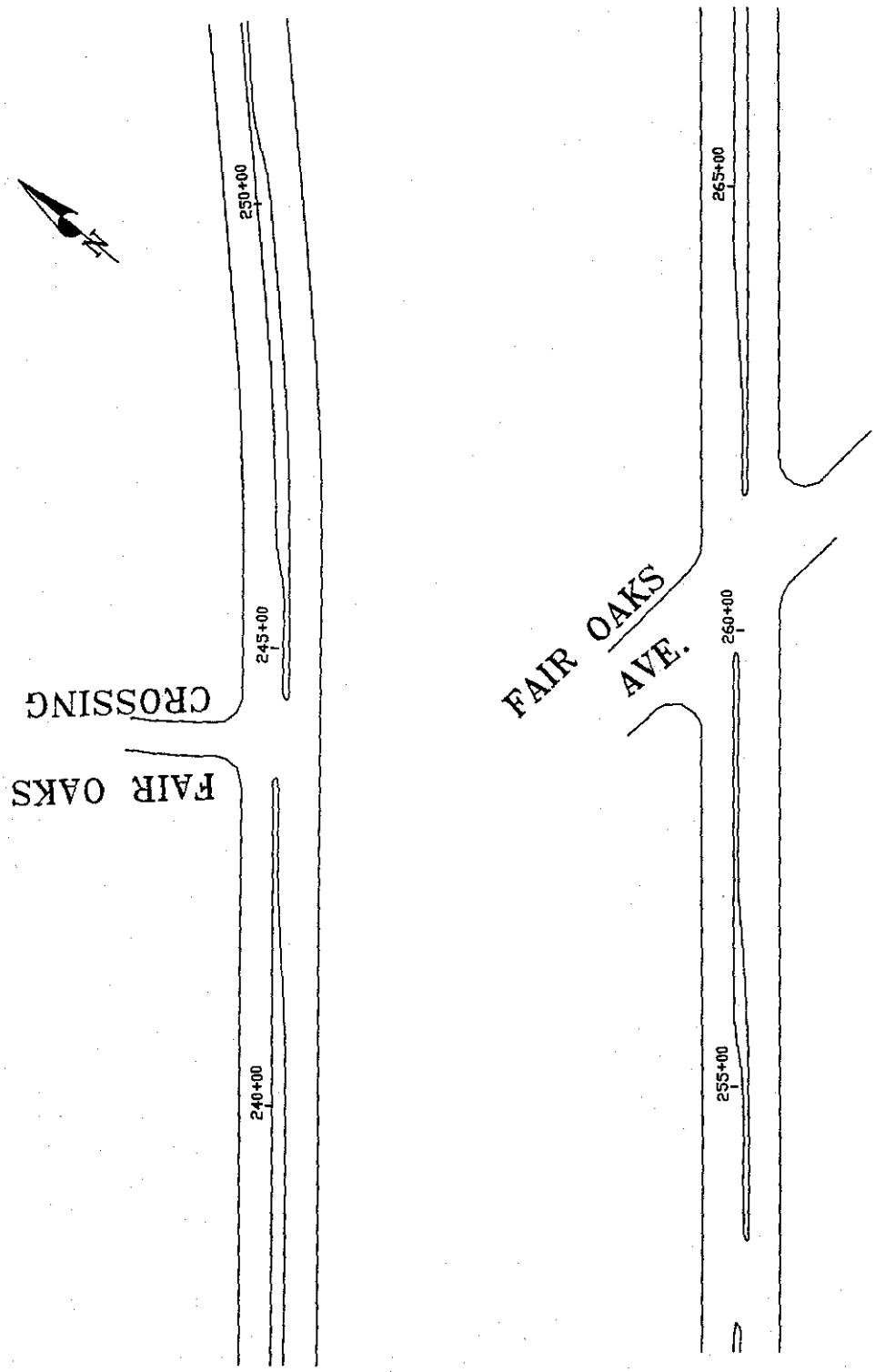
PLAN LEGEND

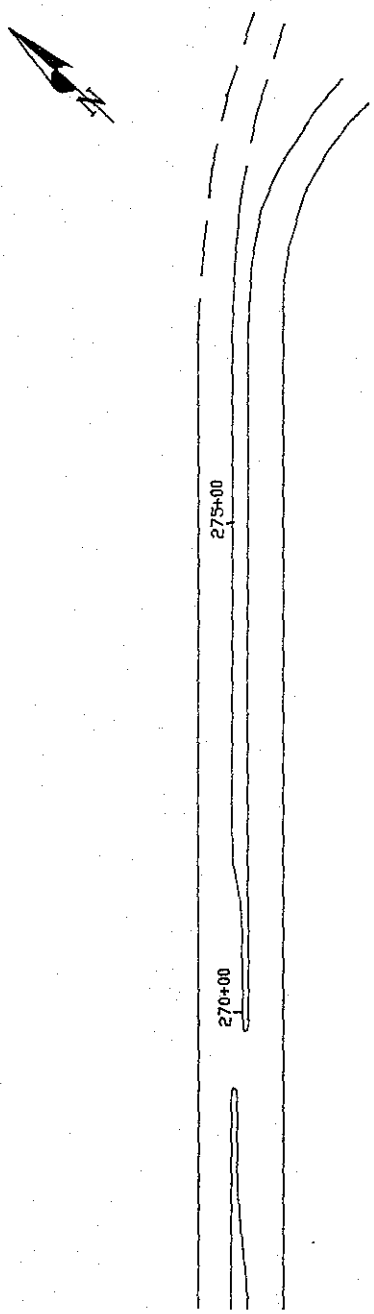
XXX + XX STATION NUMBERS

MERRIMAN
PARKWAY
150+00
155+00
160+00
COLFAX
165+00
170+00
175+00

SEDGWICK
KINGSLEY
N
180+00
185+00
190+00
PLEASENT
VIEW
GUNNISON
195+00
200+00
205+00

CHURCH
N
210+00
215+00
220+00
STONE
RIVER
225+00
230+00
235+00


FAIR OAKS
AVE.
CROSSING
FAIR OAKS
240+00
245+00
250+00
255+00
260+00
265+00


N
275+00
270+00

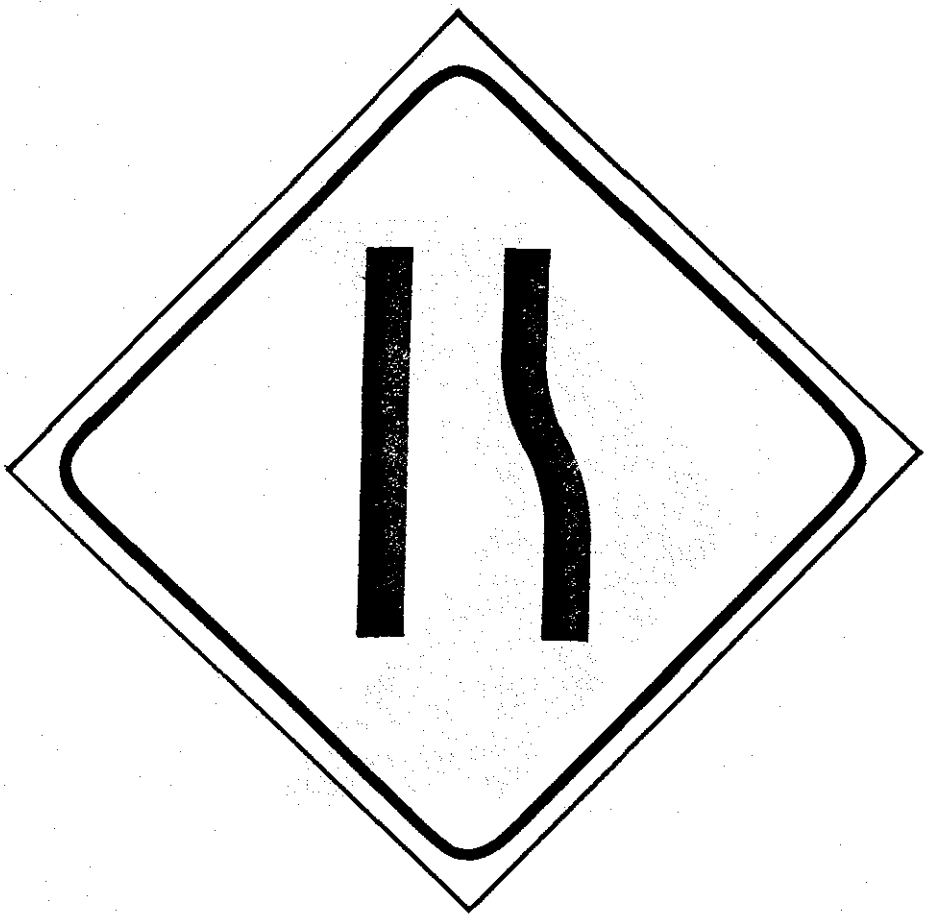
APPENDIX D

FM 1960

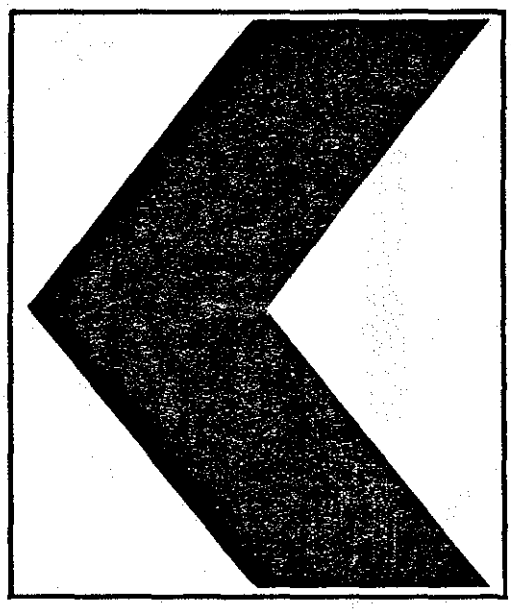
MOTORIST SURVEY

1. What does this sign mean?	(A)
