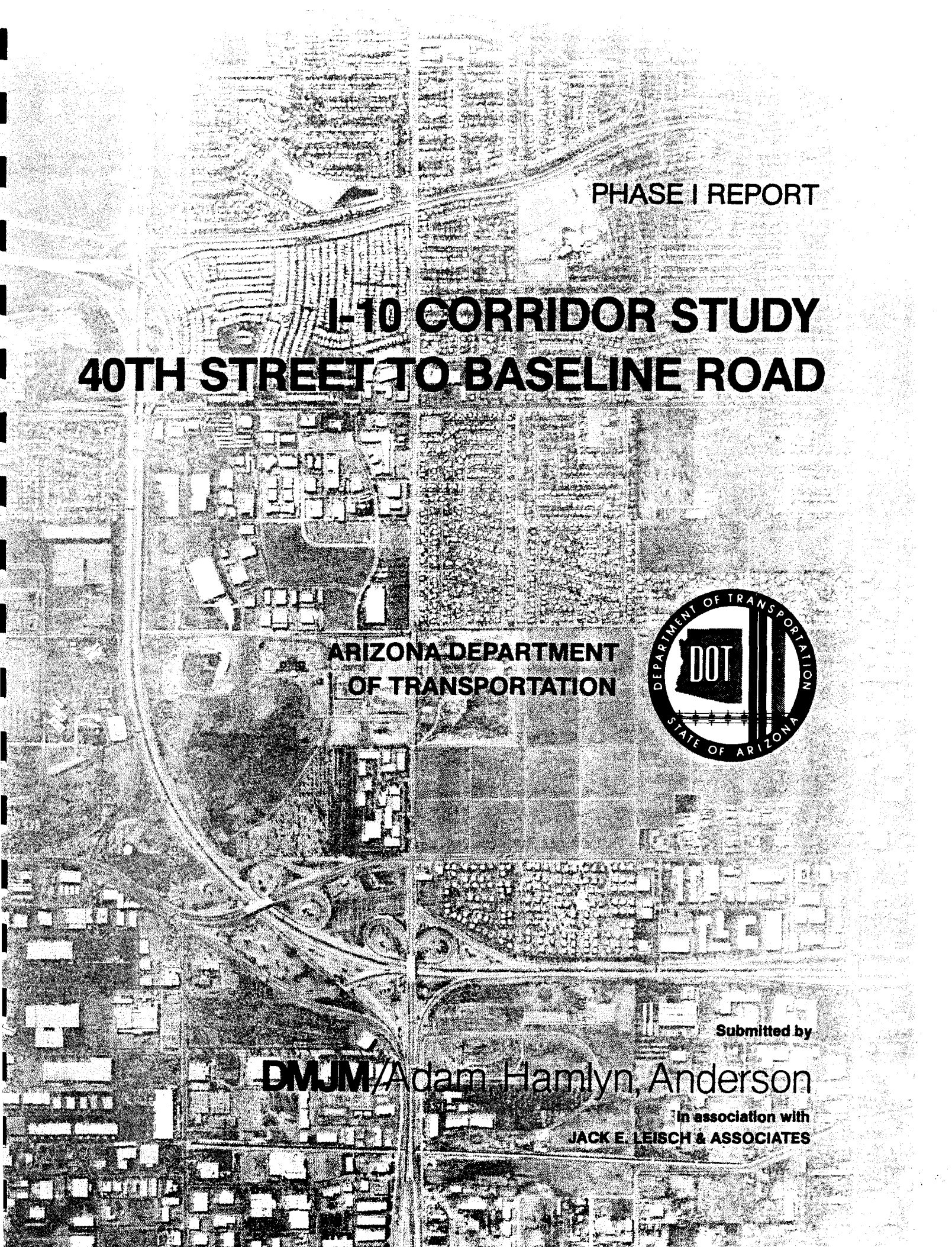

PHASE I REPORT

I-10 CORRIDOR STUDY
40TH STREET TO BASELINE ROAD

ARIZONA DEPARTMENT
OF TRANSPORTATION

Submitted by

DMJM/Adam, Hamlyn, Anderson

in association with
JACK E. LEISCH & ASSOCIATES

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I. INTRODUCTION

Phase I of the I-10 Corridor Study, consisting of the analysis and evaluation of the existing facility, is summarized in this report. The limits of the project, as shown in Figure 1, include:

- I-10 from Baseline Road to 40th Street
- Superstition Freeway from Rural Road to I-10

The I-10 corridor study employs a systems analysis approach and is comprised of four integrated phases as detailed in Figure 2. The four project phases are:

I. Analysis and Evaluation of Existing Facility
II. Development of Alternative Improvement Schemes
III. Refinement of Selected Alternatives
IV. Development of Improvement Plan and Report

The overall objectives of this project are to develop a rehabilitation plan to improve the existing geometric and operational deficiencies, while accommodating future traffic growth, and to establish a short-term construction phasing plan which can be integrated within a long-range solution. The concept alternatives developed in Phases II and III will be drawn at 1" = 200' scale, and the selected design alternative will be developed at 1" = 100' scale in the final phase.

