CTR-3-12D-88-954-1F

APPRAISAL OF CONTRACTS FOR IMPROVEMENTS ON U.S. 59 (SOUTHWEST FREEWAY) IN HARRIS COUNTY

W.V. Ward and J.T. O'Connor

RESEARCH REPORT 954-1F

PROJECT 3-12D-88-954

CENTER FOR TRANSPORTATION RESEARCH
BUREAU OF ENGINEERING RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN
JUNE 1988

PARTIAL LIST OF REPORTS PUBLISHED BY THE CENTER FOR TRANSPORTATION RESEARCH

This list includes some of the reports published by the Center for Transportation Research and the organizations which were merged to form it: the Center for Highway Research and the Council for Advanced Transportation Studies. Questions about the Center and the availability and costs of specific reports should be addressed to: Director; Center for Transportation Research; ECJ 2.5; The University of Texas at Austin; Austin, Texas 78712.

7-1 "Strength and Stiffness of Reinforced Concrete Rectangular Columns Under Biaxially Eccentric Thrust," by J. A. Desai and R. W. Furlong, January 1976.

7-2F "Strength and Stiffness of Reinforced Concrete Columns Under Biaxial Bending," by V. Mavichak and R. W. Furlong, November 1976.

16-1F "Oil, Grease, and Other Pollutants in Highway Runoff," by Bruce Wiland and Joseph F. Malina, Jr., September 1976.

23-1 "Prediction of Temperature and Stresses in Highway Bridges by a Numerical Procedure Using Daily Weather Reports," by Thaksin Thepchatri, C. Philip Johnson, and Hudson Matlock, February 1977.

23-2 "Analytical and Experimental Investigation of the Thermal Response of Highway Bridges," by Kenneth M. Will, C. Philip Johnson, and Hudson Matlock, February 1977.

23-3F "Temperature Induced Stresses in Highway Bridges by Finite Element Analysis and Field Tests," by Atalay Yargicoglu and C. Philip Johnson, July 1978.

29-2F "Strength and Behavior of Anchor Bolts Embedded Near Edges of Concrete Piers," by G. B. Hasselwander, J. O. Jirsa, J. E. Breen, and K. Lo, May 1977.

114-4 "Durability, Strength, and Method of Application of Polymer-Impregnated Concrete for Slabs," by Piti Yimprasert, David W. Fowler, and Donald R. Paul, January 1976.

114-5 "Partial Polymer Impregnation of Center Point Road Bridge," by Ronald Webster, David W. Fowler, and Donald R. Paul, January 1976.

114-6 "Behavior of Post-Tensioned Polymer-Impregnated Concrete Beams," by Ekasit Limsuwan, David W. Fowler, Ned H. Burns, and Donald R. Paul, June 1978.

114-7 "An Investigation of the Use of Polymer-Concrete Overlays for Bridge Decks," by Huey-Tsann Hsu, David W. Fowler, Mickey Miller, and Donald R. Paul, March 1979.

114-8 "Polymer Concrete Repair of Bridge Decks," by David W. Fowler and Donald R. Paul, March 1979.

114-9F "Concrete-Polymer Materials for Highway Applications," by David W. Fowler and Donald R. Paul, March 1979.

118-9F "Observation of an Expansive Clay Under Controlled Conditions," by John B. Stevens, Paul N. Brotcke, Dewaine Bogard, and Hudson Matlock, November 1976.

123-30F "Overview of Pavement Management Systems Developments in the State Department of Highways and Public Transportation," by W. Ronald Hudson, B. Frank McCullough, Jim Brown, Gerald Peck, and Robert L. Lytton, January 1976 (published jointly with the Texas State Department of Highways and Public Transportation and the Texas Transportation Institute, Texas A&M University).

172-1 "Axial Tension Fatigue Strength of Anchor Bolts," by Franklin L. Fischer and Karl H. Frank, March 1977.

172-2F "Fatigue of Anchor Bolts," by Karl H. Frank, July 1978.

176-4 "Behavior of Axially Loaded Drilled Shafts in Clay-Shales," by Ravi P. Aurora and Lymon C. Reese, March 1976.

176-5F "Design Procedures for Axially Loaded Drilled Shafts," by Gerardo W. Quiros and Lymon C. Reese, December 1977.

177-1 "Drying Shrinkage and Temperature Drop Stresses in Jointed Reinforced Concrete Pavement," by Felipe Rivero-Vallejo and B. Frank McCullough, May 1976.

177-3 "A Study of the Performance of the Mays Ride Meter," by Yi Chin Hu, Hugh J. Williamson, and B. Frank McCullough, January 1977.

177-4 "Laboratory Study of the Effect of Nonuniform Foundation Support on Continuously Reinforced Concrete Pavements," by Enrique Jimenez, B. Frank McCullough, and W. Ronald Hudson, August 1977.

177-6 "Sixteenth Year Progress Report on Experimental Continuously Reinforced Concrete Pavement in Walker County," by B. Frank McCullough and Thomas P. Chesney, April 1976.

177-7 "Continuously Reinforced Concrete Pavement: Structural Performance and Design/Construction Variables," by Pieter J. Strauss, B. Frank McCullough, and W. Ronald Hudson, May 1977.

177-9 "CRCP-2, An Improved Computer Program for the Analysis of Continuously Reinforced Concrete Pavements," by James Ma and B. Frank McCullough, August 1977.