Response	Percent
A. Road construction ahead	17.6
B. Flagger ahead	77.5
C. Guard for School crossing ahead	2.9
D. Not Sure	2.0

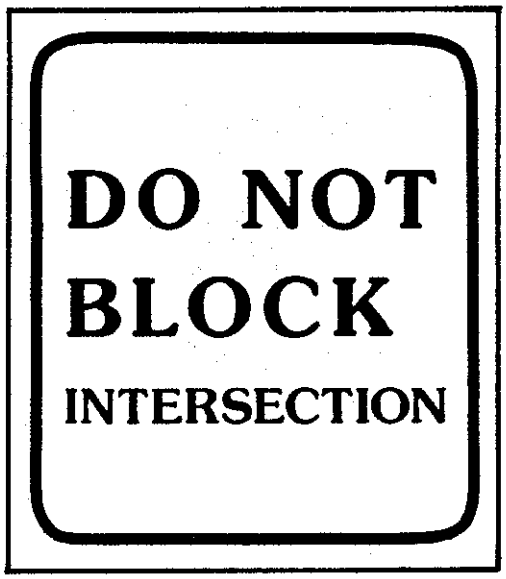
1. What does this sign mean?	(B)
Response	Percent
A. There are 500 feet of construction 500 feet ahead	6.8
B. The next 500 feet of road are under construction	25.2
C. You will be driving through a construction area 500 feet ahead	66.0
D. Not Sure	1.9



2. What does this sign mean?	(A)
Response	Percent
A. Median narrows	15.7
B. Right lane ends	78.4
C. Right turn lane marker	2.9
D. Not Sure	2.9