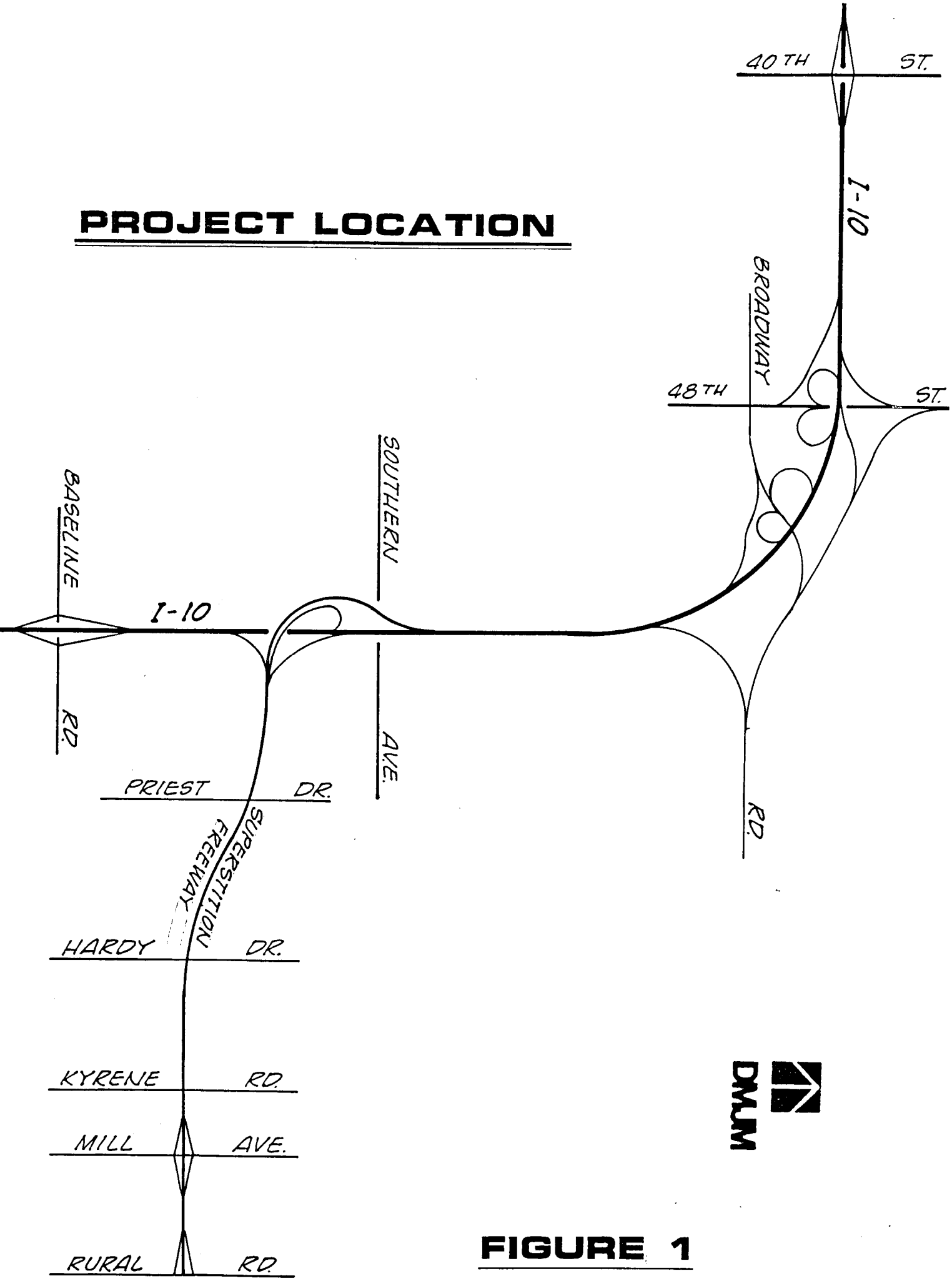
The analysis and evaluation of the existing facility completed in Phase I are summarized in the following report.

ANALYSIS PROCEDURE

The existing geometric and operational features of the facility were inventoried and analyzed to determine the existing deficiencies. The deficiencies noted during the evaluation will help to identify high priority improvement areas in both short- and long-term solutions. Operating performance was also evaluated for each individual freeway segment. The elements considered in the analysis were:

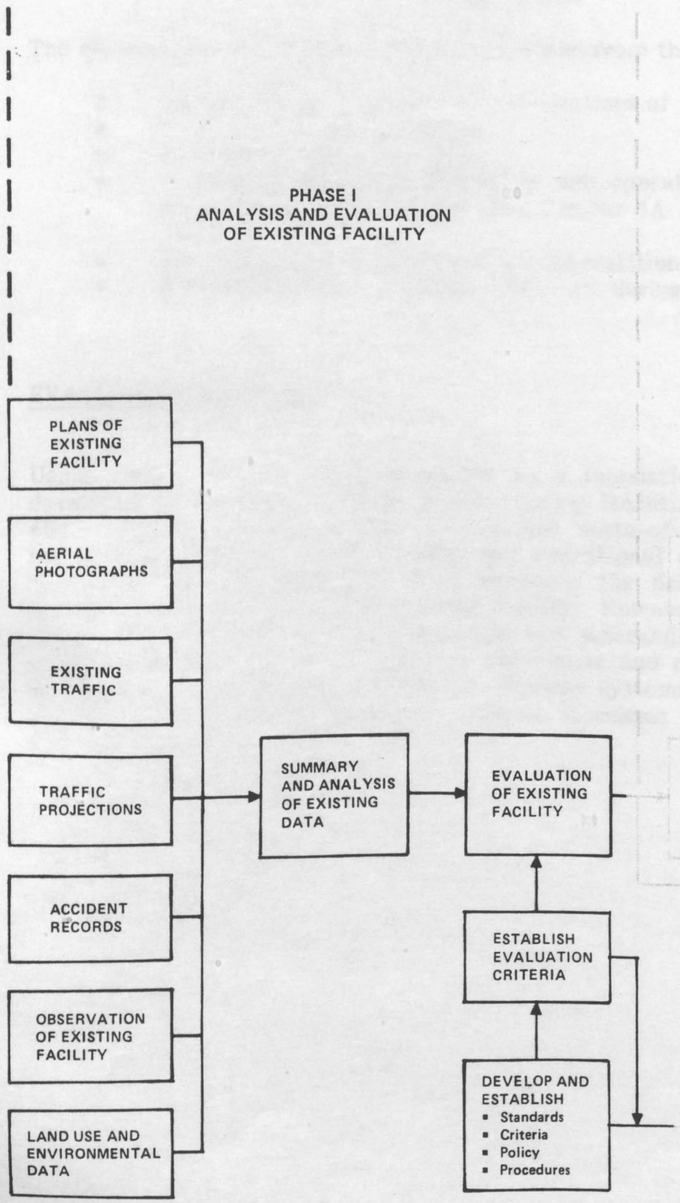
Geometric Features	Operational Features
• Horizontal Alignment	• Lane Continuity
• Stopping Sight Distance	• Lane Balance
• Cross Section	• Ramp Sequence
• Exit and Entrance Design	• Signing

PROJECT LOCATION



DMJM

FIGURE 1



SCOPE OF WORK FLOWCHART

Performance Measures

- Accident Experience
- Level of Service/
  Operating Speeds

The elements were analyzed using data obtained from the following sources:

- As-built plans, profiles and cross sections of the existing facilities;
- Videotapes of the roadways;
- Existing traffic count data;
- A field inventory of geometric and operational features of freeway segments and interchanges (See Figures 3A & 3B for sample field data forms);
- Speed-delay runs on I-10 and the Superstition Freeway; and
- Field observation of traffic operations during peak-traffic periods.