177-10 "Development of Photographic Techniques for Performing Condition Surveys," by Pieter Strauss, James Long, and B. Frank McCullough, May 1977.

177-11 "A Sensitivity Analysis of Rigid Pavement Overlay Design Procedure," by B. C. Nayak, W. Ronald Hudson, and B. Frank McCullough, June 1977.

177-12 "A Study of CRCP Performance: New Construction Vs. Overlay," by James I. Daniel, W. Ronald Hudson, and B. Frank McCullough, April 1978.

177-13 "A Rigid Pavement Overlay Design Procedure for Texas SDHPT," by Otto Schnitter, W. R. Hudson, and B. F. McCullough, May 1978.

177-15 "Precast Repair of Continuously Reinforced Concrete Pavement," by Gary Eugene Elkins, B. Frank McCullough, and W. Ronald Hudson, May 1979.

177-16 "Nomographs for the Design of CRCP Steel Reinforcement," by C. S. Noble, B. F. McCullough, and J. C. M. Ma, August 1979.

177-17 "Limiting Criteria for the Design of CRCP," by B. Frank McCullough, J. C. M. Ma, and C. S. Noble, August 1979.

177-18 "Detection of Voids Underneath Continuously Reinforced Concrete Pavements," by John W. Birkhoff and B. Frank McCullough, August 1979.

183-7 "Permanent Deformation Characteristics of Asphalt Mixtures by Repeated-Load Indirect Tensile Test," by Joaquin Vallejo, Thomas W. Kennedy, and Ralph Haas, June 1976.

(Continued inside back cover)

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
TX-88+954-1F		

4. Title and Subtitle	5. Report Date
APPRAISAL OF CONTRACTS FOR IMPROVEMENTS ON U.S. 59 (SOUTHWEST FREEWAY) IN DISTRICT 12, HARRIS COUNTY	June 1988
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
W. V. Ward and J. T. O'Connor	Research Report 954-1F
9. Performing Organization Name and Address	10. Work Unit No.
Center for Transportation Research The University of Texas at Austin Austin, Texas 78712-1075	11. Contract or Grant No. Research Study 3-12D-88-954
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Texas State Department of Highways and Public Transportation; Transportation Planning Division P. O. Box 5051 Austin, Texas 78763-5051	Final
	14. Sponsoring Agency Code

15. Supplementary Notes

Study conducted in cooperation with the Texas State Department of Highways and Public Transportation. Research Study Title: "Appraisal of Contracts for Improvements on U.S. 59 (Southwest Freeway) in Harris County"

16. Abstract

Major improvements to and along U.S. 59 (Southwest Freeway) between Beltway 8 and I.H. 610 (West Loop) have been proposed by the State Department of Highways and Public Transportation, with the cooperation, assistance, and financial participation of the Harris County Metropolitan Transit Authority. The improvements provide for adding lanes to the freeway, constructing a transitway and transitway interchanges along the freeway, widening and overlaying the existing freeway pavement, making frontage road intersections, and adding a freeway interchange at Fountainview.

Construction operations will be difficult because of the confined working room and will be further aggravated by having to be performed adjacent to the existing freeway traffic, which averages about 200,000 vehicles per weekday, and also must accommodate crossing traffic at nine major intersecting thoroughfares. Maintaining existing traffic within the freeway right of way is proposed. There are two major shopping centers along the route plus numerous other traffic dependent shopping and business enterprises for which access will have to be maintained. Proposed traffic handling schemes for each of the three segments have been planned to conform with adjacent segments so that the construction work causes a minimum of inconvenience to the traveling public passing along and across the freeway.

The Center for Transportation Research was asked to appraise the plans, critical path schedules, and specifications for each of the three segments, and then to advise and report errors or omissions which might inhibit orderly completion of improvements.

17. Key Words	18. Distribution Statement
freeway, rehabilitation, critical path schedules	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	14	

Form DOT F 1700.7 (8-69)

APPRAISAL OF CONTRACTS FOR IMPROVEMENTS ON U.S. 59 IN DISTRICT 12, HARRIS COUNTY

by

W.V. Ward
J. T. O'Connor

Research Report 954-1F

Research Project 3-12D-88-954

Appraisal of Contracts for Improvements on
U.S. 59 (Southwest Freeway)
in Harris County

conducted for the

Texas State Department of Highways
and Public Transportation

by the

Center for Transportation Research
Bureau of Engineering Research
The University of Texas at Austin

June 1988

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Texas State Department of Highways and PublicTransportation. This report does not constitute a standard, specification, or regulation.

There was no invention or discovery conceived or first actually reduced to practice in the course of or under this contract, including any art, method, process, machine, manufacture, design or composition of matter, or any new and useful improvement thereof, or any variety of plant which is or may be patentable under the patent laws of the United States of America or any foreign country.

TABLE OF CONTENTS

APPRAISAL OF CONTRACTS FOR IMPROVEMENTS ON U.S. 59 IN DISTRICT 12, HARRIS COUNTY

1. BACKGROUND AND SIGNIFICANCE

The State Department of Highways and Public Transportation represented by District 12, with the cooperation, assistance, and financial participation of the Harris County Metropolitan Transit Authority, proposes major improvements to and along U.S. 59 (Southwest Freeway) between Beltway 8 and I.H. 610 (West Loop) (see Fig 1). The improvements provide for: adding lanes to the freeway, construction of a transitway and transitway interchanges along the freeway, widening and overlaying the existing freeway pavement, frontage road improvements, improving the freeway interchanges, improving the frontage road intersections, and adding a freeway interchange at Fountainview. The proposed improvements are planned to be constructed in three contracts (Segments I, II, and III) at an estimated total cost of $200 million. The project lengths of Segments I, II, and III are 2.910, 2.699, and 2.571 miles respectively and total 8.18 miles. It is estimated that upon completion of these improvements that the user's benefits accruing therefrom will be about $400,000 per day.