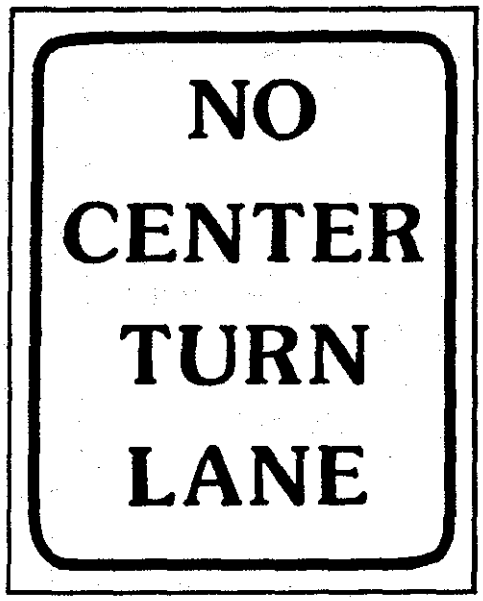
2. What does it mean when you see a series of these signs?	(B)
Response	Percent
A. Tells you to change lanes	58.3
B. Shows direction of the road	35.9
C. Turn left here	2.9
D. Not Sure	2.9



3. What does this sign mean?	(A)
Response	Percent
A. Leave room for traffic crossing at intersection	73.5
B. If your car stalls, move it out of the intersection	9.8
C. Move through the intersection quickly	15.7
D. Not Sure	1.0

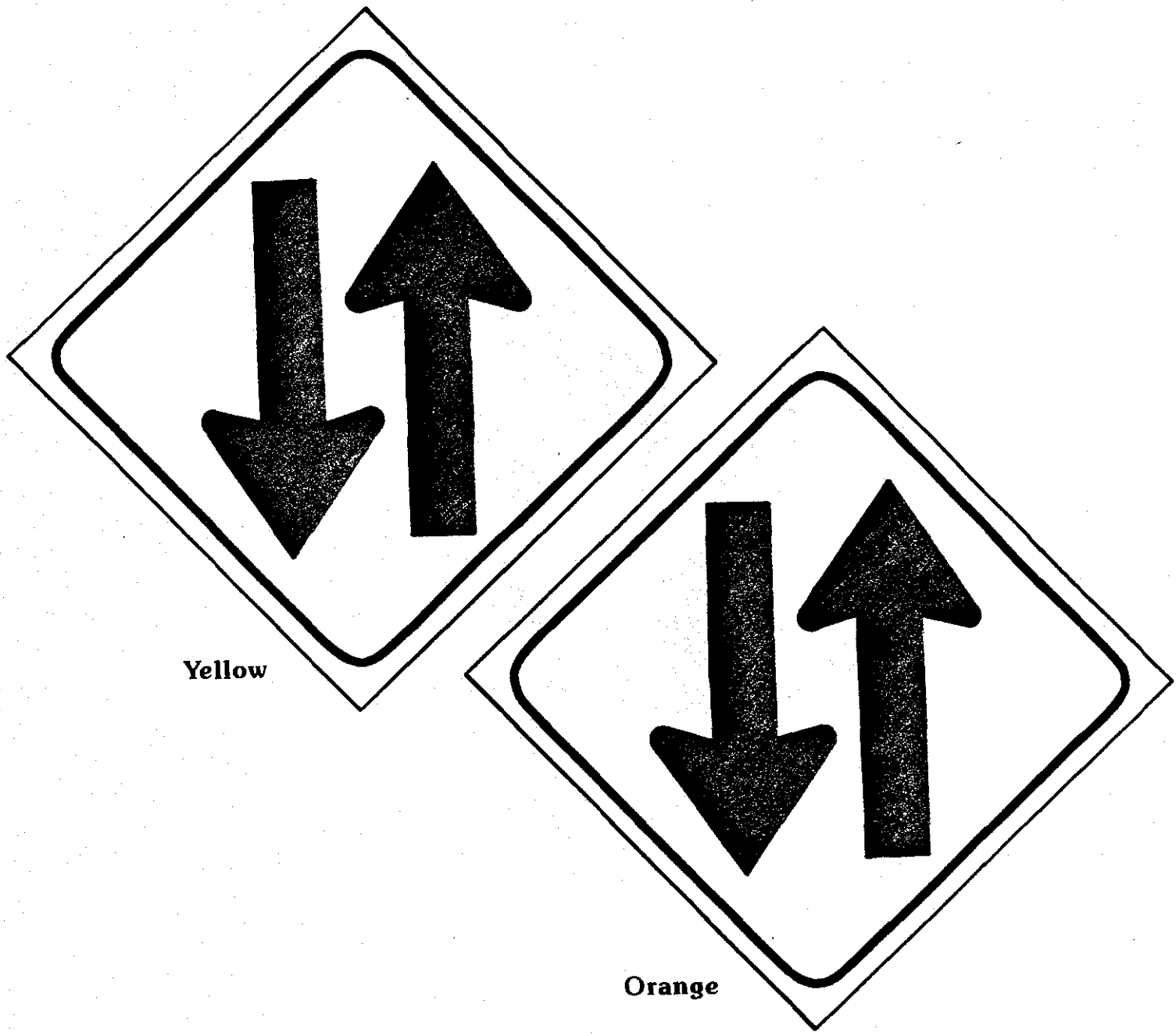
3. What should you do in response to this sign?	(B)
Response	Percent
A. Turn left	4.9
B. Stop	1.9
C. Change lanes	93.2
D. Not Sure	0

4. What does this sign mean?	(A)
Response	Percent
A. Drive in the center, the lane is not marked	3.9
B. Drive in the right lane only	46.1
C. Be alert for cars stopping to turn left	46.1
D. Not Sure	3.9