EVALUATION CRITERIA

Using 1984 AASHTO design standards as a foundation, design standards were developed as evaluation criteria of the existing facilities (see Figures 4A through 4D). These measures reflect the current state-of-the-art knowledge of the relationship between design features and operational characteristics of freeway systems. The following evaluation discusses the design, capacity, safety and operational deficiencies of the existing facility. However, this should not be taken as an inference that the original design was substandard, since design standards have been refined over the years as experience and research have brought new knowledge of the actual operation of freeway systems. In addition, unforeseen changes in land use and associated traffic increases have far exceeded earlier forecasts.

INVENTORY OF ROADWAY FEATURES
I-10 STUDY, PHOENIX
Mainline Segments

Freeway_____ Direction_____
from_____ to _____ Sheet No.___

	ROADWAY FEATURES	ADEQUACY		NOTES
		GOOD	CONSIDERATION FOR IMPROVEMENT	
ROADSIDE	Guardrail:			
	Terminals			
	Post Spacing			
	Blocked Out			
	Shoulder Offset			
	Fixed Object Offset			
	Condition			
	Sign Supports:			
	Roadside Wood			
	Roadside Steel			
	Overhead			
	Pavement Condition			
	Bridge Piers:			
	Guardrail			
	Other			
	Drainage Structures			
	Shoulders:			
	Paved Condition			
	Width			
	Delineation			
	Cross Slope			
	Ditches			
	Side Slopes			
	Pavement Markings			
	Lighting			
MEDIAN	Guardrail Barrier			
	Concrete Barrier			
	Width			
	Side Slope			
	Sign Supports:			
	Roadside Wood			
	Roadside Steel			
	Overhead			
	Light Standards			
	Bridge Piers:			
	Guardrail			
	Other			
	Shoulders:			
	Paved Condition			
	Width			
	Delineation			
	Cross Slope			

Figure 3A

INVENTORY OF ROADWAY FEATURES
I-10 STUDY, PHOENIX
Interchange

Freeway_____ Direction_____
With_____ Sheet No.____

	ROADWAY FEATURES	ADEQUACY		NOTES
		GOOD	CONSIDERATION FOR IMPROVEMENT	
ENTRANCE	Curvature			
	Taper Length			
	Appurtenances at M.E.			
	Pavement Markings			
	Sight Distance			
	Lane Balance			
EXIT	Curvature			
	Taper Length			
	Appurtenances at Nose			
	Pavement Marking			
	Sight Distance			
	Lane Balance			
GENERAL	Roadside Appurtenances:			
	Sign Supports			
	Light Standards			
	Other			
	Ramp Sequence			
	Pavement Marking			
	Lighting			
	Lane Continuity			
	Route Continuity			
CROSS STREET	Number of Lanes			
	Traffic Control			

Figure 3B

CRITERIA FOR EVALUATION OF GEOMETRIC FEATURES

Feature	Rating			1984 AASHTO Policy Page Reference
	Good	Fair	Poor	
HORIZONTAL ALIGNMENT • Design Speed • Degree of Curve	> 70 mph < 3°	55-70 mph 3°-5°	< 55 mph > 5°	187-191
STOPPING SIGHT DISTANCE • Design Speed	> 65 mph	50-65 mph	> 50 mph	305-315
CROSS SECTION • Deficiencies	Engineering Review of Field Inventory			666
EXIT DESIGN (Taper/Parallel) • Curve at Nose • Length	< 3°/3° > 500'/ 600'	(3°-5°)/(3°-5°) 400'-500'/ 400'-600'	> 5°/ 5° < 400'/ 400'	1037-1045
ENTRANCE DESIGN (Taper/Parallel) • Curve at Merge • Length	< 5°/5°	5°-8°/5°-8° 700'-900'/ 500'-700'	> 8°/8° < 700'/ 500'	1037-1045

Figure 4A

CRITERIA FOR ANALYSIS OF ROADWAY FEATURES

CROSS-SECTIONAL ELEMENTS

Roadway Features	Rating	
	Desirable	**Considerations for Safety Improvements**
Shoulder Width		
• 4-lane Sections	10'-12' Right 4'-8' Left	< 10' Right < 4' Left
• 6-8 Lane Sections	10'-12' Both sides	< 10' Either side
Shoulder Cross Slope		
• Superelevation	.02-.06	< .02 > .06
• Break in Cross Slope	• Algebraic difference ≤ .04	• Algebraic difference > .07
Median		
• Width	≥ 22'	< 22'
• Slope	6:1 - 10:1	> 6:1, < 10:1
• Concrete or Flexible Barrier	• Installed on median ≤ 40	• Not installed on median ≤ 40
Side Slopes	• ≥ 3:1, with appropriate toe of slope design, or protected	• < 3:1, and not protected
Ditches	• Traversable or protected	• Not traversable and not protected
Pavement Condition	• Stable • Has good skid resistance	• Deteriorating • Polished

Figure 4C

CRITERIA FOR ANALYSIS OF ROADWAY FEATURES

APPURTENANCES

Roadway Features	Rating	
	Desirable	Considerations for Safety Improvements
Sign Supports	• 30' off roadway with appropriate side slopes • Breakaway or protected by guardrail	• Within 30' of roadway and not breakaway or protected by guardrail
Bridge Piers	• 30'off roadway with appropriate side slopes • Adequately protected	• Within 30' of roadway and not adequately protected
Light Standards	• 30' off roadway with appropriate side slopes • Breakaway or protected by guardrail	• Within 30' of roadway and not breakaway or protected by guardrail
Guardrail		
• Terminals	• Flared with breakaway cable terminal • Crash cushion	• Does not meet current standards
• Post Spacing	• 6'-3"	• Not 6'-3"
• Design	• Blocked out	• Not blocked out
• Condition	• Undamaged	• Damaged, rusted, etc.
Drainage Structure	• 30' off roadway with appropriate side slopes • Safe design • Protected by guardrail	• Within 30' of roadway of hazardous design and not protected by guardrail

Figure 4D

II. EVALUATION OF THE SYSTEM

Two types of analyses and evaluations are presented in this report:

- An evaluation of the geometric and operational features of the freeway system; and
- An analysis of current traffic volumes, operational characteristics and the levels of service provided by elements of the system, i.e., freeway segments and interchanges.

The existing geometric and operational features were evaluated for the entire freeway system. There were four geometric features, four operational features and two performance measures used in the evaluation. The ratings of **good, fair** and **poor** were based on the established evaluation criteria.

For the existing features, a **good** rating implies a desirable standard, a **fair** equates with a minimum standard, while the **poor** rating indicates below standard design. The evaluation is shown graphically on Exhibits 1A through 1C on pages 21-23. The Geometric (G) and Operational (O) features of each segment of the facility in comparison to its Performance Measures (PM) of safety (accidents) and the quality of traffic flow (level of service) demonstrate the relationship between existing design features and the performance of the facility.