Construction operations will be difficult because of the confined working room which will be further aggravated because the construction is to be performed adjacent to the existing freeway traffic, which averages about 200,000 vehicles per weekday, and also accommodate crossing traffic at nine major intersecting thoroughfares. Existing traffic is proposed to be maintained within the freeway right of way. There are two major shopping centers along the route plus numerous other shopping and business enterprises which are traffic dependent for which access will have to be maintained. Proposed traffic handling schemes for each of the three segments have been planned to conform with adjacent segments such that the construction work causes a minimum of inconvenience to the traveling public passing along and across the freeway.

Preliminary analysis of the construction requirements for Segment III, as constrained by a required traffic control plan, indicates that the contract can be completed in about three calendar years. This analysis included allowances for average weather conditions and considered that the contractor would be required to work a two-shift per day five-day week. The construction requirements for Segments I and II are of slightly less scope and magnitude than for Segment III and it was assumed that these could also be completed in three years.

The magnitude and proximity of the proposed construction operations are such that the movement of people, goods, and services along the projects will be restrained as will access to abutting property and intersecting city streets. It is the objective of the Department of Highways and the Harris County Metropolitan Transit Authority that the improvements be constructed in an orderly manner as soon as practicable with a minimum of interference to the traveling public and abutting property. It is important that the construction plans and specifications be comprehensive, complete, and correct in order for the three segments to be completed expeditiously and coordinated in time, space, and detail. Consequently, the Center for Transportation Research was asked by the Department to appraise the plans and specifications and critical path schedules provided for each of the three segments. Along with and following the appraisal CTR was to advise and report the occurrence of errors or omissions which could inhibit the orderly, coordinated, and expeditious completion of the improvements.

CTR was first notified of the Department's desires for the appraisal at a meeting on February 28, 1988 among representatives from the Department, the MTA, and CTR. At that time the Department planned to let Segment III to contract in July 1988 followed by Segments I and II within a month or two. In order for an appraisal to be useful to the Department such findings would have to be communicated before a May 1, 1988 deadline for making changes in the plans and specifications. At the meeting the objectives of the appraisal and specifics issues to be investigated were discussed. As a consequence of the February 28 meeting a study proposal covering the principal objectives and issues was prepared by CTR and submitted to the Department on March 7, 1988. The Department subsequently approved the proposal March 16, 1988 with the condition that CTR address, in the final report, three issues cited by District 12 in their approval transmittal letter of March 11, 1988. These three issues were included in a modified study proposal submitted by CTR on March 24, 1988.

Completed plans for Segments II and III were made available by the Department at the beginning of the study and those for Segment I were received within two weeks. Specification item dealing with traffic control, working time, and working sequence were available for Segments II and III but not for Segment I. However, this omission was not considered as inhibiting the appraisal since recommendations by CTR affecting Segment II and III specifications would be applicable to Segment I. The number of plan sheets for each set of plans were as follows: Segment I - 886, Segment II - 762, and Segment III - 1,114, for a total of 2,762 sheets

2. BENEFITS

A well planned and executed scheme of construction and traffic handling will reduce the amount of congestion and user's operating costs during the period of construction and will decrease the total time of construction such that the user's benefits to be derived from the completed improvements may be returned sooner. The economic benefits

