Report No. FAA-CT-81-13

MATH MODEL STUDY OF GLIDE SLOPE SITES FOR RUNWAY 19L, SAN FRANCISCO INTERNATIONAL AIRPORT, SAN FRANCISCO, CALIFORNIA

John Walls

DATA REPORT

APRIL 1981

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TECHNICAL CENTER
Atlantic City Airport, N.J. 08405

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16. Abstract

Results of a math model study for the runway 19L Instrument Landing System (ILS) glide slope at the San Francisco International Airport, San Francisco, California, are presented. This study was performed at the request of the Western Region to determine the effects on glide slope performance resulting from proposed relocation of the glide slope and proposed construction of an improved dike. Course structure and level run plots for the existing Null Reference System and an alternative Capture Effect System are presented for high and low tidal conditions.

The results presented are the output from the ILS glide slope mathematical model computer program developed by the Transportation Systems Center and run on the Honeywell 66/60 computer at the Federal Aviation Administration Technical Center.

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INTRODUCTION

PURPOSE.

The purpose of this study was to provide computer modeled glide slope performance data for runway 19L at the San Francisco International Airport. The separate and combined effects of proposed relocation of the glide slope site and proposed construction of an elevated dike near the approach end of the runway are presented.

BACKGROUND.

The Null Reference (NR) glide slope currently serving runway 19L at the San Francisco International Airport, San Francisco, California, exceeds threshold crossing height standards. In order to correct this problem, the Western Region plans to relocate the glide slope site 123 feet closer to the runway end. In addition, independent of glide slope relocation, an elevated dike is planned for construction directly beyond the approach end of the runway to prevent San Francisco Bay water from flowing onto the airport.

The Western Region requested computer analysis of the effects of the above proposals, individually and in combination, on glide slope performance when utilizing NR and Capture Effect (CE) Systems. This request was referred to the Federal Aviation Administration (FAA) Technical Center by Airway Facilities Service, Terminal Aids Branch, AAF-420.

DISCUSSION

The FAA Technical Center conducted glide slope computer model studies through application of a mathematical model developed by the Transportation Systems Center (TSC) which was converted for use in the Technical Center's Honeywell 66/60 computer. This modeling technique is described in references 1, 2, and 3. The results presented are considered preliminary since this model has not been validated. Model validation is currently in process.

Figure 1 shows the runway 19L layout and site location with elevation contour lines. The existing dike is shown. The proposed dike, constructed to a height of 13.5 feet above sea level, will be at the same location as the existing dike but extended to provide additional protection to the left and right of the runway end. The terrain profile lines shown were used to determine elevation profiles required for program input. Figures 2 through 5 are plots typical of the terrain data prepared for input to the computer program. Figures 2 and 3 were generated for the existing glide slope location and dike with high and low tidal conditions. Figures 4 and 5 show the terrain data for the proposed site and dike for high and low tidal conditions. Similar profiles were prepared for the remaining combinations of high and low tide with the existing site/proposed dike and proposed site/existing dike. Thus, eight profiles depicting the combinations of site, dike, and tide constituted terrain input for computer study. (Note: There is no provision in the program to distinguish between the signal reflection qualities of the rough surface (piled, broken concrete) of the existing dike and the smooth surface of the proposed dike.)

Two instrument landing antenna systems were modeled with the profiles: the Null Reference and the Capture Effect Systems. The Null Reference System, which is currently installed for the 3.0° glide slope, utilizes antenna heights of 28.65 and 14.25 feet for the upper and lower antennas, respectively. These heights were used in all Null Reference System modeling conducted. Capture Effect modeling was performed

with antenna heights of 14.32, 28.65, and 42.97 feet. Altitude input for all level runs was 1,200 feet. Aircraft velocity for all simulations was 240 feet per second.

DATA PRESENTATION

The computer model results consist of 32 plots which are presented in figures 6A through 13D. These plots are divided into two groups of 16 plots each. The first group consists of course structure plots (figures 6A through 9D) showing course deviation error versus distance from threshold. The second group of plots are level run results (figures 10A through 13D) showing course deviation indication versus elevation angle. Each group of plots is divided into four sets of plots which are categorized according to glide slope and dike combinations (see table 1).

TABLE 1. SITE AND DIKE COMBINATIONS

Course Structure Results

Figure Nos.	Combination
6A-6D	Existing site, existing dike
7A-7D	Proposed site, proposed dike
8A-8D	Existing site, proposed dike
9A-9D	Proposed site, existing dike

Level Run Results

Figures Nos.	Combinations
10A-10D	Existing site, existing dike
11A-11D	Proposed site, proposed dike
12A-12D	Existing site, proposed dike
13A-13D	Proposed site, existing dike

Letter Designators

Letter	Antenna System	Tide
A	Null Reference	high
B	Null Reference	low
C	Capture Effect	high
D	Capture Effect	low

Table 2 is an index for convenient location of desired plots. Table 3 summarizes the actual path angle, path width, and path symmetry data which are presented on individual output plots.

Examination of the data presented indicates that zone 2 performance of both the Null Reference and Capture Effect Systems are well within the tolerances established by FAA Order OA P 8200.1, paragraph 217, for Category I operational systems. The Capture Effect System exhibits fewer course structure aberations and glidepath changes as a result of dike construction or tidal conditions.

TABLE 2. PLOT INDEX

Combination				Course Structure Plot		Level Run Plot	
Site	Dike	Antenna	Tide	Figure No.	Page No.	Figure No.	Page No.
EX	EX	NR	HI	6A	8	10A	16
EX	EX	NR	LO	6B	8	10B	16
EX	EX	CE	HI	6C	9	10C	17
EX	EX	CE	LO	6D	9	10D	17
P	P	NR	HI	7A	10	11A	18
P	P	NR	LO	7B	10	11B	18
P	P	CE	HI	7C	11	11C	19
P	P	CE	LO	7D	11	11D	19
EX	P	NR	HI	8A	12	12A	20
EX	P	NR	LO	8B	12	12B	20
EX	P	CE	HI	8C	13	12C	21
EX	P	CE	LO	8D	13	12D	21
P	EX	NR	HI	9A	14	13A	22
P	EX	NR	LO	9B	14	13B	22
P	EX	CE	HI	9C	15	13C	23
P	EX	CE	LO	9D	15	13D	23

EX - Existing
P - Proposed

TABLE 3. DATA SUMMARY

	Null Reference Ant.		Capture Effect Ant.	
	Tide		Tide	
Existing Site — Existing Dike	High	Low	High	Low
Actual Path Angle	2.96°	2.95°	3.00°	3.01°
Path Width	.72°	.57°	.68°	.67°
Symmetry - 90 Hz	52%	50%	50%	49%
Proposed Site — Proposed Dike				
Actual Path Angle	2.99°	2.96°	3.05°	3.05°
Path Width	.62°	.52°	.62°	.61°
Symmetry - 90 Hz	47%	51%	49%	52%
Existing Site — Proposed Dike				
Actual Path Angle	2.95°	2.92°	3.00°	3.01°
Path Width	.65°	.58°	.68°	.68°
Symmetry - 90 Hz	48%	55%	48%	50%
Proposed Site — Existing Dike				
Actual Path Angle	2.99°	3.01°	3.04°	3.06°
Path Width	.67°	.54°	.61°	.61°
Symmetry - 90 Hz	51%	47%	51%	48%

REFERENCES

1. ILS Glide Slope Performance Prediction, DOT/FAA, Report No. FAA-RD-74-157, 1974.

2. User's Manual for Generalized ILS GLD-ILS Glide Slope Performance Prediction: Multipath Scattering, DOT/FAA, Report No. FAA-RD-76-186, 1976.