The evaluation exhibits clearly identify freeway segments which have **poor** ratings for a number of the geometric, operational, and performance elements. These areas may indicate a high priority for improvement. Therefore, the evaluation is valuable in determining the extent of existing deficiencies and as input in the priority scheduling of short- and long-term improvement projects.

GEOMETRICS

For balance in freeway design all geometric elements should, as far as is economically feasible, be developed to provide safe and efficient operations at the design speed established for prevailing conditions on the facility.

Horizontal Alignment

The horizontal geometry in the corridor is adequate, with the exception of the system connections between I-10 and the Superstition Freeway, since it complies with 70 mph design standards. The I-10 eastbound connection to the Superstition Freeway consists of a compound curve, which goes from a flatter to a sharper curve. Motorists tend to brake approaching the sharper curve, which sets off a

chain reaction of braking when the ramp is near capacity, causing a breakdown in traffic flow. The Superstition Freeway loop ramp to eastbound I-10 is extremely sharp and presents an obvious design discontinuity between the two facilities.

Stopping Sight Distance

Sight distance is the length of highway visible to the driver. Sight distance everywhere along a highway should be adequate for drivers traveling at the design speed to come to a safe stop before reaching a stationary object in the roadway. The study area has desirable stopping sight distances on the mainline, with the exception of the eastbound connection to the Superstition Freeway. Sight distance at that location is obstructed by the bridge parapet which lies 4 feet off the edge of pavement.

Cross Section

The cross-sectional elements which were evaluated consisted of: the width of lanes, shoulders and median; roadside hazards and sideslopes; and type and condition of guardrail. These general characteristics contribute to the safety and quality of traffic flow of the system. Narrow lanes, shoulders and medians and unexpected hazards close to the roadway cause drivers to reduce their speed which decreases the quality of traffic flow and increases the accident potential.

The lanes, right shoulders and median widths on the Superstition Freeway meet current standards, except for a short segment between Hardy Road and Priest Road, where the median tapers down to 16 feet. The left shoulder width is 4 feet on I-10, which is adequate for the 4-lane section from the Superstition Freeway to Baseline Road. However, the left shoulder is inadequate for the 6-lane section on I-10 from the Superstition Freeway to 40th Street.

The area adjacent to the roadway is generally free of unprotected hazards and has traversable sideslopes and ditches. All of the installed guardrail is blocked out with 6'-3" post spacing according to current standards. Therefore, the roadway features of the cross section are good, except for the section on I-10, which has inadequate left shoulders.

Exit and Entrance Design

The design of a ramp terminal should include adequate transition lengths for the speed changes required to maneuver from the freeway to the ramp and vice versa. This removes the accelerating and decelerating vehicles from the mainline, thereby providing uniform operating speeds and smooth maneuvers on the freeway. Long tapers and gentle curvatures at the nose and merging end allow for safer driving maneuvers through the transition.

The exit taper lengths are generally inadequate for the entire system. The curvature at the nose and merging end are below standard in several locations,

especially at the loop ramps at 48th Street, Broadway Road and the Superstition Freeway.

OPERATIONS

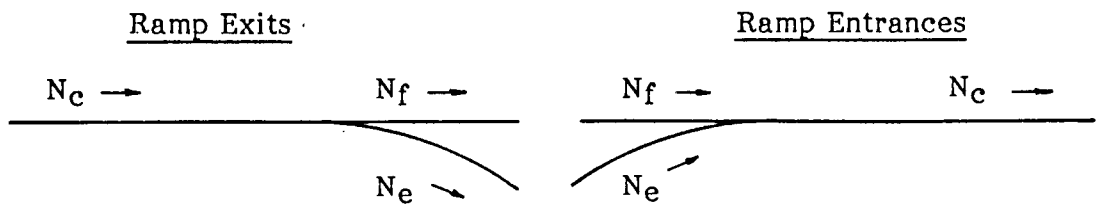
Lane Continuity

Route and lane continuity provides continuous lanes on a given route allowing the through driver to remain on the route without forced lane changes. This is achieved through the use of basic lanes and right-hand exits and entrances. Simplifying the driver's task by reducing unnecessary lane changes lessens the accident potential.

There are three basic lanes on I-10 from 40th Street to the Superstition Freeway and two basic lanes from the Superstition Freeway to Baseline Road. In the eastbound direction, the left lane ends past the Superstition Freeway entrance, thereby eliminating one through lane. The basic lane is added in the westbound direction from the Superstition Freeway on the right, which maintains lane continuity. There are three basic lanes on the Superstition Freeway.

Lane Balance

Lane balance is an important operational feature used to ease the merging and diverging of ramp traffic by minimizing forced lane changes and erratic maneuvers. At exits, an optional lane should be provided to allow a driver to either exit or remain on the freeway, with the maximum of one lane being dropped at the exit. Therefore, on all exits the sum of the exit lanes and freeway lanes past the exit should be one more than the number of lanes before the exit. The criteria for lane balance is shown in the following diagrams:



GENERAL FORMULA	MAXIMUM	MINIMUM
$N_c = N_f + N_e - 1$	$N_c = N_f + N_e$	$N_c = N_f + N_e - 1$

(N_c, N_f, N_e, - Number of lanes, respectively, on: freeway carrying combined traffic; freeway, exclusive of ramp traffic; exit or entrance ramp.)

On eastbound I-10, the auxiliary lanes between the consecutive loop ramps at the 48th Street and Broadway Road interchanges create a condition of lane imbalance. At the Superstition Freeway eastbound exit there is also a lane drop. On westbound I-10, at the Broadway Road exit, the auxiliary lane from the Superstition Freeway entrance is dropped, and at the termination of the Superstition Freeway at I-10 lane balance requirements are not fulfilled.

Ramp Sequence

The sequencing and spacing of ramps along a freeway are important for safe, efficient freeway operations. Adjacent ramps should be located at appropriate distances from each other to avoid conflicts caused by overlapping merging and diverging maneuvers. The spacing of ramps was evaluated separately for the following four sequences:

(1) Successive exits — (potential overloading of right lane)

(2) Successive entrances — (potential overloading of right lane)

(3) Entrance followed by an exit — (weaving section)

(4) Exit followed by an entrance

Extremely short weaving sections exist between the loop ramps on eastbound I-10 at Broadway Road and 48th Street. Between the westbound I-10 entrance ramp at Baseline Road and the Superstition Freeway exit ramp, there is inadequate distance causing critical weaving patterns. The ramps between Mill Avenue and Rural Road in both directions on the Superstition Freeway provide inadequate weaving distances. On westbound I-10, the heavy volume entering from the Superstition Freeway and crossing the exiting flow to Broadway Road causes a difficult weaving situation.