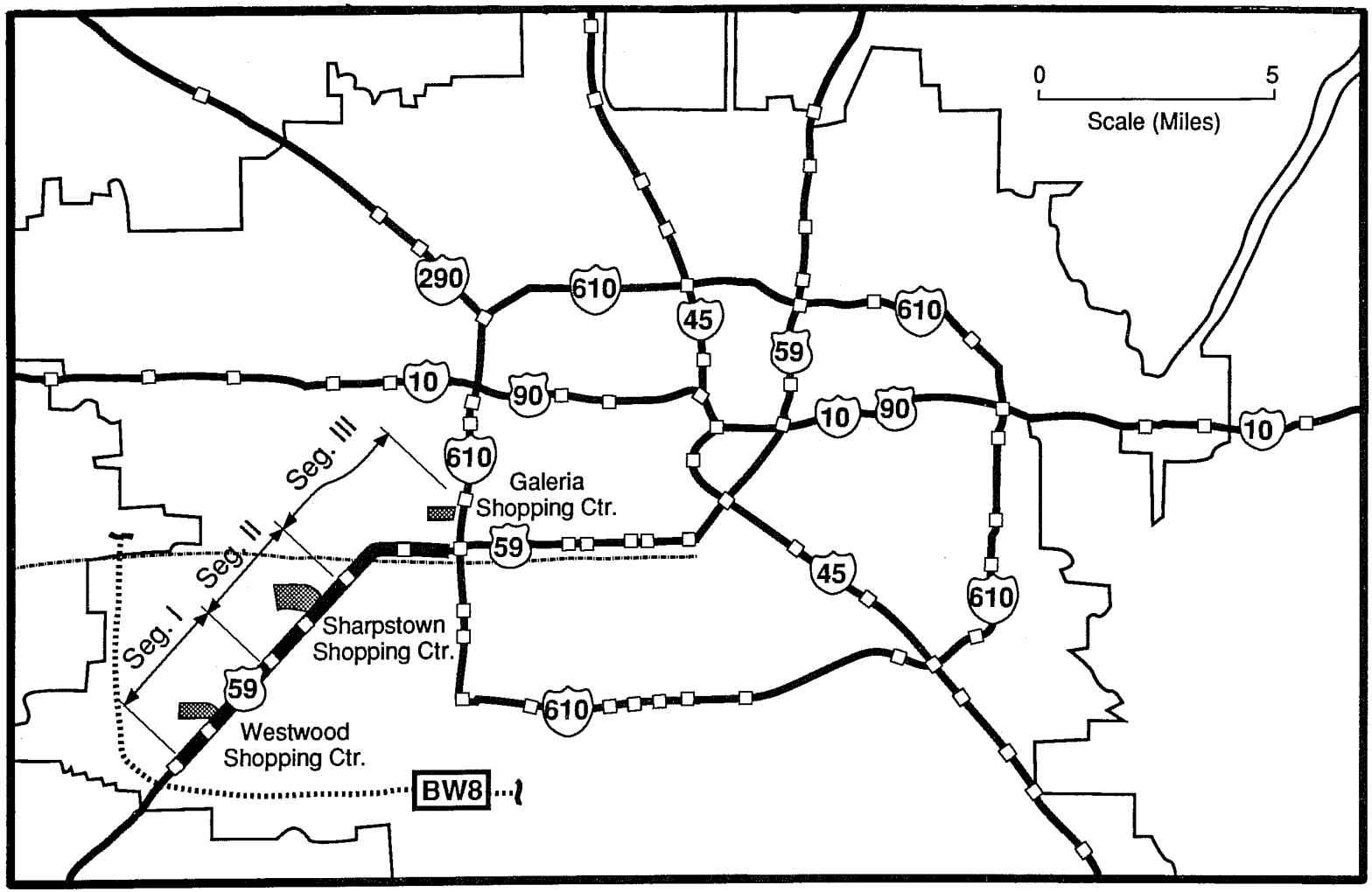

Fig 1. Locations of Proposed Improvements to U.S. 59 (Southwest Freeway)

accruing to highway users from good traffic operations, during the construction period and from an early completion date, that can be achieved by superior planning, can be substantial, and may be greater than the construction cost of the improvements. Additional benefits from orderly and coordinated construction operations would be the reduction of the jeopardy relating to contractor's claims and lawsuits due to interference and conflicts between the adjoining contracts.

3. OBJECTIVES

The principal objectives of this study are to review the Department's plans and specifications to appraise

(a) the quality of the planning with respect to claims-free, orderly, and coordinated construction and traffic handling sequencing for all three contracts;

(b) the sequencing of the letting dates for the three contracts; and

(c) the proposed working time and related milestones for assessing liquidated damages for each project.

4. IMPLEMENTATION

The findings of this study of the Department's planning may, if necessary, be used as a guideline by the Department to make necessary modifications to the plans and specifications in order to achieve the objective of orderly and coordinated construction operations among three adjoining construction contracts.

5. ORGANIZATION OF STUDY AND WORK

The appraisal was performed by a team composed of CTR staff and part-time former SDHPT employees. The team composition was as follows: Dr. Jim O'Connor, Assistant Professor of Civil Engineering at the University of Texas; William V. Ward, CTR staff, P.E.; Ken Hankins, CTR staff, P.E.; Gerald Peck, part-time, retired SDHPT, P.E.; John Mounce, retired SDHPT, P.E.; Dennis Smalley, part-time, retired SDHPT right-of-way and utility agent and public affairs officer; and Beth Loy, part-time, technical and administrative assistant. The three part-time, former SDHPT employees have long,varied, and wide experience in freeway plan preparation and problems attendant therewith and are familiar with the subject segment of the Southwest Freeway and surrounding environment. Team member Smalley lives in Houston and is particularly knowledgeable about the Southwest Freeway and the likely effects of the proposed construction on traffic and abutting property and provided useful insight on these effects. In the study proposal the budget included provisions for two other faculty professional engineers to be part of the study team; but during the time of the appraisal process between March 16 and May 1, 1988, their services were not available and some of the work related issues were not evaluated to the degree originally held to be desirable.

The study team reviewed the Segment III plans first as this segment was scheduled to be let to contract first. The general procedure in appraising the plans was to assign a team member to review one or more critical issues from the list contained in the study proposal work plan. The team spent approximately the same amount of time in reviewing each segment. In pursuing the inquiry into certain issues the team members also reported on any other significant defects or omissions they happened to uncover. As a consequence of the time available and the resources, the scope of the review was wider than it was deep. It is concluded, however, that a much more intense review and the application of more time and resources would probably not have uncovered any additional revelations of substance or the likelihood of discovering a "fatal flaw."