3. Computer Study of Tulsa International Airport Runway 17R Glide Slope Sites, DOT/FAA, Report No. FAA-RD-79-27, 1979.

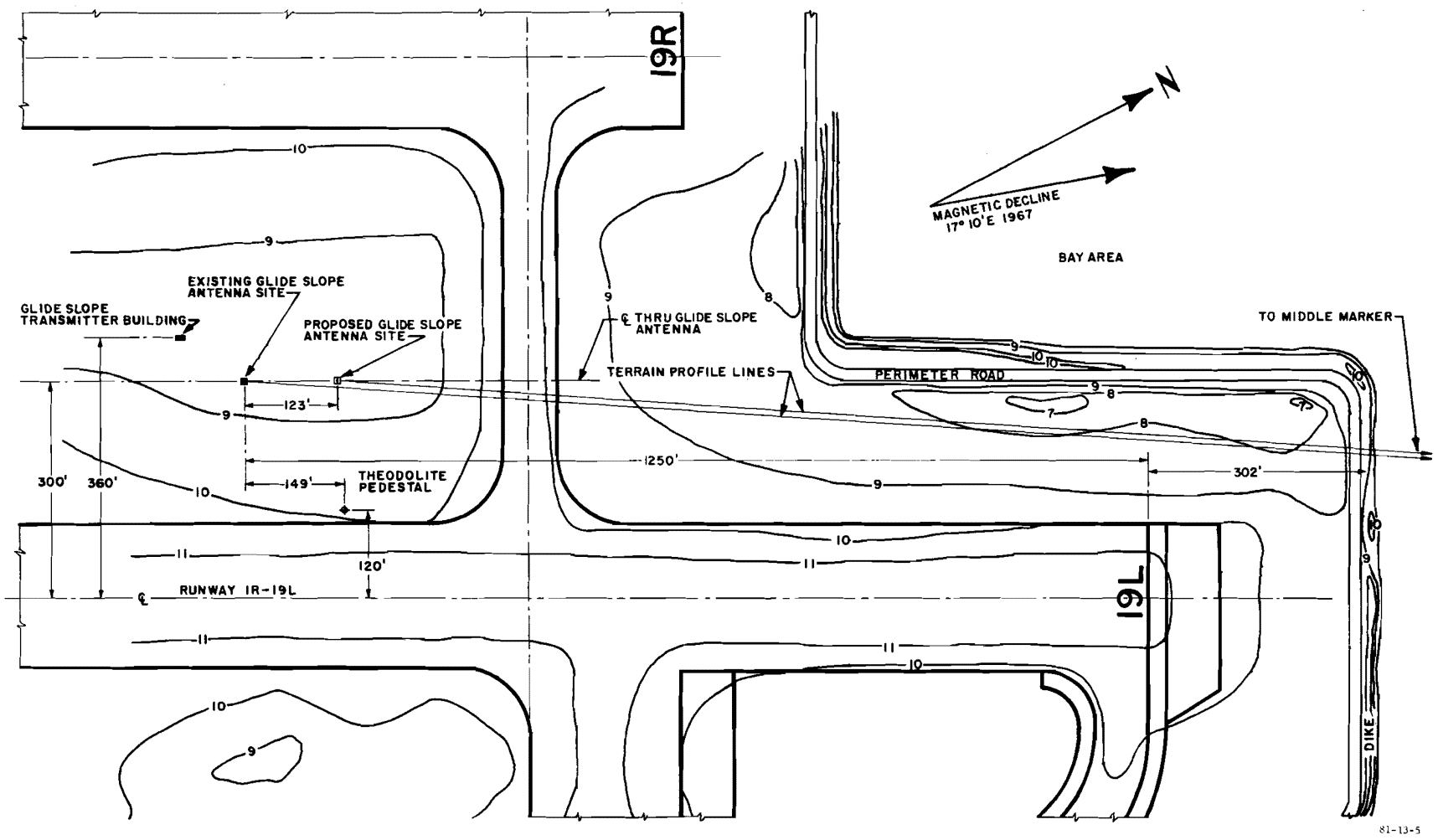


FIGURE 1. RUNWAY 19L LAYOUT/SITE LOCATIONS

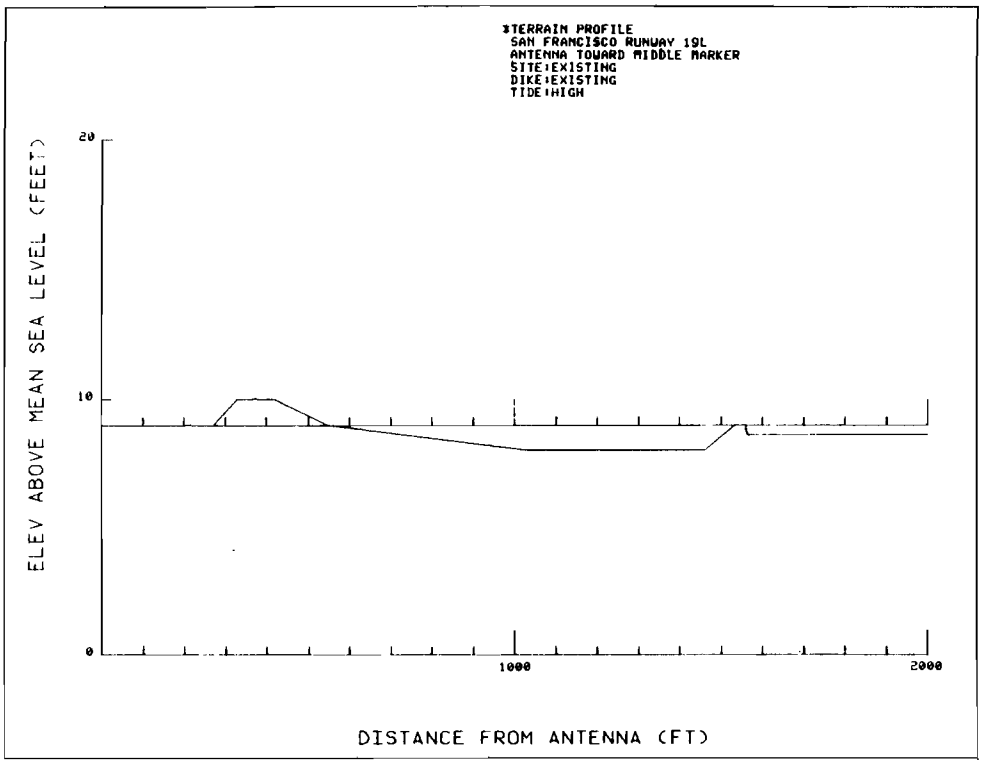


FIGURE 2. TERRAIN PROFILE, EXISTING SITE, EXISTING DIKE, HIGH TIDE