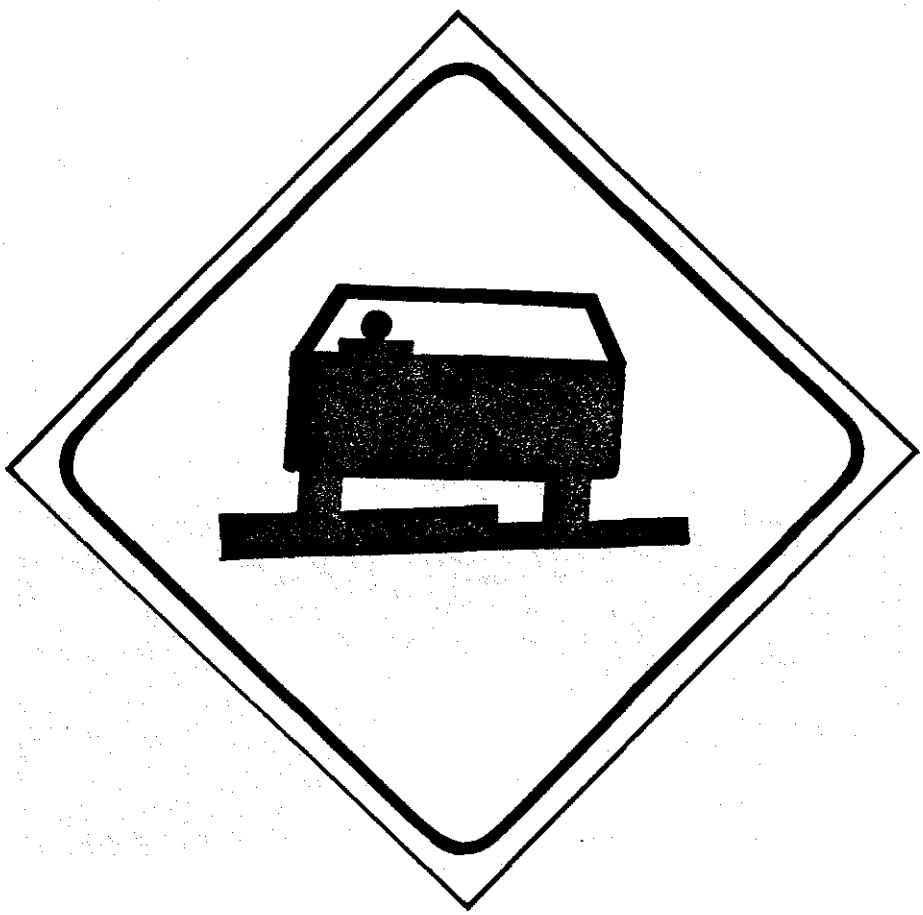


4. What does this sign mean?	(B)
Response	Percent
A. A lane for left turns is not provided	78.6
B. Do not turn from the center lane	14.6
C. Drive in the outside lane only	4.9
D. Not Sure	1.9

5. What does this sign mean?	(A and B)
Response	Percent
A. Divided road ahead	88.7
B. Obstacles in the road ahead	4.4
C. Merging traffic ahead	5.4
D. Not Sure	1.5

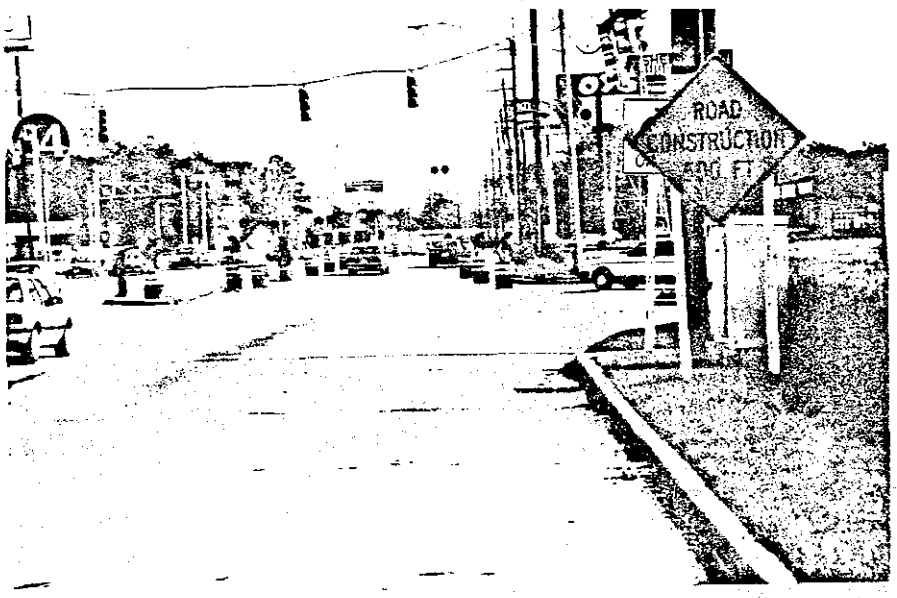


6. Why are these signs different colors?	(A and B)
Response	Percent
A. Don't Know	44.5



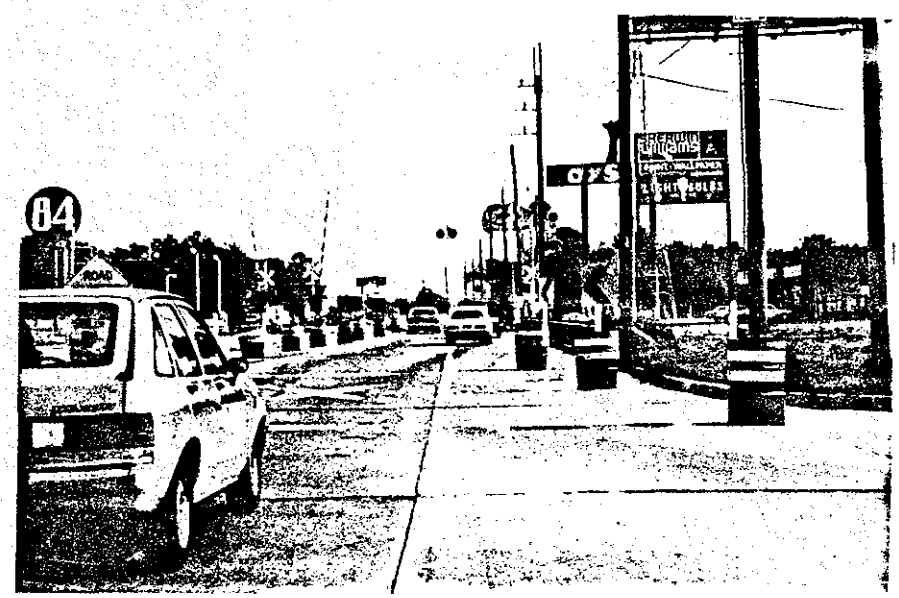
7. What does this sign mean?	(A and B)
Response	Percent
A. Low shoulder	13.2
B. Uneven pavement	83.9
C. Bumpy road	1.0
D. Not Sure	2.0