Signing

Guide signing is provided to aid drivers in their navigational tasks. The sequence and spacing of ramps, lane balance and lane continuity affect the information and the complexity of the signing required. The most important criteria of signing are the number of advance guide signs and the message units displayed per sign to provide positive guidance to the motorist with the minimum amount of information.

The existing guide signs generally conform to the standards except for those exceeding the maximum message units per sign.

PERFORMANCE MEASURES

Accidents

The accident data used in the analysis were from July 1, 1982 to June 30, 1985. The collected data was analyzed in relationship to mainline freeway segments around logical areas of interchange influence. The analysis indicated that the accident rates on the system are generally above the average accident rate for urban freeways in the State of Arizona. The highest accident rates occurred on the following segments:

- Eastbound Superstition Freeway between Hardy Drive and Rural Road;
- Westbound Superstition Freeway between Mill Avenue and I-10;
- Eastbound I-10 around the 48th Street/Broadway Road interchange complex; and
- Westbound I-10 at the 40th Street interchange.

Operating Speeds

Speed-delay studies were taken on I-10 from Guadalupe Road to 32nd Street and on the Superstition Freeway from Mill Avenue to 40th Street on I-10. Morning peak hour runs were conducted between 6:30 and 8:30 a.m. in the westbound direction, while the eastbound direction was traveled in the evening peak hours between 4:30 and 6:30 p.m. An average of these runs is shown graphically on the speed-profiles of Exhibits 1A through 1C, and clearly depict how the quality of traffic flow is greatly reduced during peak hours.

Level of Service

Level of service (LOS) is a measure of the quality of traffic flow. The existing freeway segments are operating at or near capacity (LOS D and E) on the following sections:

- I-10 eastbound from 40th Street to the Superstition Freeway;
- I-10 westbound from the Superstition Freeway to 40th Street;
- Superstition Freeway eastbound from I-10 to Rural Road; and
- Superstition Freeway westbound from Rural Road to I-10.

III. EXISTING TRAFFIC VOLUMES AND LEVEL OF SERVICE

The existing traffic volumes were based upon daily and hourly traffic volume counts provided by ADOT and the City of Tempe. Peak hour volumes were developed for all segments of the freeway system. Capacity analyses were performed to determine levels of service for the mainline segments, ramps and weaving sections. The volumes and levels of service are shown in Exhibit 2 on page 24.

FREEWAY SEGMENTS

Virtually all of the freeway segments are performing at or near capacity (Level of Service D or E) due to an inadequate number of lanes. The only segments operating at Level of Service C or better are on I-10 south of the Superstition Freeway.

RAMP TERMINALS

Virtually all of the ramps in the study area are operating at or near capacity. In many cases this is due to the high concentration of vehicles in lane 1 rather than inherent deficiencies due to ramp design or sequencing. However, at certain locations, the provision of additional lanes on the mainline will not improve the ramp operating performance. Particularly critical locations are:

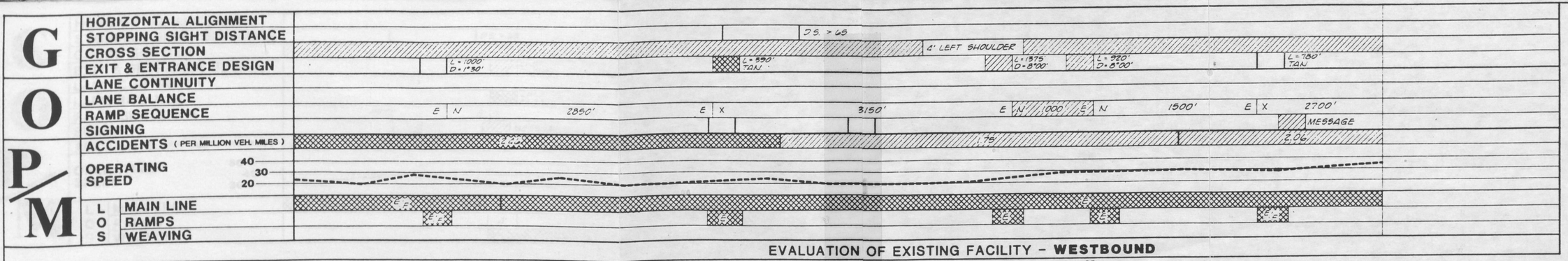
- The major system interchange ramps between the Superstition Freeway and I-10; and
- The consecutive loop ramps at 48th Street and Broadway Road on eastbound I-10.

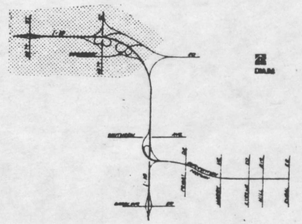
IV. SUMMARY AND CONCLUSIONS

The Phase I report presents a detailed analysis and evaluation of the geometric and operational features of the I-10 Corridor Study Area. The results of this phase of the study not only identify the existing deficiencies but will provide the basis for development and evaluation of alternative improvement schemes.

Virtually all sections of this freeway system are operating at or near capacity during peak periods. The addition of mainline freeway lanes would not in itself resolve the existing or future capacity, safety, and operational problems. The modification of interchanges may be necessary to correct the deficiencies in lane continuity, lane balance and ramp sequence, and to eliminate critical weaving sections.

Specific deficiencies other than the inadequate number of lanes on I-10 which have the most profound effect on capacity, safety, and operations include: the inadequate design of exit and entrance ramps; the sequencing of consecutive loop ramps on mainline I-10 at 48th Street and Broadway Road; the lane drop at the westbound I-10 exit to Broadway Road; and the geometric deficiencies at the major system interchange of I-10 with the Superstition Freeway. These deficiencies and their effect on the performance of the facility will be compounded when the Hohokam Freeway is completed.