6. SUMMARY OF FINDINGS

A number of potential issues to be reviewed were listed in the work plan in the study proposal. It was anticipated that inquiry into these issues would reveal whether or not the planning for the subject segment of U.S. 59 (Southwest Freeway) was adequate; and if not, what sort of changes should be made to the plans and specifications? During the appraisal process CTR communicated to District 12, orally and in writing, with the results of the appraisal, which were: suggestions relating to specific changes in the plans and specifications, the identification of apparent errors, inconsistencies and omissions in the plans and specifications, and comments responding to particular issues put forth by the Department. The summary of findings is presented as a series of comments displayed side by side with the issues listed in the proposal work plan. Some other issues came up during the appraisal process and these have been added to the study proposal list. The issues and associated comments are as follows:

ISSUES AND COMMENTS

ISSUES	COMMENTS
A. Logic of sequence (1) Traffic control	*Only one alternative general traffic control plan was considered or was even apparent assuming the general desideratum to accommodate all existing traffic within the U.S. 59 ROW. The alternate would be to use the entire median area for temporary traffic lanes for each direction of freeway travel as alternate sides of the freeway are re-constructed. This would be accomplished by moving the Concrete Median Barrier to the far edge of the existing median as each side of the freeway is worked on. We were told that this scheme was considered and rejected because it required more traffic diversions. This scheme would, however, provide more working room than the general scheme required by the plans.*
(2) Dependent and adjoining construction	*Provisions should be made in each contract such that traffic can be "handed off" to the adjoining contract regardless of the phase of construction or traffic operations underway on the adjoining contract. Such provisions, if needed, should be paid for as extra work. To do otherwise may make one contractor liable for the actions of a third party (the adjacent contractor) for the "on time and in phase" performance.*
B. Activity durations for critical path scheduling	*There was insufficient time to make a detailed check of each construction activity. The overall critical path scheduling analysis performed by METRO appeared to be satisfactory and resulted in a reasonable estimate of contract working time. However an assumption was made that the contractor would be allowed to pursue an 80-hour, 2-shift, work week. The general opinion of the contractors, to whom we addressed this matter, was that a 60 to 70-hour, 1-shift, 6-day work week would be more efficient and less taxing on the productivity and personnel turnover rate. As a result, the contract working time may be extended beyond that of METRO's original analysis.*
C. Sequencing of letting dates	*Each segment appears to have sufficient options and flexibilities in the sequence of construction activities and within the conditions set out in the contracts that an able contractor should be able to conform to the construction phases on the abutting contract even if the abutting contract fails to perform as predicted and directed. The order of letting Segments I and II is not considered critical if the interval between lettings does not exceed two months. It is agreed that Segment III should be let first since it is the largest of the three contracts and on completion will provide substantial traffic benefits should the completion of the adjacent segments be delayed. In any case lettings should be delayed until it is reasonably certain that the right of entry dates for needed rights of way are firm. Unanticipated delays for critical parcels of ROW will make it difficult to enforce strict compliance with a prescribed critical path schedule.*

D. Assumptions as to unit productivity of various construction activities

The assumed unit production rates in METRO'S schedule analysis appears to be optimistic for the frontage paving and intersection operations. As discussed previously, these operations require special attention in order to come up with some special designs and details that will help the contractor. The assumed unit production rates for two-shift operations may be optimistic. Some authorities report productivity losses as much as 25% for the second shift.

E. Selection of milestone events

Did not have sufficient time to identify or justify additional milestone events. The Phase I, II, and III milestones required in the plans appear to be satisfactory.

F. Resource demand

(1) Manpower loading charts for both early start and levelling of resources

(2) Pavement materials requirements per day

Not addressed.

G. Criticality of schedule

(1) Percent critical path activities

(2) Float time histogram

(3) Sufficiency of lead time for acquiring materials and fabrication

The assumptions made by METRO as to the sequence of construction activities in Phase I, of Segment III are considered extremely parallel in character (64% of all activities are deemed critical). This sequencing may be overly conservative. The assumptions as to the sequence of activities for Phase II, Segment II are serial in character (only 17% of the activities are critical). This may indicate a schedule that is too tight. The sufficiency of lead time for procurement of materials was found not to be a problem if the contractor appropriately plans his work. Initial concerns related to the delivery of structural steel and high-mast lighting equipment.

H. Effectiveness of contractual schedule management requirements placed on the contractor

Requiring the contractor to furnish and maintain a microcomputerized Critical Path Method system is well taken. However, for the system to effective, it must be regularly updated. Unfortunately, some sort of motivation is needed. An economic analysis of contractor costs indicates that a withholding penalty of 25% (in addition to the regular 5%) of the monthly construction progress payments will be needed to encourage a contractor to maintain and update the system.

I. Adequacy of staging and storage areas, both on and off site

It would be highly desirable for the state to acquire vacant land, as near as possible to the construction sites, to be made available to the contractor for the duration of construction for each segment. This land should be used for the storage and processing of construction materials, storage of construction equipment, and parking for the contractor's employees. The benefits would be to reduce the adverse impact of construction operations on the abutting property and the street system furnishing access to the construction sites.

J. Effectiveness of liquidated damages

Since the public benefits derived from the completed contracts are very large, almost any reasonable (within the ordinary capabilities of the Department and of the most efficient highway contractors as conditioned by state and federal regulations) approach of securing early completion would be justified. Our opinion is that liquidated damages at the ends of Phase I in the range of $5,000 to $10,000 per day and at the end of Phase III in the range of $15,000 to $25,000 per day would be justifiable and defensible. Refer to our Technical Memorandum of April 25, 1988, for more about this issue.

K. Use of bonus/penalties

The contractors we discussed this matter with seemed receptive to idea of bonus payments particularly if they are liable to large liquidated damages. If it is decided to permit bonus payments it should, however, be clearly stated in the specifications that the Department will have to limit the amount of time a contractor will be permitted to work because of the Department's limited administrative resources. We believe that the most manageable manner of using the bonus/penalty approach would be to require the contractor to include in his bid the product of the given bonus value (to the state) of the working day and the number of working days the contractor believes he can perform the work.