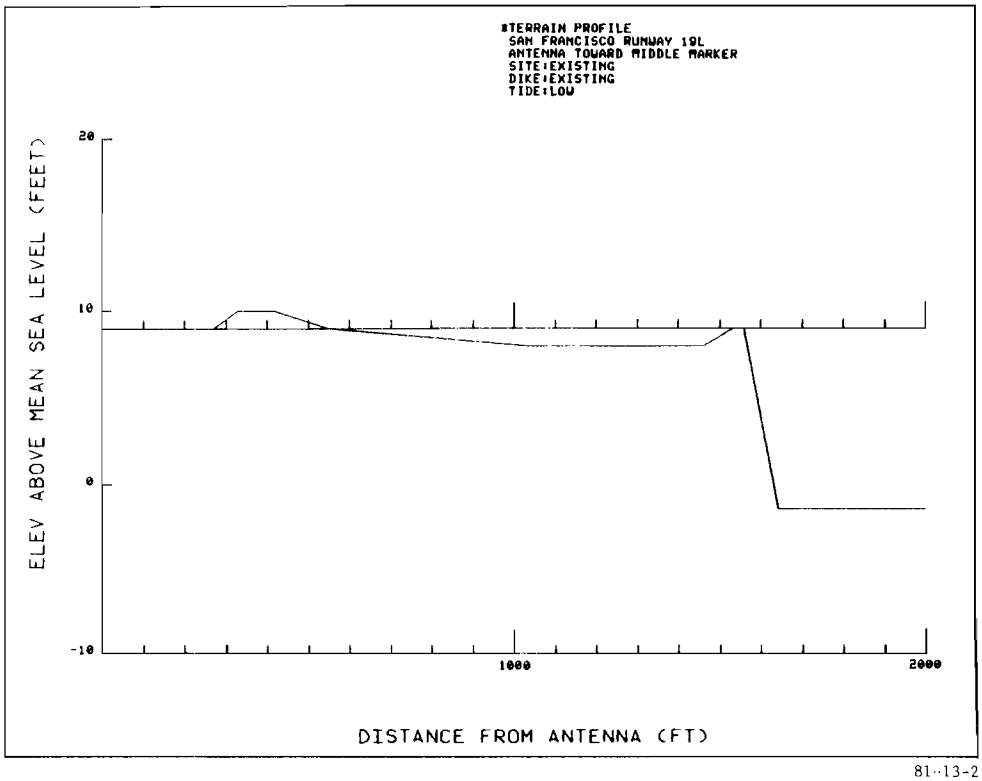


FIGURE 3. TERRAIN PROFILE, EXISTING SITE, EXISTING DIKE, LOW TIDE

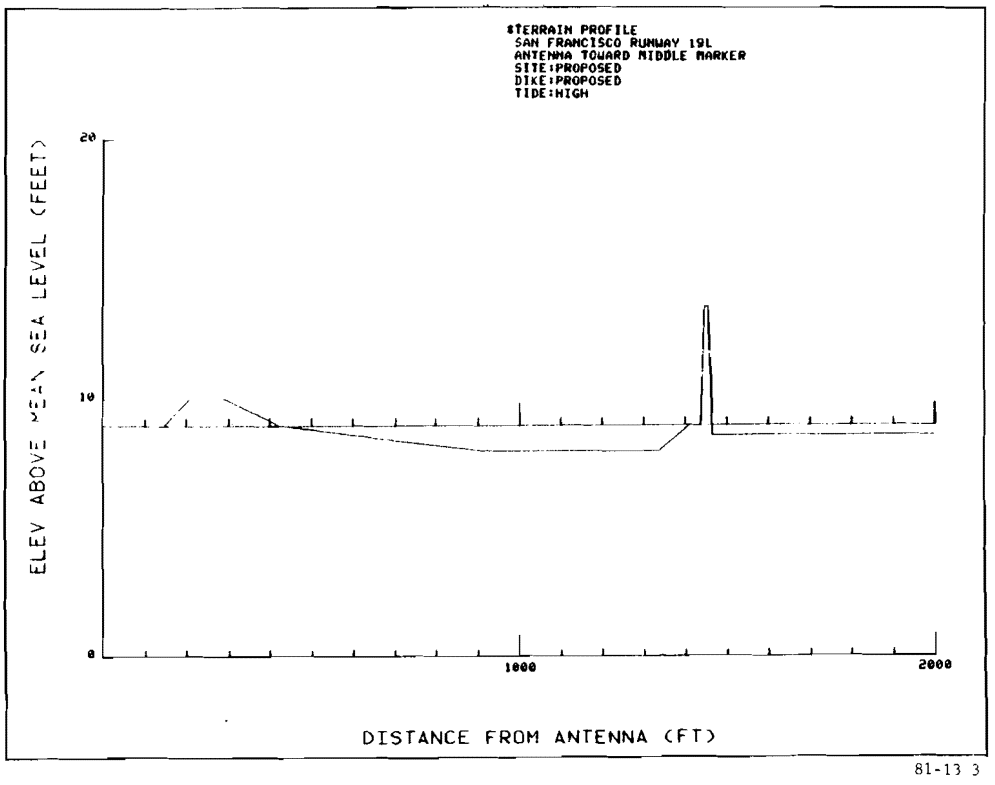


FIGURE 4. TERRAIN PROFILE, PROPOSED SITE, PROPOSED DIKE, HIGH TIDE

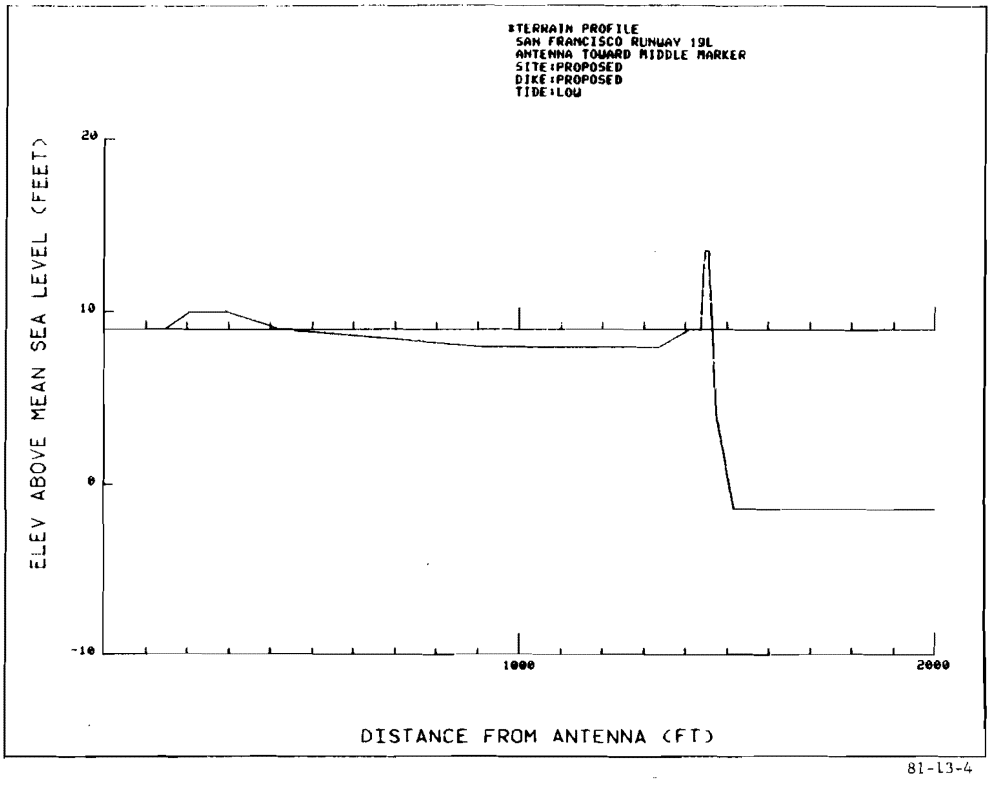
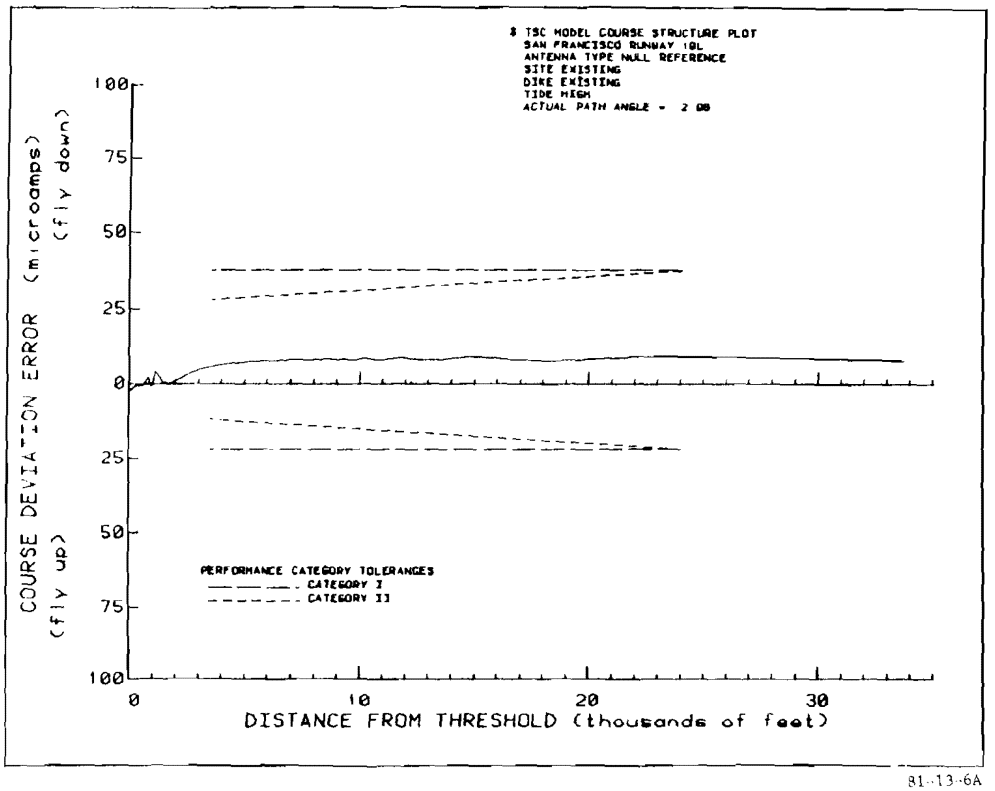
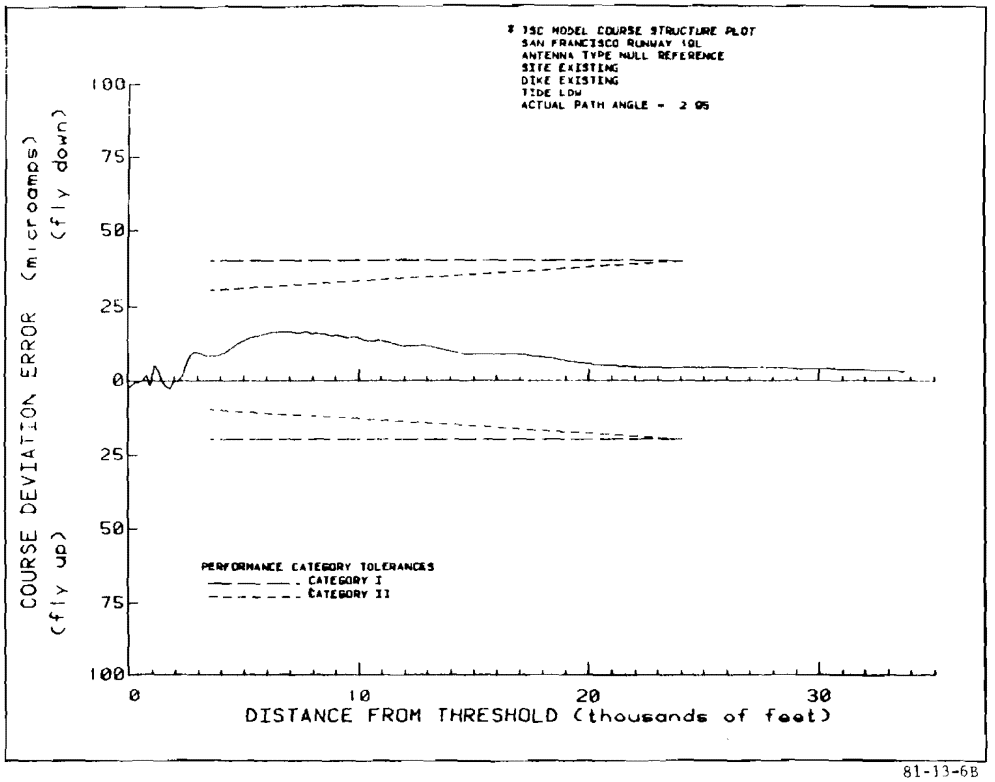