SYSTEM KEY MAP

LEGEND

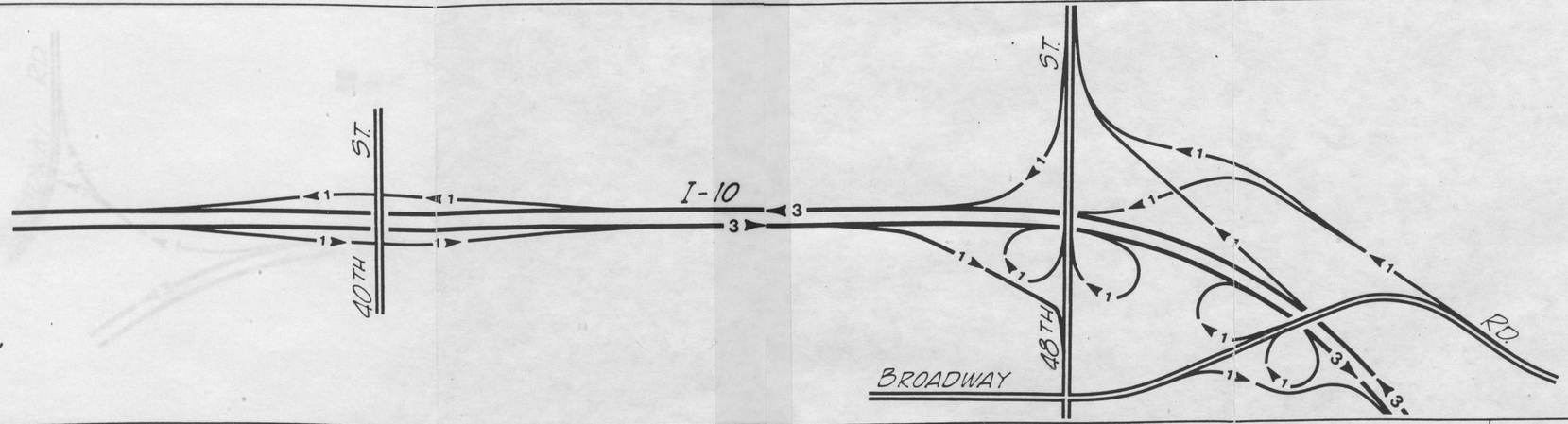
G..... GEOMETRIC FEATURES

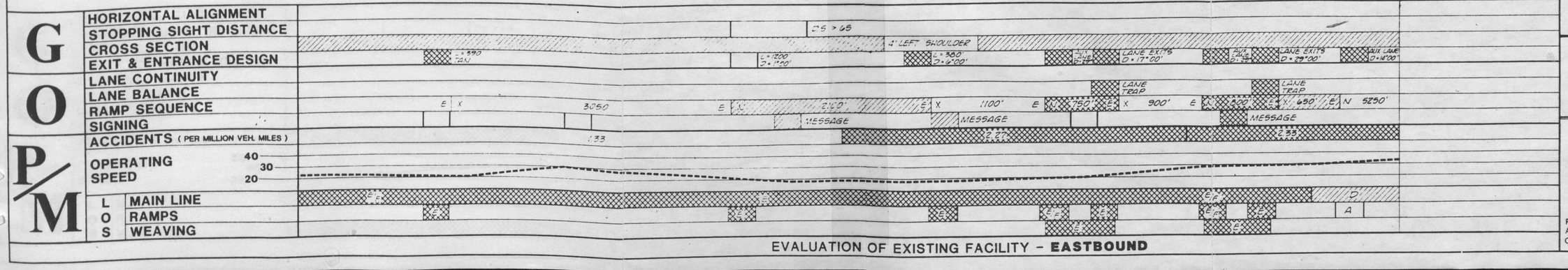
O..... OPERATIONAL FEATURES

P/M .... PERFORMANCE MEASURES

RATING OF EXISTING CONDITION

GOOD — FAIR — POOR





I-10 CORRIDOR STUDY

40th Street to Baseline Road

EVALUATION OF EXISTING GEOMETRIC AND OPERATIONAL FEATURES

DMJM/Adam, Hamlyn, Anderson

in association with

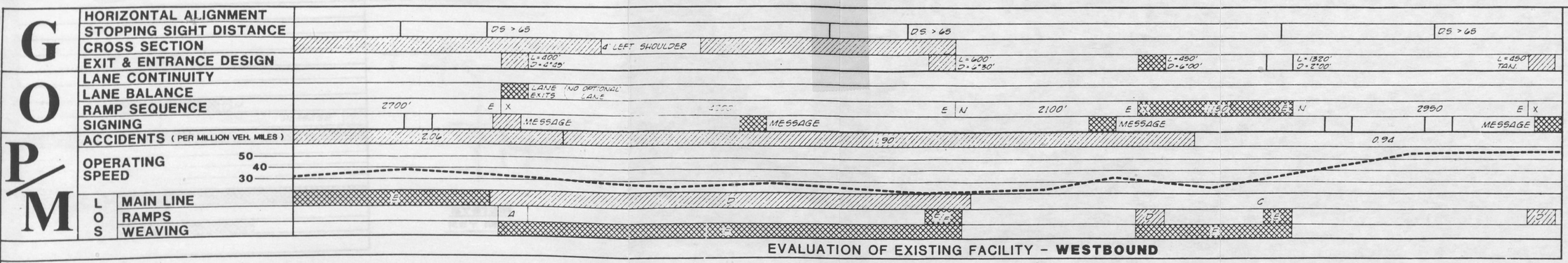
JACK E. LEISCH & ASSOCIATES

EXHIBIT 1A

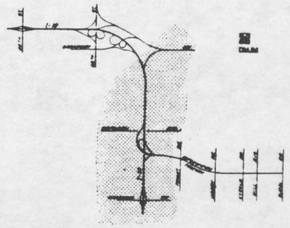
PREPARED FOR ARIZONA DEPARTMENT OF TRANSPORTATION

SCALE: 1"=400'