L. Potential problems

(1) Interfaces between contract segments

Provisions should be made to "hand off" traffic to adjacent segments in order to match any phase of work on the adjacent segment.

(2) Weather effects

An independent analysis was made of the estimated amount of working days not available due to weather. We used the only weather data available which was collected at Houston Intercontinental Airport, about 20 to 25 miles removed from the subject segment of the Southwest Freeway, as representative of the construction site. We agree that the 200 working days available per year assumed by METRO in their analysis of the working time is reasonable assuming that the contractor is permitted work 6 days a week. It is difficult to estimate the effects of the rain on working days since the effect is much more pronounced on some items of work than others. Since only a relatively small part of the construction operations involve dirt work and excavation, these projects are not considered particularly sensitive to marginal weather conditions.

(3) Third party interference

(a) Right of way

(b) Utilities

(c) Property access

The bigeest effect will be on the Department's ability to require of the contractor a minimum working time schedule and administer same without excessive difficulties. Interference will be more critical where large bonuses or damages are involved which suggests that third party problems should be anticipated and resolved as far in advance as possible.

(4) Multi-shift productivity losses	*One authority we consulted with said that productivity losses for the second shift of a two shift a day highway construction operation may be expected to be 25 percent.*
(5) Owner induced changes	*This has to do with correcting errors or omissions in the plan or improving the design through field changes and how to mitigate the effect. This problem could in some instances be mitigated by having it clearly understood in the specification that the "ownership" of float time as determined by the Critical Path Method would belong to the state. The state should not honor any claim from a contractor with respect to working time due to state-caused delays unless such delays can be shown to affect the critical path. The necessity for making changes that may affect the critical path should be considered carefully before being executed.*
(6) Compatibility of design with traffic control plan	*Overall this appeared to be satisfactory. In our review notes we picked up a few details that may conflict.*
(7) Completeness of plans	*The plans appeared to be of satisfactory quality and complete. Our exceptions are contained in our technical memorandums showing the results of our review.*
(8) Responsibility for maintenance of facilities under traffic	*Our recommendation is to make this the contractor's responsibility and reimburse him for same.*
(9) Need for special Force Accounts to take care of unpredictable events	*Recommend establishing special Force Account funds to handle urgent construction needs such as that associated with property access or safety needs and for which appropriate bid items are not predictable.*
(10) Site drainage	*We saw no problems as the drainage is straightforward. The only drainage dependency we noted was between Segment I and Segment II. Segment II provides the outfall for part of the Segment I drainage system. This should not be critical if there is any reasonable amount of cooperation between the respective contractors.*
(11) Operation of traffic signals	*It is our understanding that the Department and the City of Houston are working on an agreement whereby the state will reimburse the City for operating and maintaining all the traffic signals affected by and that affect the construction and traffic operations along Segments I, II, and III.*

M. Consultation with Attorney General regarding legal aspects, reducing potential for future litigation

We briefed Mr. Grady Click, assistant Attorney General, respecting the subject projects and related legal matters. Mr. Click suggested several additions to the specification which he thought would reduce the potential claims by contractors or make the resolution of such claims more expedient. Suggested were additions to the specifications to

(1) require the use of Administration Contested Case Procedure as cited in Title 43 of Texas Register;

(2) specify limits of Department's personnel commit ment where related to administering contractors work; and

(3) require escrowing of bid documents. Mr. Click also urges Department to operate and maintain a microcomputer system to record progress of work and all other events relevant to construction opera tions. Refer to our TM dated April 26, 1988.

N. Sensitivity of letting dates to provide "window" during which construction operations can be scheduled so as to not interfere with the frontage road traffic during the Christmas holiday shopping season

It is recommended that, during the Christmas season, the contractor be prohibited from doing any construction work in or adjacent to the intersections of all (9) streets crossing and interchanging with the Southwest Freeway within the limits of the subject contracts. It is expected that the operations of the intersections will have a greater effect on accessibility to the shopping areas than work parallel to the frontage roads. The timing of the lettings did not appear to be very sensitive in that the variety and volume of work in each segment is such that a contractor should be able to schedule critical work, other than that affecting access to the shopping areas, around a holiday "window" regardless of the letting date and without unduly delaying the overall time to complete each segment.

O. Can the segments be let in the order of III, I, and then II

Refer to Item C, preceding, "Sequencing of Letting Dates."

P. Consideration for bonus/incentive contacts provided that there is a reasonable limit to daily and weekly working time conceded to the contractor such that the Department can provide adequate personnel to administer each contract

Refer to Item K, preceding, "Use of Bonus/Penalties." and to Item J, "Effectiveness of Liquidated Damages." In addition it should be made clear in the specifications that the Department's commitment of resources and to timely responses with respect to materials testing and approval, inspection, field layout, measurement of quantities, and general construction administration is limited and that the contractor's permitted work schedule will have to take into account these limitations. It will also have to be spelled out under what conditions the state will permit a claim due to the Department's late-performance in administering the contract.