FIGURE 5. TERRAIN PROFILE, PROPOSED SITE, PROPOSED DIKE, LOW TIDE



81-13-6A

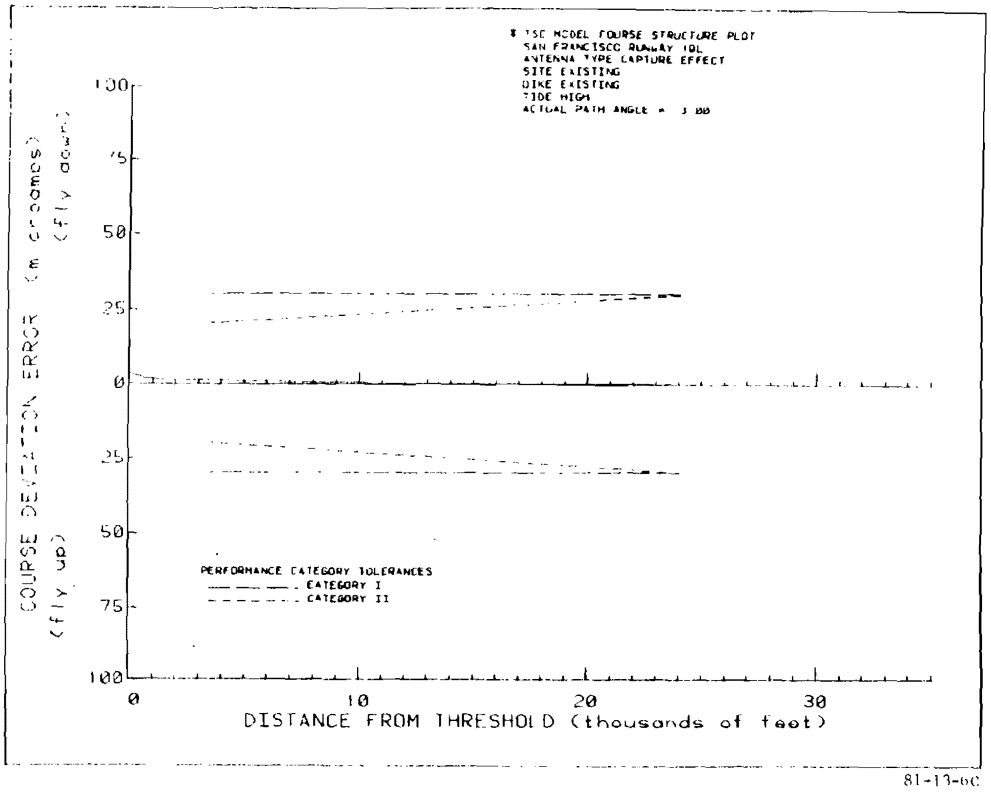
NULL REFERENCE ANTENNA, HIGH TIDE



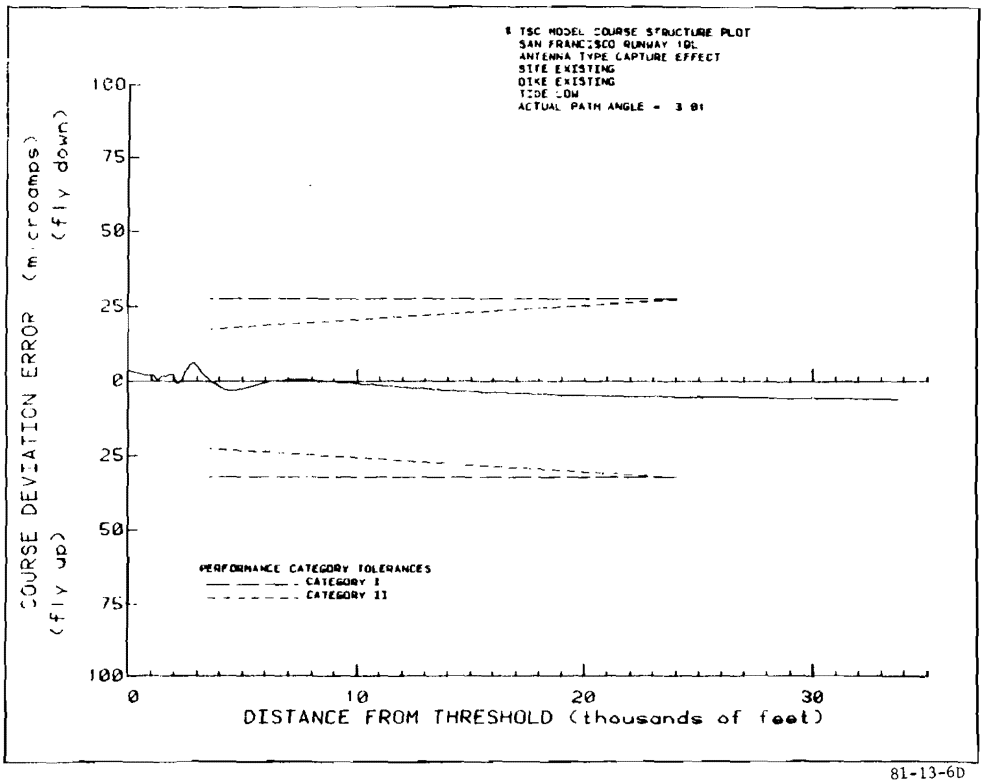
81-13-6B

NULL REFERENCE ANTENNA, LOW TIDE

FIGURE 6. COURSE STRUCTURE PLOT, EXISTING SITE, EXISTING DIKE (Sheet 1 of 2)

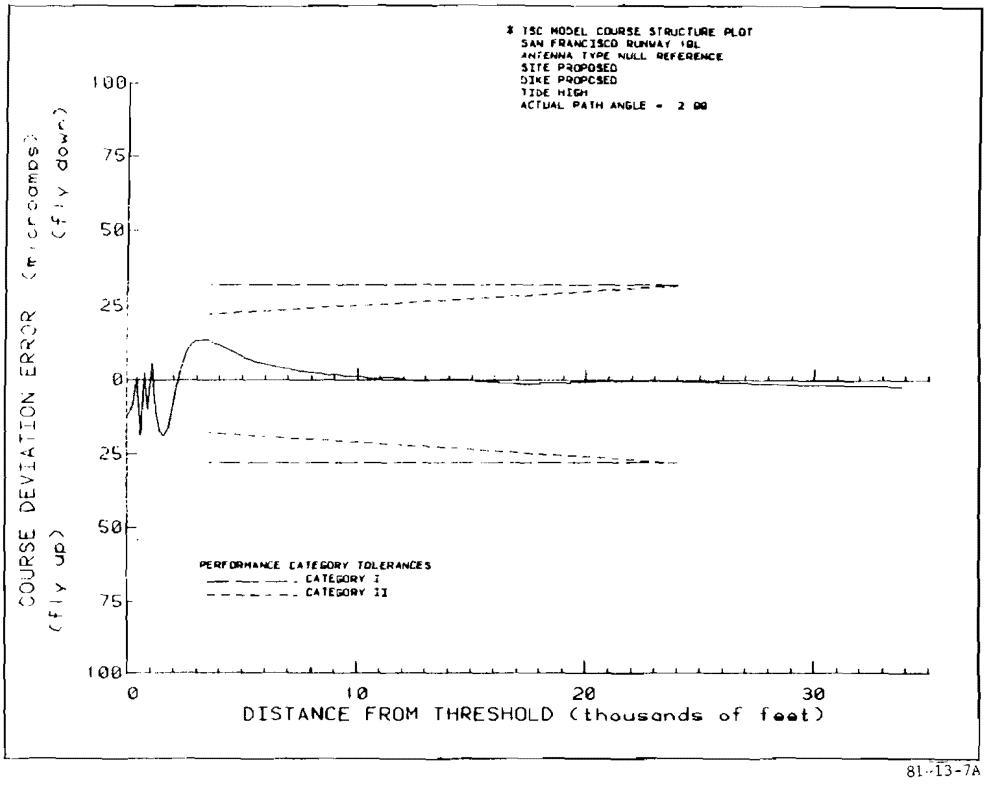


CAPTURE EFFECT ANTENNA, HIGH TIDE



CAPTURE EFFECT ANTENNA, LOW TIDE

FIGURE 6. COURSE STRUCTURE PLOT, EXISTING SITE, EXISTING DIKE (Sheet 2 of 2)