OCTOBER 1985



EVALUATION OF EXISTING FACILITY - **WESTBOUND**



SYSTEM KEY MAP

LEGEND

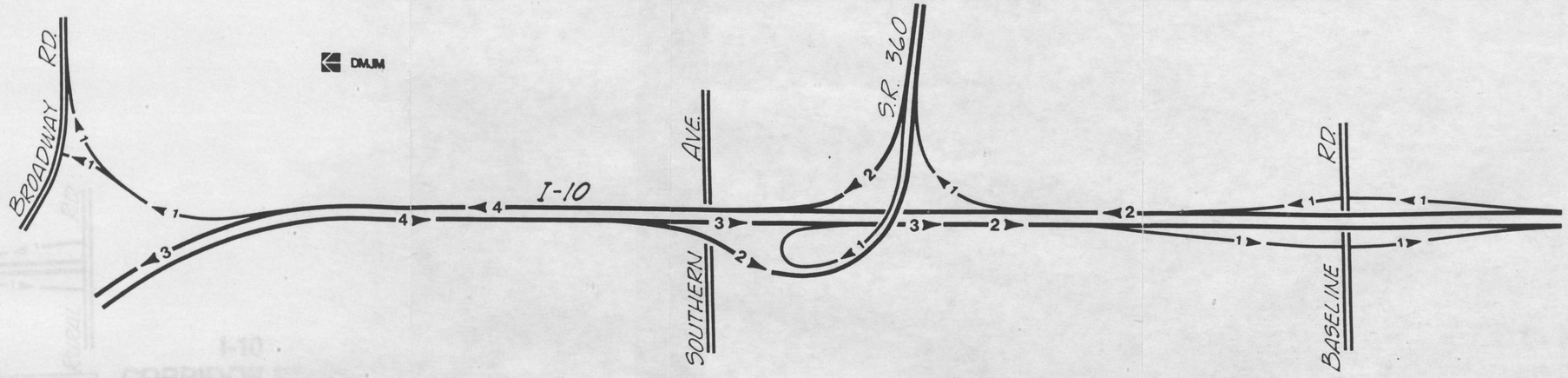
G..... GEOMETRIC FEATURES

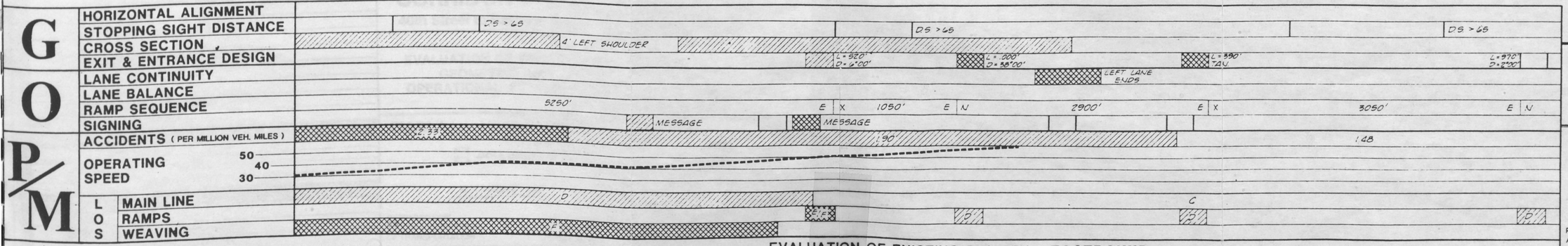
O..... OPERATIONAL FEATURES

P/M .... PERFORMANCE MEASURES

RATING OF EXISTING CONDITION

GOOD — FAIR — POOR





EVALUATION OF EXISTING FACILITY - **EASTBOUND**

I-10 CORRIDOR STUDY

40th Street to Baseline Road

EVALUATION OF EXISTING GEOMETRIC AND OPERATIONAL FEATURES

DMJM/Adam, Hamlyn, Anderson

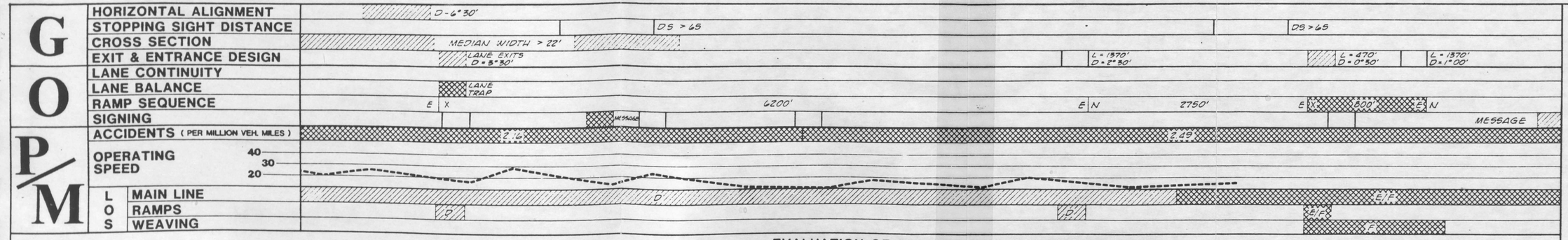
in association with

JACK E. LEISCH & ASSOCIATES

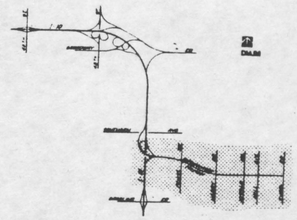
EXHIBIT 1B

PREPARED FOR
ARIZONA DEPARTMENT
OF TRANSPORTATION

SCALE: 1"=400'
OCTOBER 1985



EVALUATION OF EXISTING FACILITY – **WESTBOUND**



SYSTEM KEY MAP

LEGEND

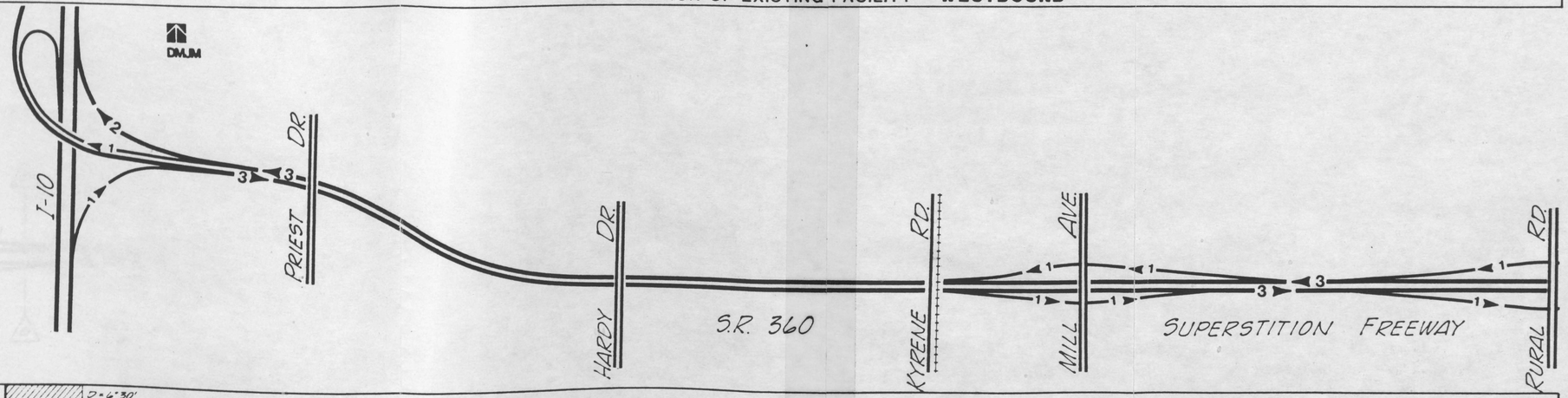