Q. In depth consideration as to the frequency of driveways and street intersections and the effect this may have on the duration of construction

Perhaps the most critical construction activity with respect to early completion, meeting schedules, accommodating of third parties and abutting property, sensitivity to adverse weather, and the effect on congestion will be the reconstruction of the frontage roads, particularly during Phase I, Step 2. It is recommended that special consideration be given to: (1) means of speeding up construction as: suggested in Item Q, preceding; (2) making and updating a complete inventory of driveways; (3) identifying the various abutting property owners and tenants and negotiating for their cooperation and minimum access needs during construction; and (4) preparing detail plans for handling access and intersection traffic with the objective providing the contractor with as much working room as possible.

R. Anticipation of particular construction problems and/or delays which could be a consequence of lack of quality in plan preparation

During discussions about working time and the effect thereon of field changes it was suggested that a review of the adequacy of past construction plans prepared by the same consulting firms responsible for the preparation of the plans for Segments I, II, and III might suggest a way to avoid future repetition of errors or omissions found in the past plans. The consequences of the adequacy of construction plans on thirteen projects were investigated. These project plans were prepared by the five consultants responsible for plans for Segments I, II, and III. Adequacy was judged by the number of and causes for field changes executed during construction operations on the thirteen projects investigated. A summary of the findings was conveyed by our TM of April 27, 1988. The total number (53) of field changes for thirteen projects did not appear to be unusual or to warrant the prediction that history would repeat itself. The most likely type of error or omission of any significance which precipitated field changes was associated with utility adjustments. However, there was insufficient time to trace back the origins and causes of this type of field change and consequently it would be difficult to predict whether or not to expect utility adjustment problems due to plan errors in the Segments I, II, and III construction plans.

7. LISTING OF TECHNICAL MEMORANDA PREVIOUSLY SUBMITTED

A. "Meeting with selected contractors to discuss the proposed construction contracts (Segments I, II, and III) providing for improvements along U.S. 59 (Southwest Freeway) between Beltway 8 and I.H.-610 (West Loop)," by Bill Ward, April 15, 1988.

B. "Notes on review of plans for improvements on Segments I, II, and III of U.S. 59 (Southwest Freeway)," by John B. Mounce, April 21, 1988.

C. "Qualitative determination of benefits and costs to SDHPT (owner) and highway users due to proposed improvements along U.S. 59 (Southwest Freeway)," by Bill Ward, April 25, 1988.

D. "Suggested measures to be taken to enhance prevention of claims and defensibility of specifications, "by Bill Ward, April 26, 1988.

E. "Subjective groupings of environmental items and the intensity of inspection demands affecting construction bid items related to job completion," by Bill Ward, Jim O'Connor, and Ken Hankins, April 26, 1988.

F. "Study of past field changes as associated with consulting engineering firms and resident engineers," by Bill Ward, Jim O'Connor, and Ken Hankins, April 27, 1988.

G. "Issues for investigation," by Gerald B. Peck, April 27, 1988.

H. "METRO'S schedule, liquidated damages, and the use of a bonus," by Jim O'Connor, April 27, 1988.

I. Histograms for each month in the year of 1978-87 for average rainfall by categories of rainfall, by Jim O'Connor and Bill Ward.

J. Worksheets for comparing various estimates of raindays and workdays for typical year in Houston, by Jim O'Connor.

8. RECOMMENDED ISSUES FOR FURTHER STUDY

A. A microcomputer-based system for recording the progress of work and other information relevant to the defense of claims should be developed.

B. Decreasing the construction time for street intersections and driveways and in general reducing the duration of the "down time" during construction operations contribute to the degradation of traffic operations.

(Continued from inside front cover)

183-8 "The Resilient and Fatigue Characteristics of Asphalt Mixtures Processed by the Dryer-Drum Mixer," by Manuel Rodriguez and Thomas W. Kennedy, December 1976.

183-9 "Fatigue and Repeated-Load Elastic Characteristics of Inservice Portland Cement Concrete," by John A. Crumley and Thomas W. Kennedy, June 1977.

183-10 "Development of a Mixture Design Procedure for Recycled Asphalt Mixtures," by Ignacio Perez, Thomas W. Kennedy, and Adedare S. Adedimila, November 1978.

183-11 "An Evaluation of the Texas Blackbase Mix Design Procedure Using the Indirect Tensile Test," by David B. Peters and Thomas W. Kennedy, March 1979.

183-12 "The Effects of Soil Binder and Moisture on Blackbase Mixtures," by Wei-Chou V. Ping and Thomas W. Kennedy, May 1979.

184-1 "The TEXAS Model for Intersection Traffic—Development," by Clyde E. Lee, Thomas W. Rioux, and Charlie R. Copeland, December 1977.

184-2 "The TEXAS Model for Intersection Traffic — Programmer's Guide," by Clyde E. Lee, Thomas W. Rioux, Vivek S. Savur, and Charlie R. Copeland, December 1977.

184-3 "The TEXAS Model for Intersection Traffic—User's Guide," by Clyde E. Lee, Glenn E. Grayson, Charlie R. Copeland, Jeff W. Miller, Thomas W. Rioux, and Vivek S. Savur, July 1977.

184-4F "Application of the TEXAS Model for Analysis of Intersection Capacity and Evaluation of Traffic Control Warrants," by Clyde E. Lee, Vivek S. Savur, and Glenn E. Grayson, July 1978.

188-1 "Behavior of Stage-Cast Inverted T-Beams with the Precast Flange in Tension," by S. A. A. Wahidi and R. W. Furlong, August 1976.

188-2F "Strength and Behavior of Stage-Cast Inverted T-Beams," by Richard W. Furlong, August 1978.