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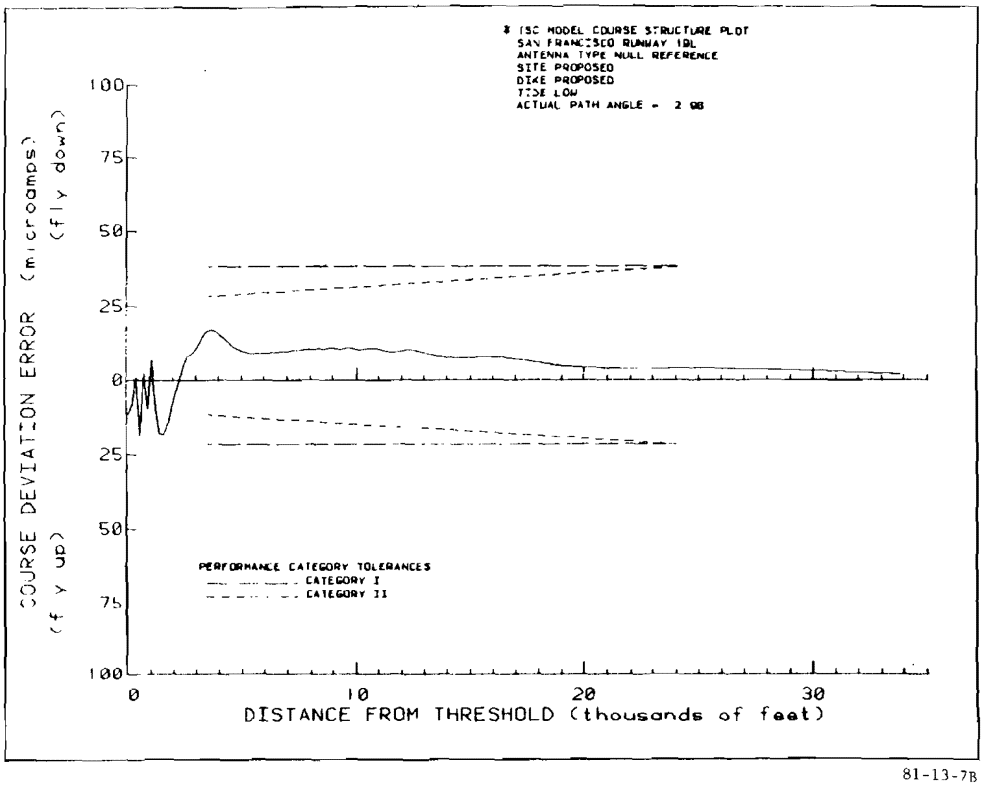
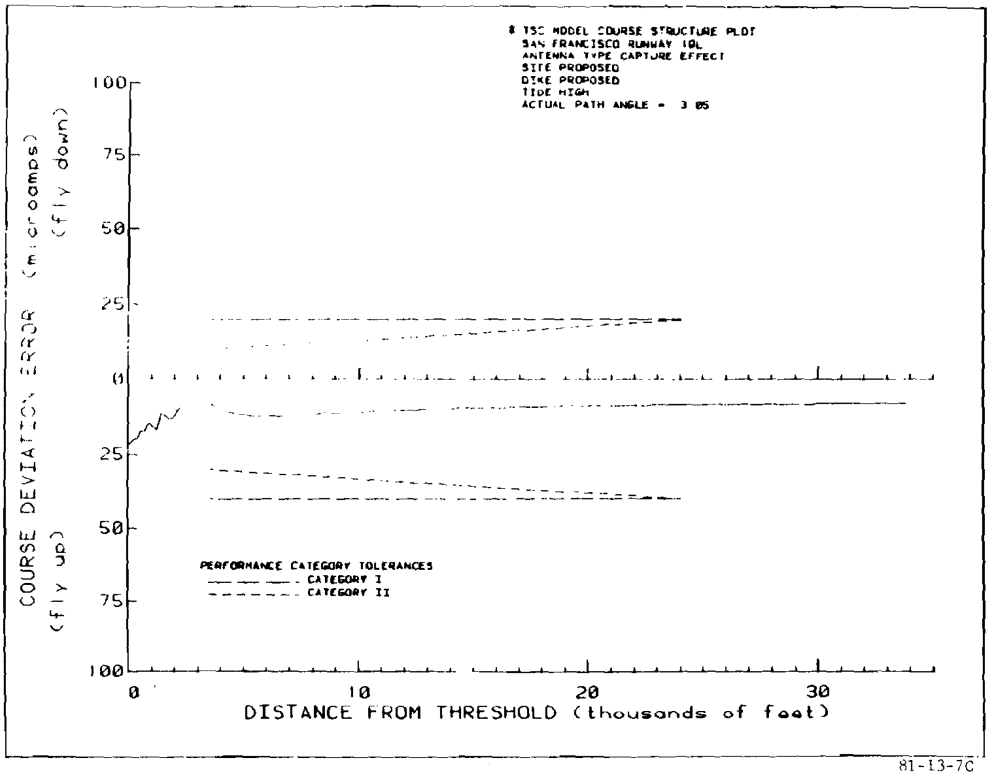


NULL REFERENCE ANTENNA, LOW TIDE

FIGURE 7. COURSE STRUCTURE PLOT, PROPOSED SITE, PROPOSED DIKE (Sheet 1 of 2)



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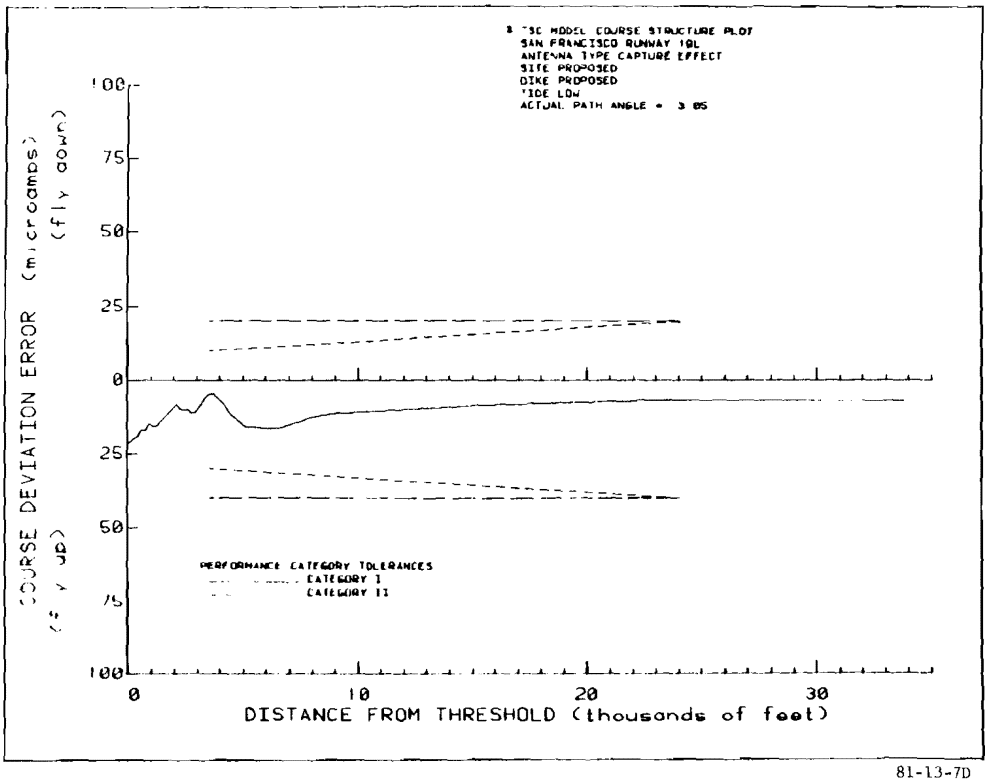
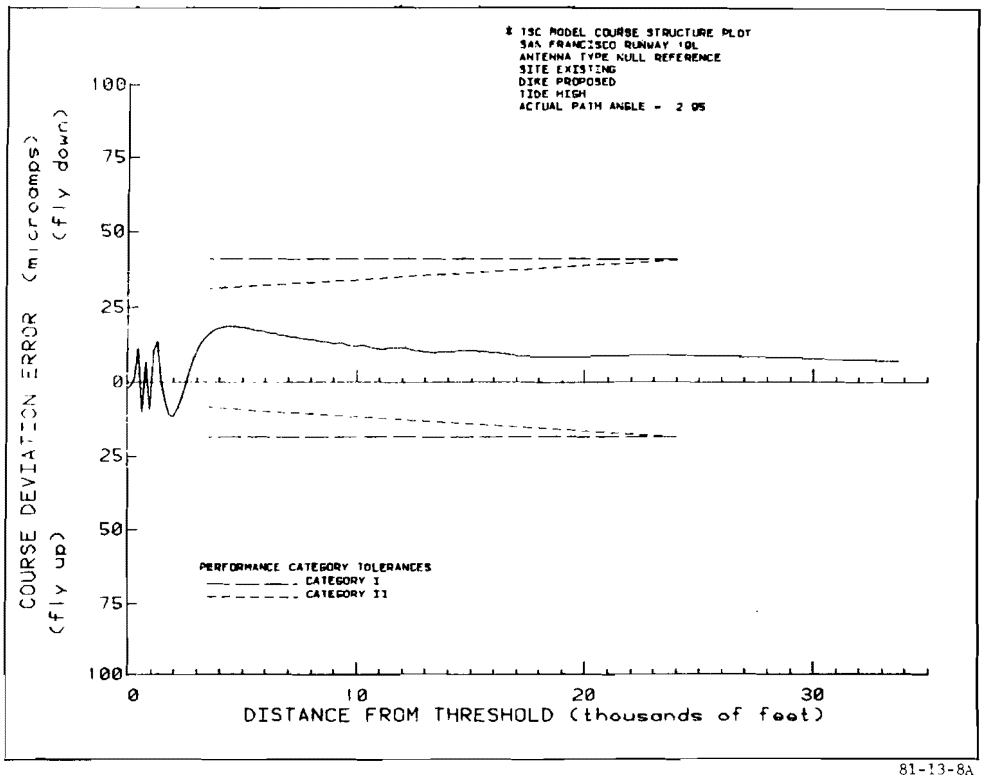


CAPTURE EFFECT ANTENNA, LOW TIDE

FIGURE 7. COURSE STRUCTURE PLOT, PROPOSED SITE, PROPOSED DIKE (Sheet 2 of 2)