8. What does this sign mean?	(A)
Response	Percent
A. Flagger ahead	85.1
B. School crossing guard ahead	1.0
C. Road construction ahead	13.9
D. Not Sure	0

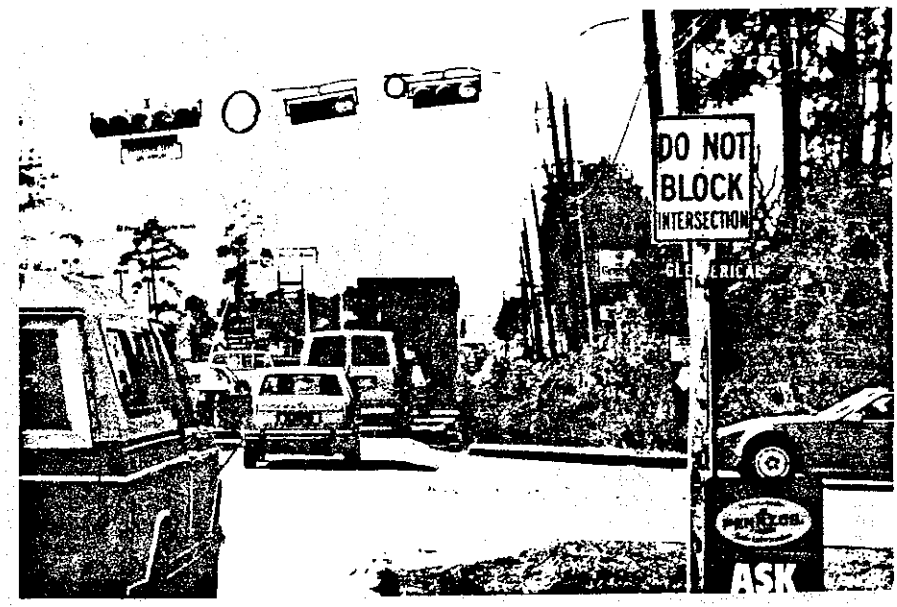


8. What does this sign mean?	(B)
Response	Percent
A. You will be driving through a construction area 500 feet ahead	58.3
B. The next 500 feet of road are under construction	33.0
C. There are 500 feet of construction 500 feet ahead	8.7
D. Not Sure	0

9. What does this sign mean?	(A)
Response	Percent
A. Left turn lane marker	9.9
B. Left lane ends	79.2
C. Median narrows	8.9
D. Not Sure	2.0



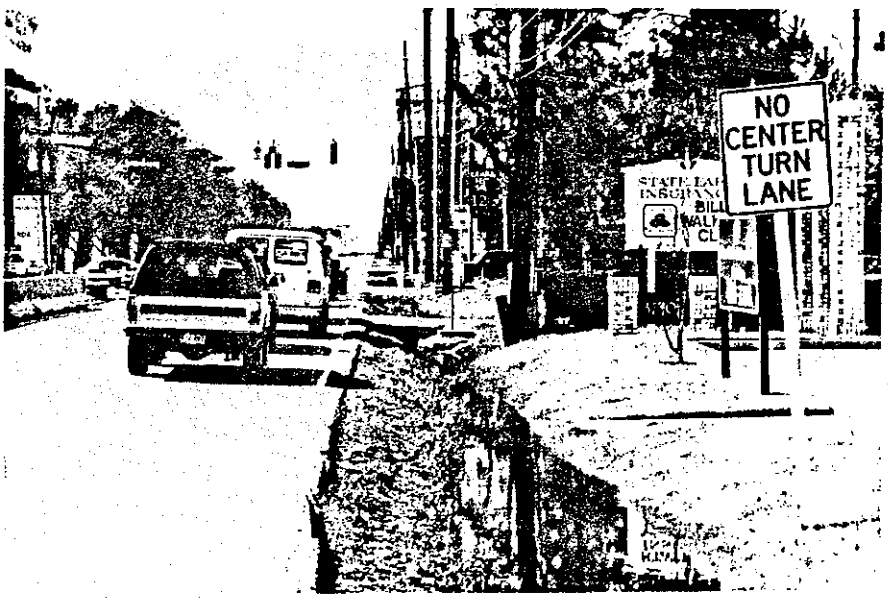
9. What do the orange and black arrow signs mean?	(B)
Response	Percent
A. Do not turn left between signs	1.0
B. Shows direction of the road	92.2
C. Sharp turns in the road	1.0
D. Not Sure	5.8