196-1F "Design of Reinforcement for Notched Ends of Prestressed Concrete Girders," by Gangadharan Menon and Richard W. Furlong, August 1977.

198-1F "Control of Cracking on the Side Faces of Large Reinforced Concrete Beams," by G. C. Frantz and J. E. Breen, September 1978.

209-1F "Fatigue Loading of Cantilever Sign Structures from Truck Wind Gusts," by Bruce M. Creamer, Karl H. Frank, and Richard E. Klingner, April 1979.

212-1F "Design Criteria for Median Turn Lanes," by C. Michael Walton, Thomas W. Horne, and William K. Fung, March 1978.

244-1 "Analysis of Single Piles Under Lateral Loading," by Barry J. Meyer and Lymon C. Reese, December 1979.

245-1F "Texas Traffic Data Acquisition Program," by Han-Jei Lin, Clyde E. Lee, and Randy Machemehl, February 1980.

514-1F "Effects of Temperature Change on Plastic Crash Cushions," by Victor N. Toth and Clyde E. Lee, January 1976.

1053-1F "Social Service Agency Transportation Services: Current Operations and the Potential for the Increased Involvement of the Taxi Industry," by Walter L. Cox and Sandra Rosenbloom, August 1977.

RR 16 "The Prediction of Passenger Riding Comfort from Acceleration Data," by Craig C. Smith, David Y. McGehee, and Anthony J. Healey, March 1976.

RR 35 "Perceived Environmental Utility Under Alternative Transportation Systems: A Framework for Analysis," by Pat Burnett, March 1976.

RR 36 "Monitoring the Effects of the Dallas/Fort Worth Regional Airport — Volume I: Ground Transportation Impacts," by William J. Dunlay, Jr., Lyndon Henry, Thomas G. Caffery, Douglas W. Wiersig, and Waldo A. Zambrano, December 1976.

RR 37 "Monitoring the Effects of the Dallas/Fort Worth Regional Airport — Volume II: Land Use and Travel Behavior," by Pat Burnett, David Chang, Carl Gregory, Arthur Friedman, Jose Montemayor, and Donna Prestwood, July 1976.

RR 38 "The Influence on Rural Communities of Interurban Transportation Systems, Volume II: Transportation and Community Development: A Manual for Small Communities," by C. Michael Walton, John Huddleston, Richard Dodge, Charles Heimsath, Ron Linehan, and John Betak, August 1977.

RR 39 "An Evaluation of Promotional Tactics and Utility Measurement Methods for Public Transportation Systems," by Mark Alpert, Linda Golden, John Betak, James Story, and C. Shane Davies, March 1977.

RR 40 "A Survey of Longitudinal Acceleration Comfort Studies in Ground Transportation Vehicles," by L. L. Hoberock, July 1976.

RR 43 "A Pavement Design and Management System for Forest Service Roads — A Working Model," by Freddy L. Roberts, B. Frank McCullough, Hugh J. Williamson, and William R. Wallin, February 1977.

RR 45 "Characteristics of Local Passenger Transportation Providers in Texas," by Ronald Briggs, January 1977.

RR 46 "The Influence on Rural Communities of Interurban Transportation Systems, Volume I: The Influence on Rural Communities of Interurban Transportation Systems," by C. Michael Walton, Richard Dodge, John Huddleston, John Betak, Ron Linehan, and Charles Heimsath, August 1977.

RR 47 "Effects of Visual Distraction on Reaction Time in a Simulated Traffic Environment," by C. Josh Holahan, March 1977.

RR 48 "Personality Factors in Accident Causation," by Deborah Valentine, Martha Williams, and Robert K. Young, March 1977.

RR 49 "Alcohol and Accidents," by Robert K. Young, Deborah Valentine, and Martha S. Williams, March 1977.

RR 50 "Alcohol Countermeasures," by Gary D. Hales, Martha S. Williams, and Robert K. Young, July 1977.

RR 51 "Drugs and Their Effect on Driving Performance," by Deborah Valentine, Martha S. Williams, and Robert K. Young, May 1977.

RR 52 "Seat Belts: Safety Ignored," by Gary D. Hales, Robert K. Young, and Martha S. Williams, June 1978.

RR 53 "Age-Related Factors in Driving Safety," by Deborah Valentine, Martha Williams, and Robert K. Young, February 1978.

RR 54 "Relationships Between Roadside Signs and Traffic Accidents: A Field Investigation," by Charles J. Holahan, November 1977.

RR 55 "Demographic Variables and Accidents," by Deborah Valentine, Martha Williams, and Robert K. Young, January 1978.

RR 56 "Feasibility of Multidisciplinary Accident Investigation in Texas," by Hal L. Fitzpatrick, Craig C. Smith, and Walter S. Reed, September 1977.

RR 60 "A Pavement Design and Management System for Forest Service Roads — Implementation," by B. Frank McCullough and David R. Luhr, January 1979.

RR 61 "Multidisciplinary Accident Investigation," by Deborah Valentine, Gary D. Hales, Martha S. Williams, and Robert K. Young, October 1978.

RR 62 "Psychological Analysis of Degree of Safety in Traffic Environment Design," by Charles J. Holahan, February 1979.

RR 63 "Automobile Collision Reconstruction: A Literature Survey," by Barry D. Olson and Craig C. Smith, December 1979.

RR 64 "An Evaluation of the Utilization of Psychological Knowledge Concerning Potential Roadside Distractors," by Charles J. Holahan, December 1979.