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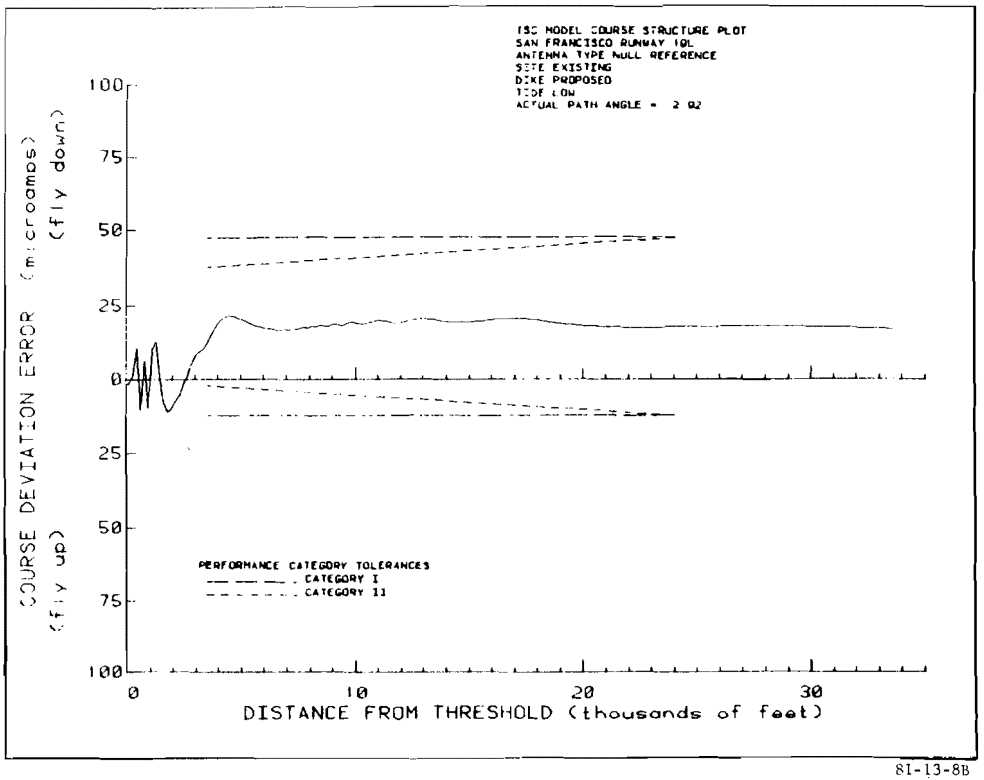
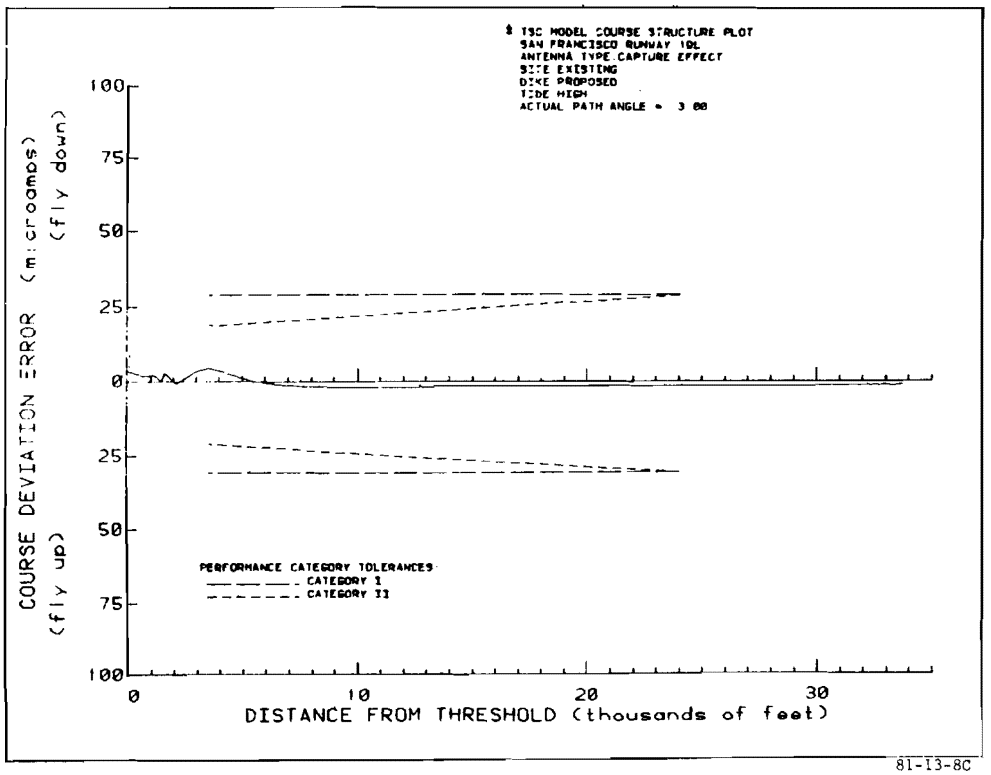


NULL REFERENCE ANTENNA, LOW TIDE

FIGURE 8. COURSE STRUCTURE PLOT, EXISTING SITE, PROPOSED DIKE (Sheet 1 of 2)



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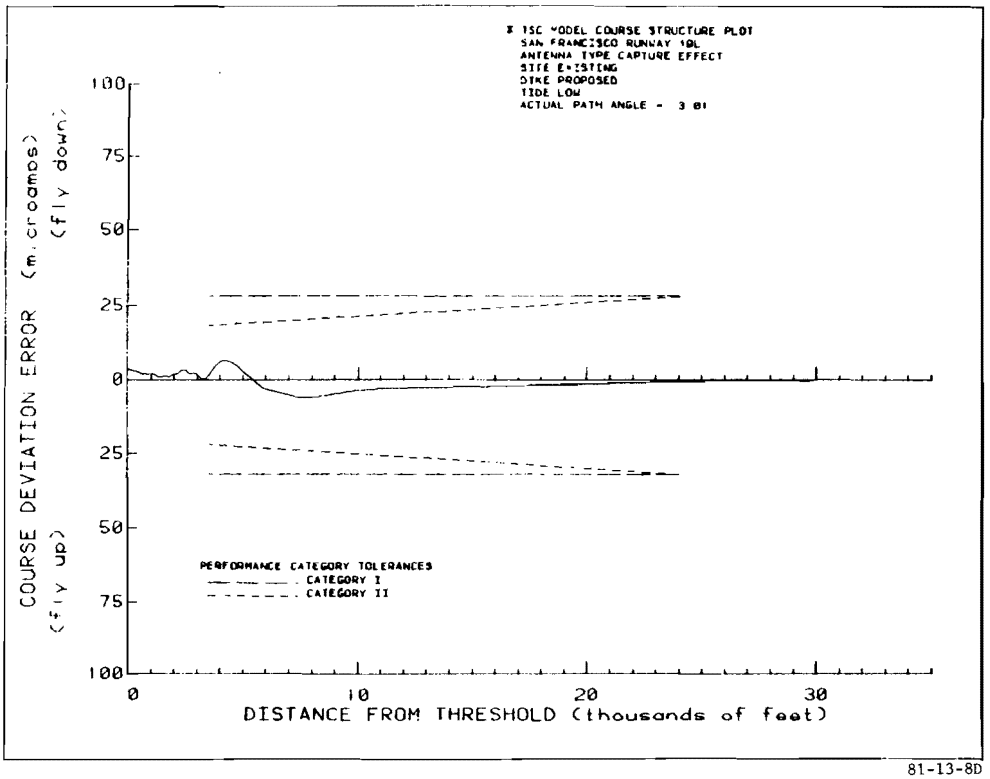
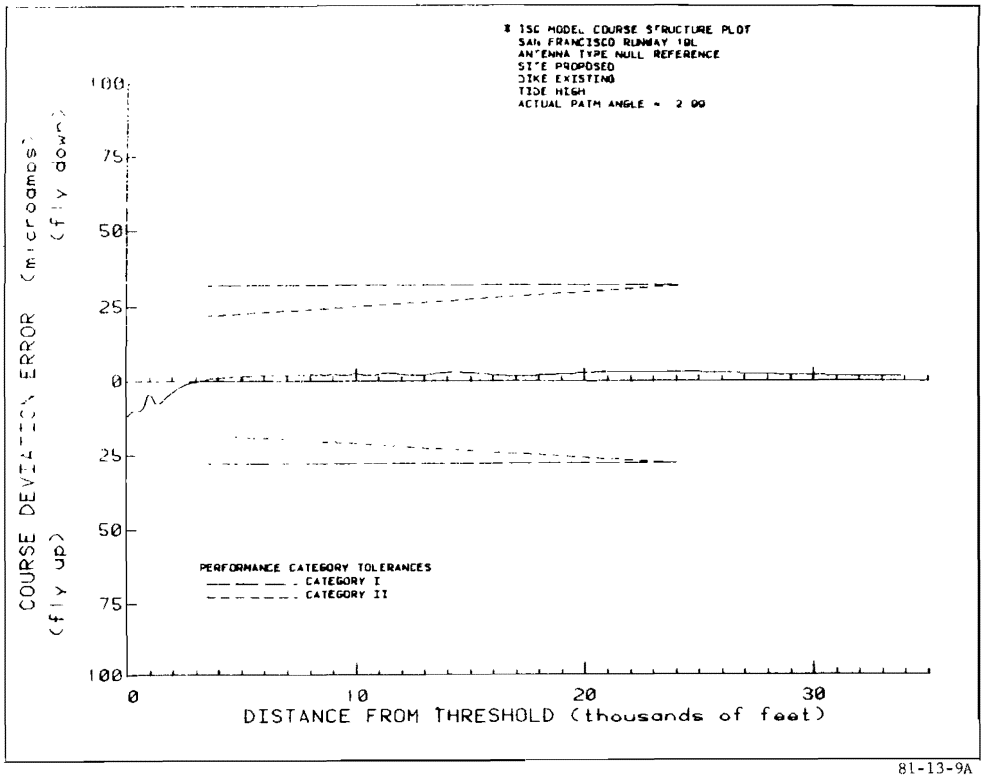