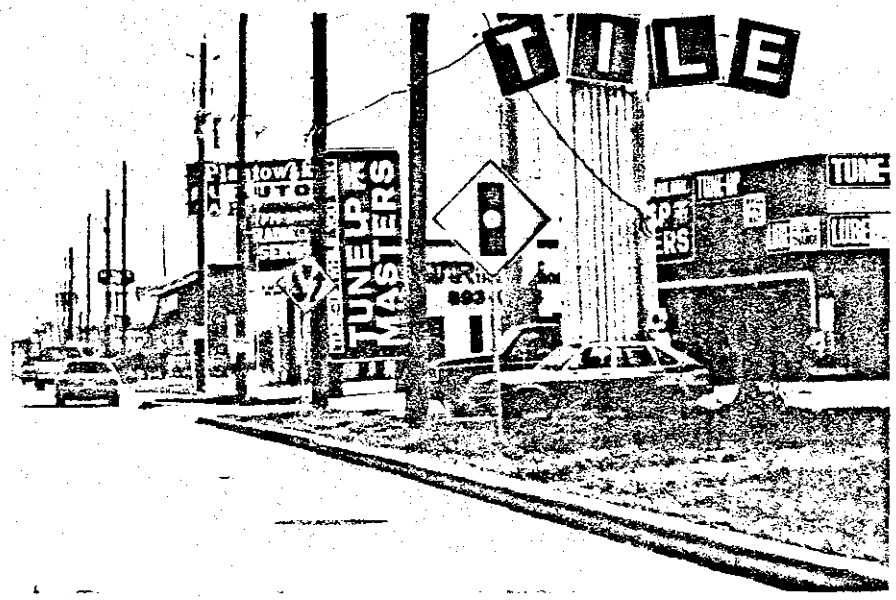
10. You are driving the pickup, what should you do at this intersection?	(A)
Response	Percent
A. Correct Response	88.1
B. Incorrect Response	10.9
C. Don't Know	1.0

10. What can you do in response to the orange sign?	(B)
Response	Percent
A. Merge left	80.6
B. Turn right at the next intersection	2.9
C. Either A or B	16.5
D. Not Sure	0

11. What does this sign mean?	(A)
Response	Percent
A. Drive in the outside lane only	29.7
B. You can not go straight at the next light	1.0
C. A lane for left turns is not provided	63.4
D. Not Sure	5.9



11. What is allowed at the intersection?	(B)
Response	Percent
A. A right turn	12.6
B. A left turn	4.9
C. Either turn is allowed	72.8
D. No turn is allowed	6.8
E. Not Sure	2.9

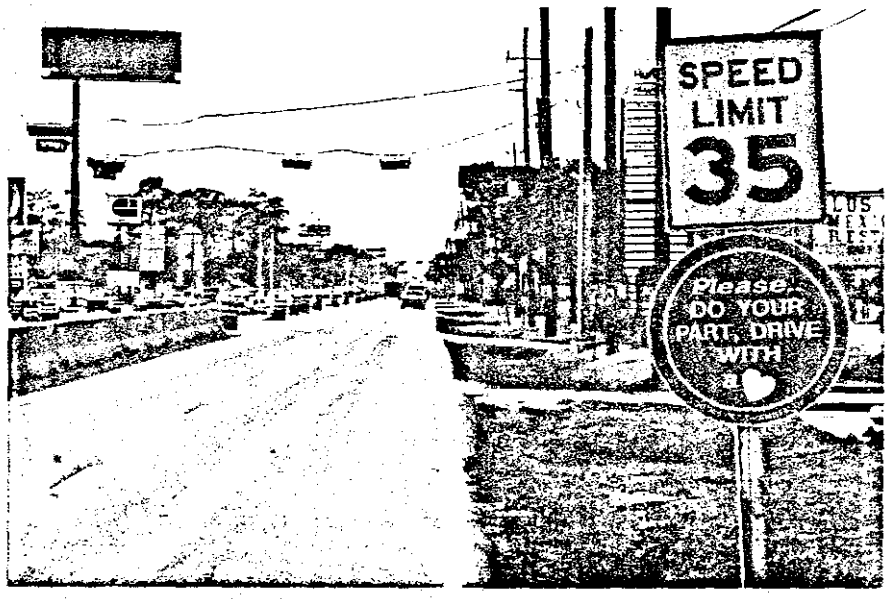


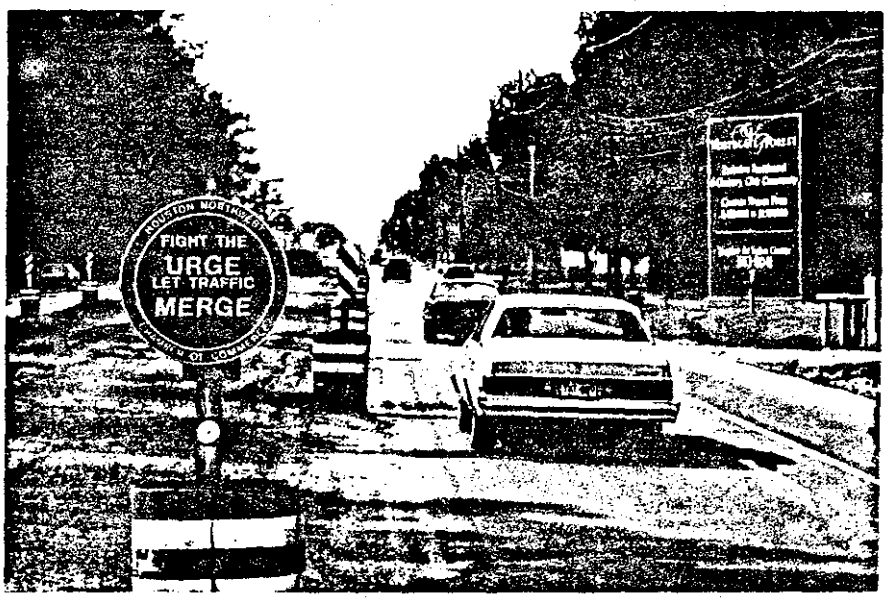
12. What does the second yellow sign mean?	(A)
Response	Percent
A. Obstacles in the road ahead	5.9
B. Merging taffic ahead	7.9
C. Divided road ahead	85.1
D. Not Sure	1.0

12. What would you do here to get to the jewelry store?	(B)
Response	Percent
A. Drive to the right of the barrels, turn into the jewelry store parking lot at the sign	83.5
B. Turn right immediately, enter jewelry store parking lot from the rear	8.7
C. Turn left, crossover at the next signal	4.9
D. Not Sure	2.9