G..... GEOMETRIC FEATURES

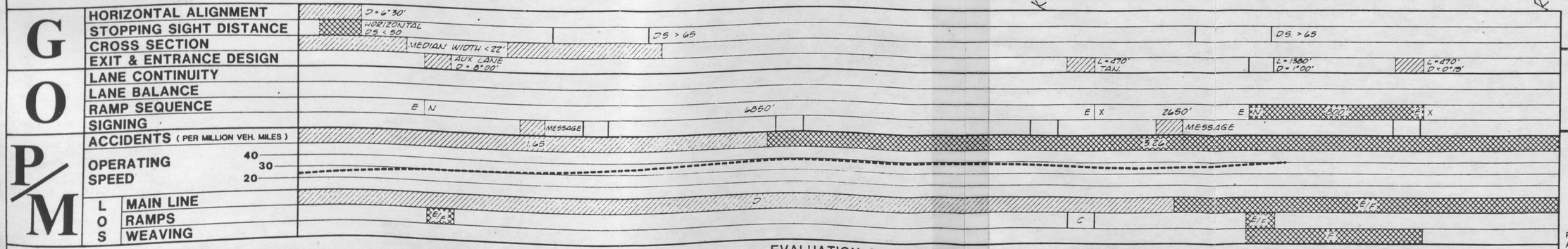
O..... OPERATIONAL FEATURES

P/M .... PERFORMANCE MEASURES

RATING OF EXISTING CONDITION

GOOD FAIR POOR





EVALUATION OF EXISTING FACILITY – **EASTBOUND**

I-10 CORRIDOR STUDY

40th Street to Baseline Road

EVALUATION OF EXISTING GEOMETRIC AND OPERATIONAL FEATURES

DMJM/Adam, Hamlyn, Anderson

in association with

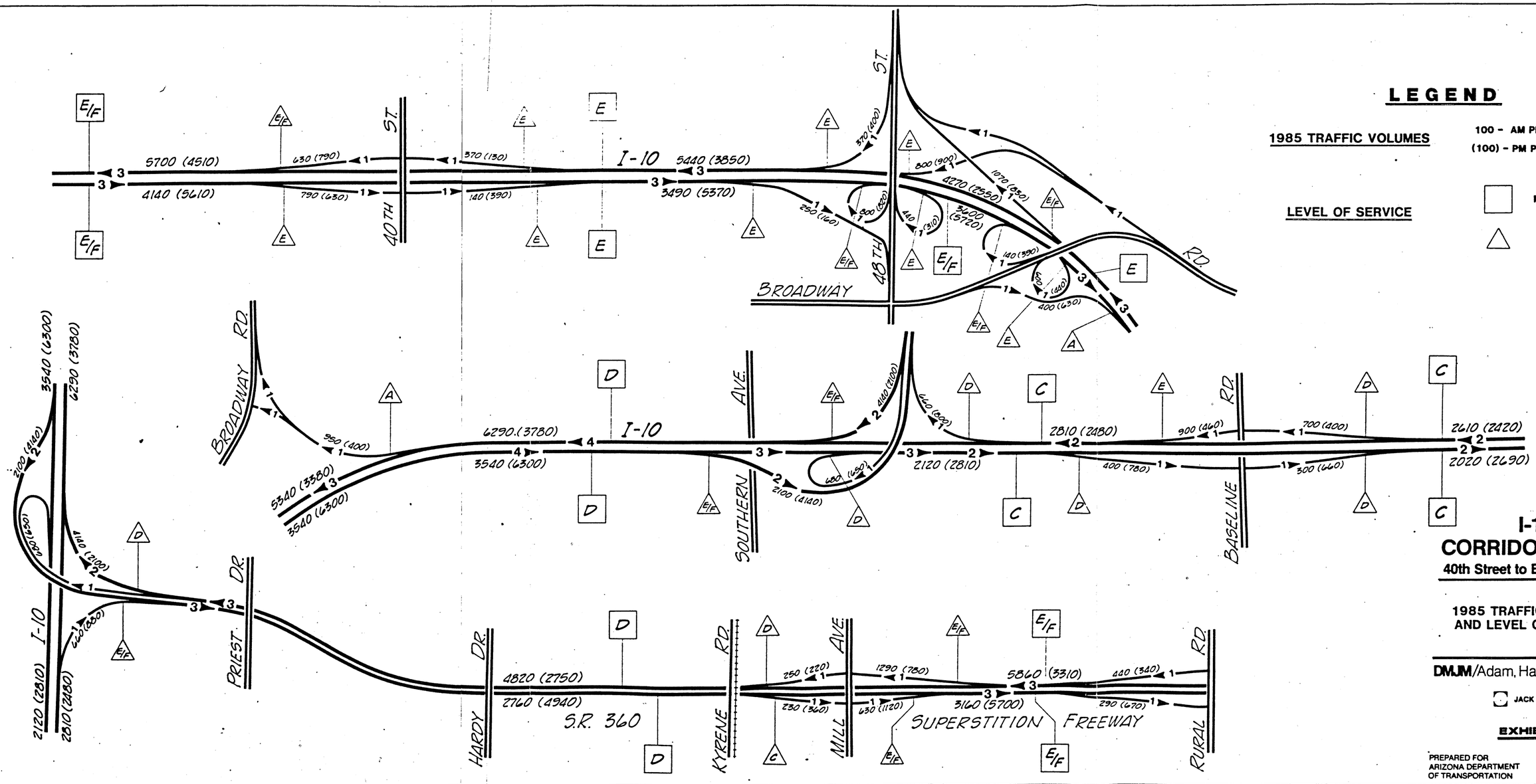
JACK E. LEISCH & ASSOCIATES

EXHIBIT 1C

PREPARED FOR ARIZONA DEPARTMENT OF TRANSPORTATION

SCALE: 1"= 400'

OCTOBER 1985



I-10 CORRIDOR STUDY

40th Street to Baseline Road

1985 TRAFFIC VOLUMES AND LEVEL OF SERVICE

DMJM/Adam, Hamlyn, Anderson
in association with
JACK E. LEISCH & ASSOCIATES

EXHIBIT 2

PREPARED FOR
ARIZONA DEPARTMENT
OF TRANSPORTATION

SCALE: 1"=400'
OCTOBER 1985