CAPTURE EFFECT ANTENNA, LOW TIDE

FIGURE 8. COURSE STRUCTURE PLOT, EXISTING SITE, PROPOSED DIKE (Sheet 2 of 2)



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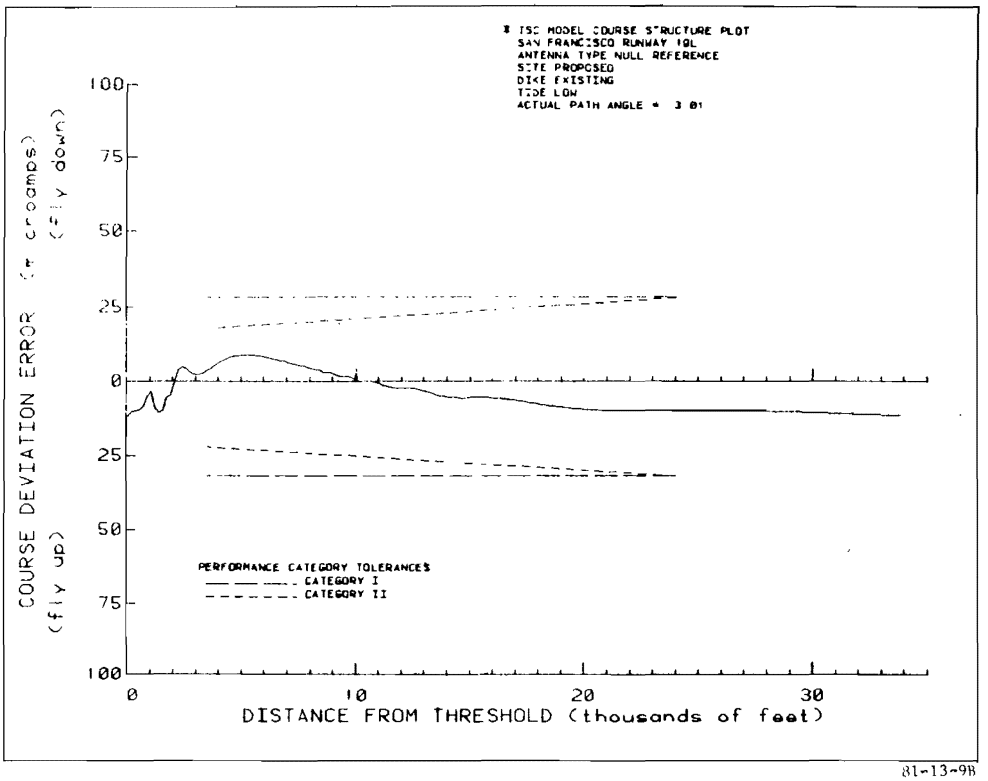
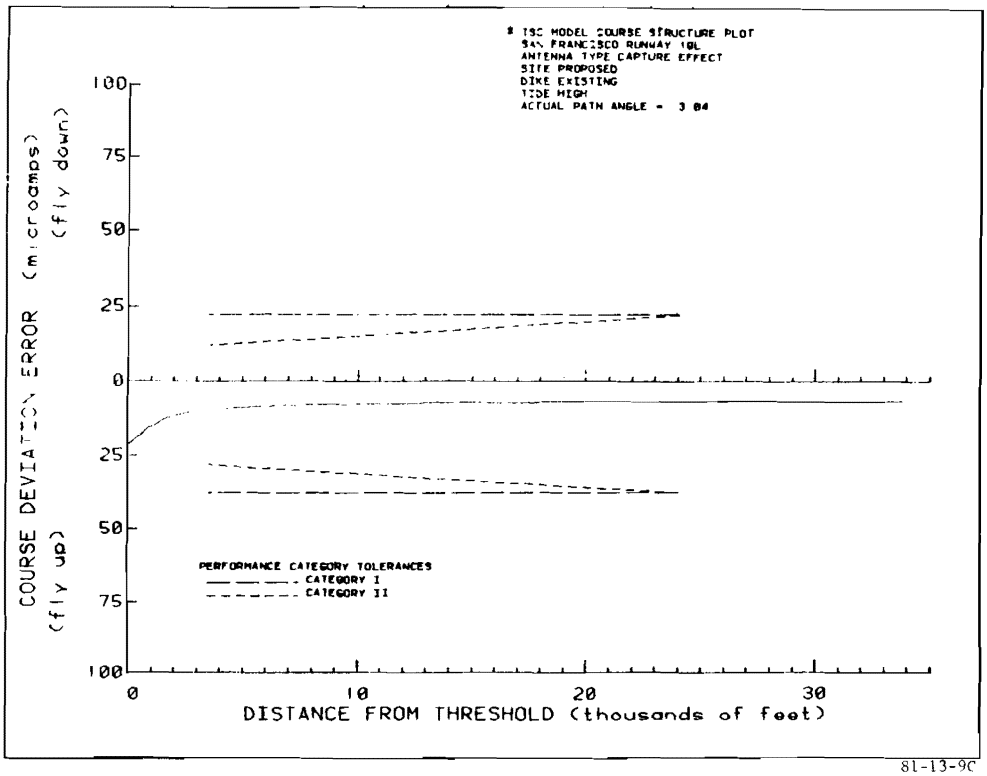


NULL REFERENCE ANTENNA, LOW TIDE

FIGURE 9. COURSE STRUCTURE PLOT, PROPOSED SITE, EXISTING DIKE (Sheet 1 of 2)



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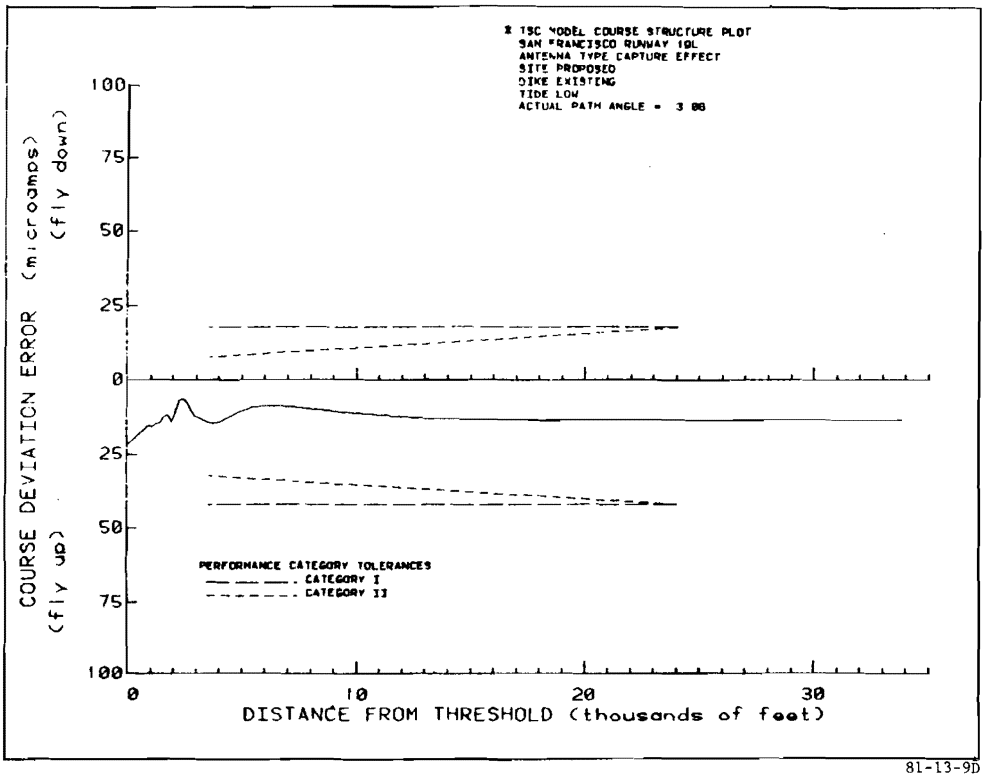
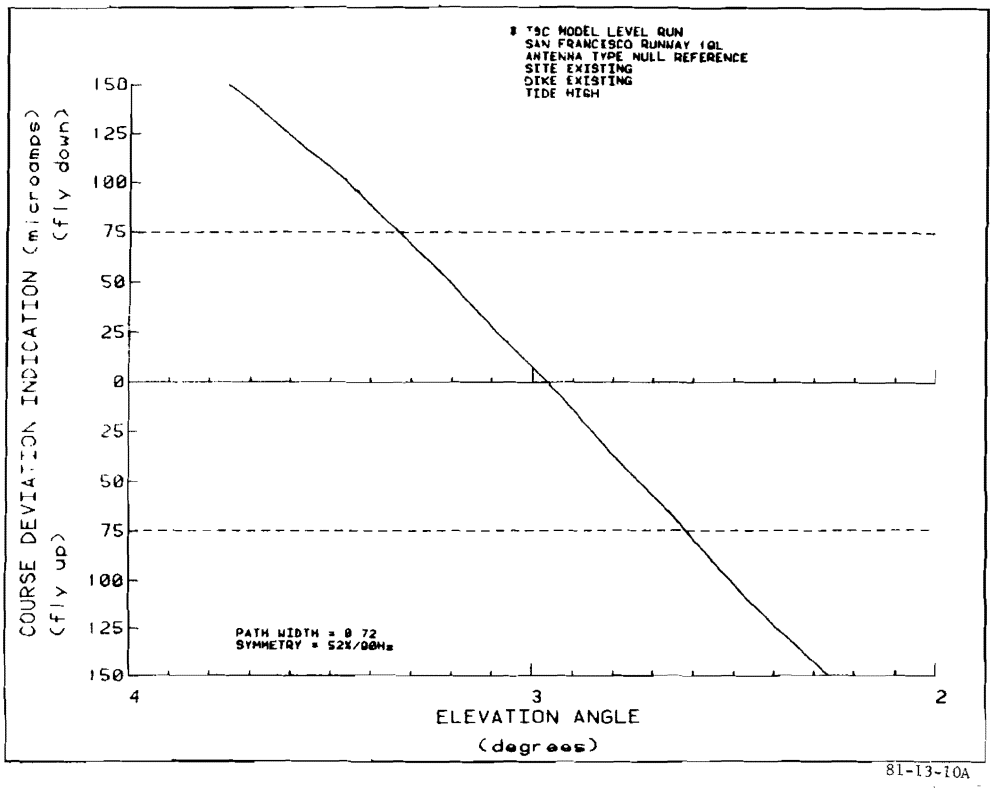