13. What does the green sign mean?	(A and B)
Response	Percent
A. Crossover here	92.2
B. Crossover at the next signal	6.9
C. Emergency vehicles cross here	0
D. Not Sure	1.0

14. What do the orange and white striped panels mean?	(A and B)
Response	Percent
A. Do not turn between these signs	7.8
B. Pay special attention to signs on these panels	9.8
C. Drive to the right of these signs	37.8
D. All the above	28.9
E. Not Sure	15.7

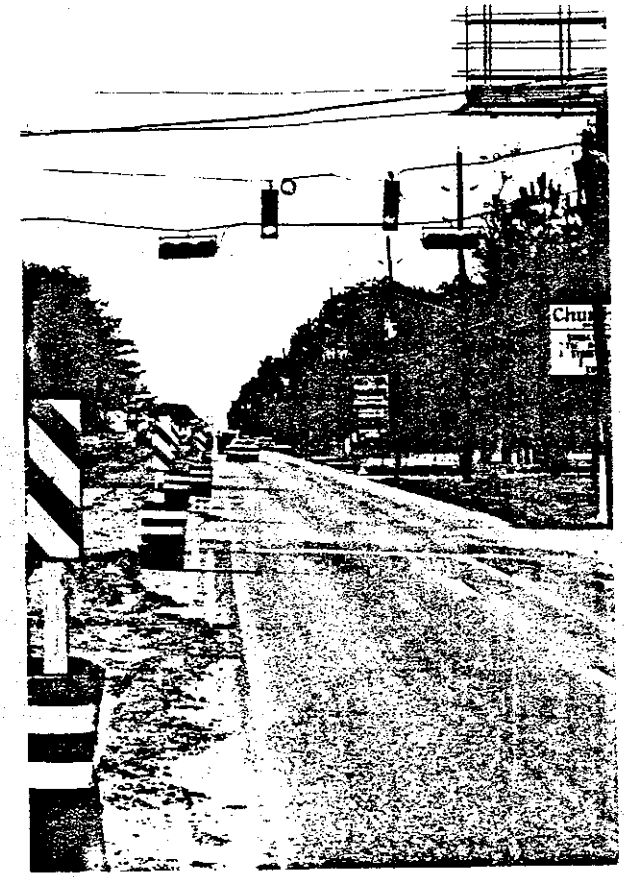




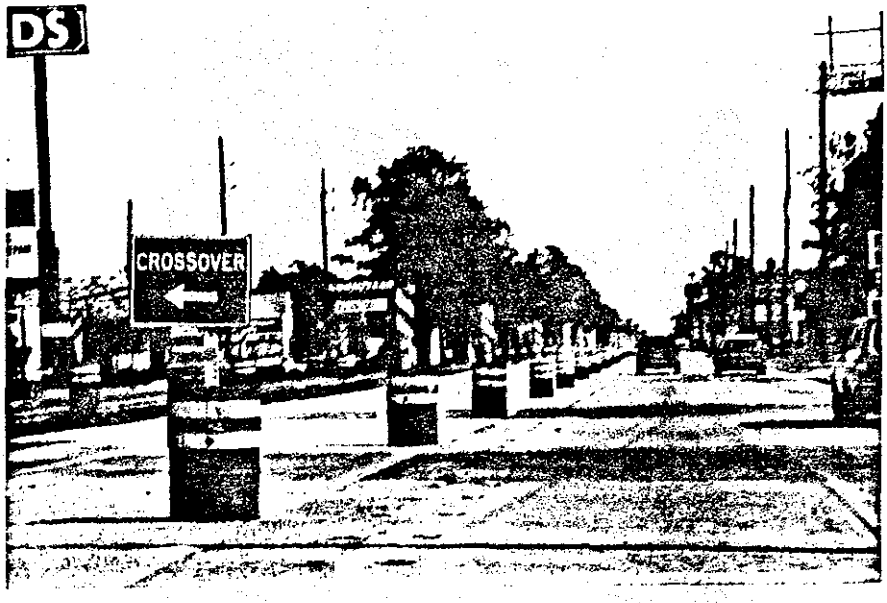
15. What is your opinion of these red signs?	(A and B)
Response	Percent
A. Like B. Dislike C. Hazard	60.3 19.6 10.8

15. What is your opinion of these red signs?	(A and B)
Response	Percent
A. Like	60.3
B. Dislike	19.6
C. Hazard	10.8

16. What does this sign mean?	(A)
Response	Percent
A. Drive in the right lane only	37.6
B. Be alert for cars stopping to turn left	56.4
C. Drive in the center, the lane is not marked	2.0
D. Not Sure	4.0

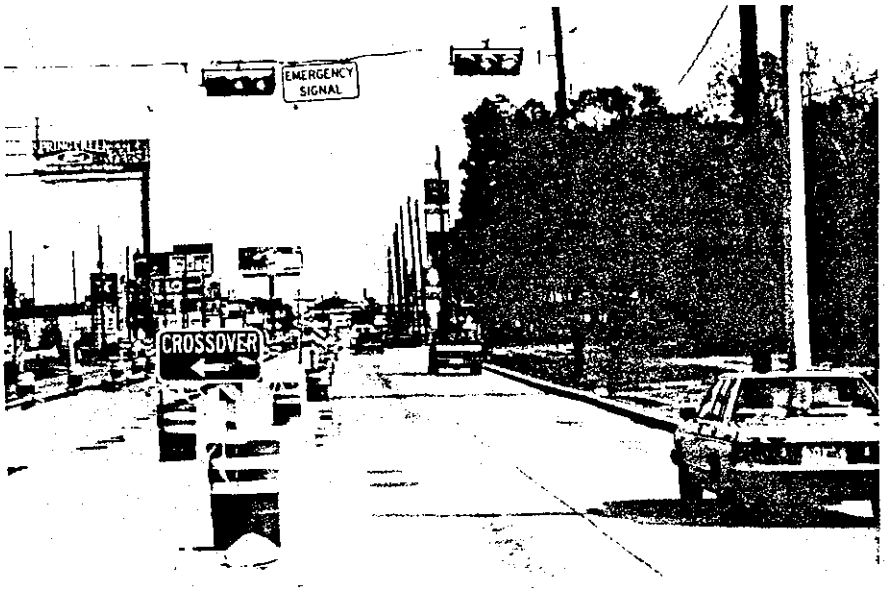


16a. Are you permitted to turn left at this light?	(B)
Response	Percent
A. Yes	78.6
B. No	16.5
C. Not Sure	4.9
16b. Is this a protected left turn?	
A. Yes	3.9
B. No	93.2
C. Not Sure	2.9

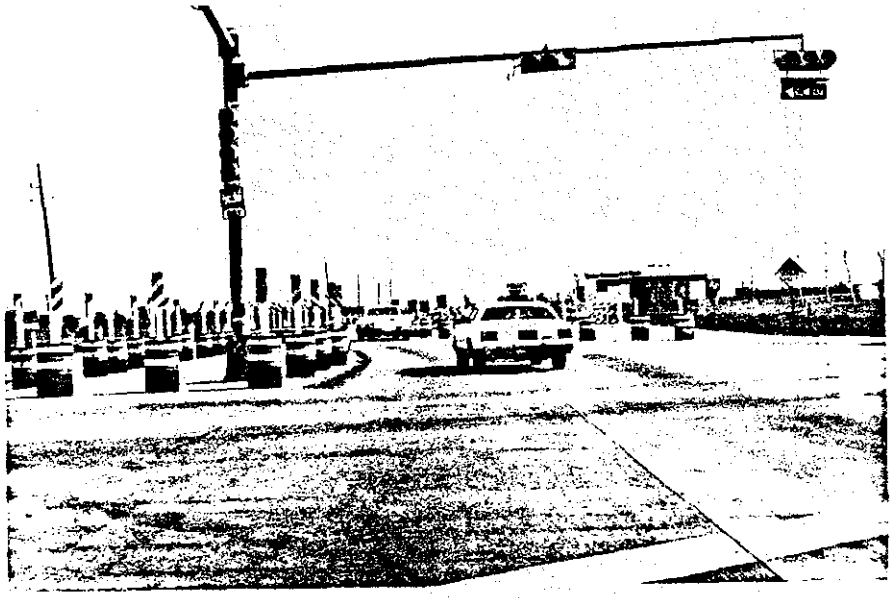


17. Are you permitted to turn left in front of the barrel with the crossover sign?	(A and B)
Response	Percent
A. Yes	55.2
B. No	38.4
C. Not Sure	4.9
Are you permitted to turn left behind the barrel with the crossover sign?	
A. Yes	42.1
B. No	48.5
C. Not Sure	7.9

18. Do you think signs like the Auto Tint Sign should be allowed in the construction area?	(A and B)
Response	Percent
A. Yes	53.5
B. No	14.4
C. If no, why not? (distracting)	14.9



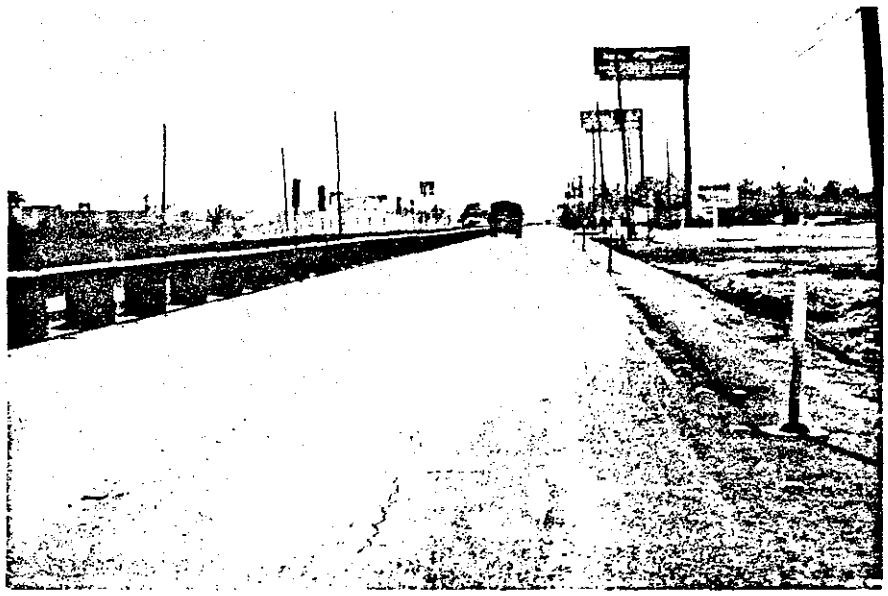
19. Are your permitted to turn left in front of the barrel with the crossover sign?	(A and B)
Response	Percent
A. Yes B. No	17.2 82.3
Are you permitted to turn left behind the barrell with the crossover sign?	
A. Yes B. No	80.2 19.3



20. Are you permitted to turn right at this intersection?	(A)
Response	Percent
A. Yes	14.0
B. No	85.0
C. Not Sure	1.0

20. Which of the following statements are true for the drivers at this intersection?	(B)
Response	Percent
A. They may drive forward or turn left at this light	91.3
B. They may only drive forward because the signal on the left is covered	0
C. They may only drive forward because the area to the left is under construction	0
D. Not Sure	1.9

21. What do the orange and white posts on the right tell you?	(A)
Response	Percent
A. Hazardous area to the right, drive to the left of the posts	70.0
B. Shows the right edge of the pavement	26.0
C. Park between these posts	0
D. Not Sure	4.0



21. What do the white posts on the right tell you?	(B)
Response	Percent
A. Hazardous area to the right, drive to the left of the posts	35.9
B. Shows the right edge of the pavement	58.3
C. Park between these posts	0
D. Not Sure	5.8