CAPTURE EFFECT ANTENNA, LOW TIDE

FIGURE 9. COURSE STRUCTURE PLOT, PROPOSED SITE, EXISTING DIKE (Sheet 2 of 2)



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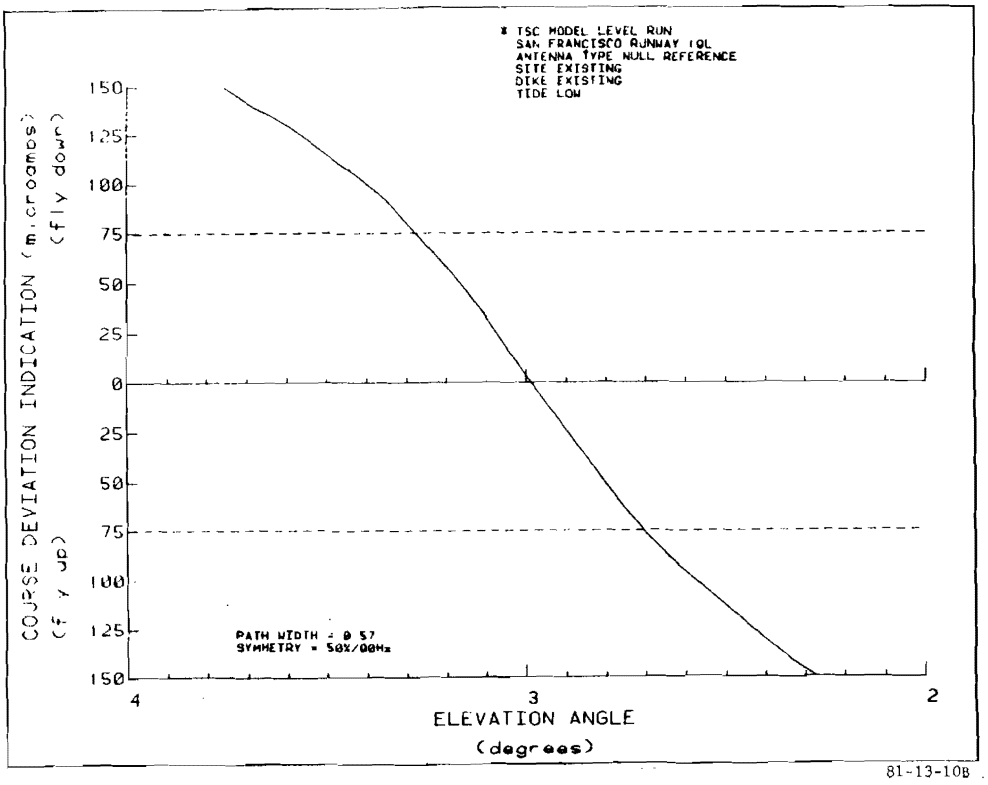
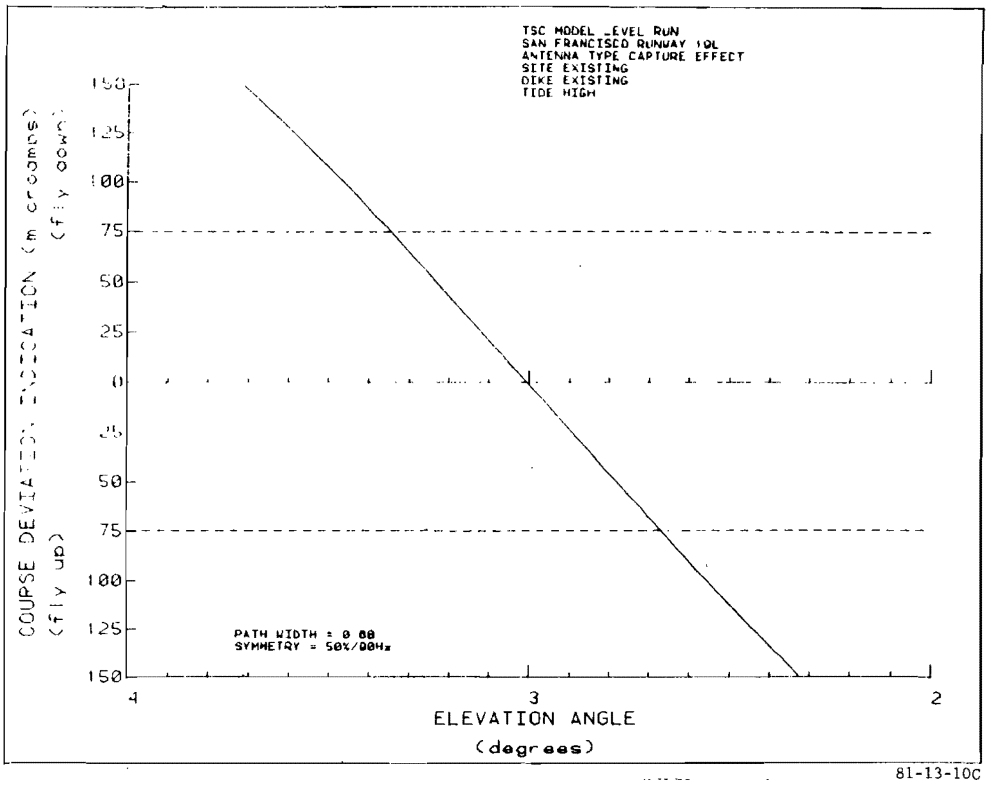
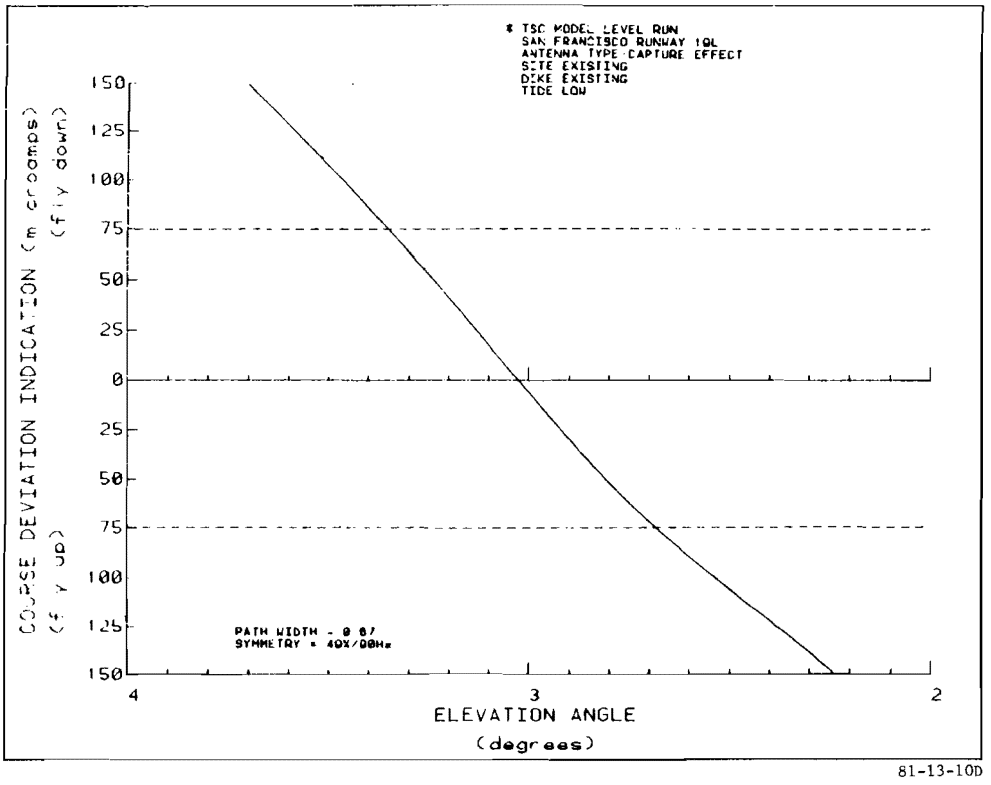


NULL REFERENCE ANTENNA, LOW TIDE

FIGURE 10. LEVEL RUN PLOT, EXISTING SITE, EXISTING DIKE (Sheet 1 of 2)

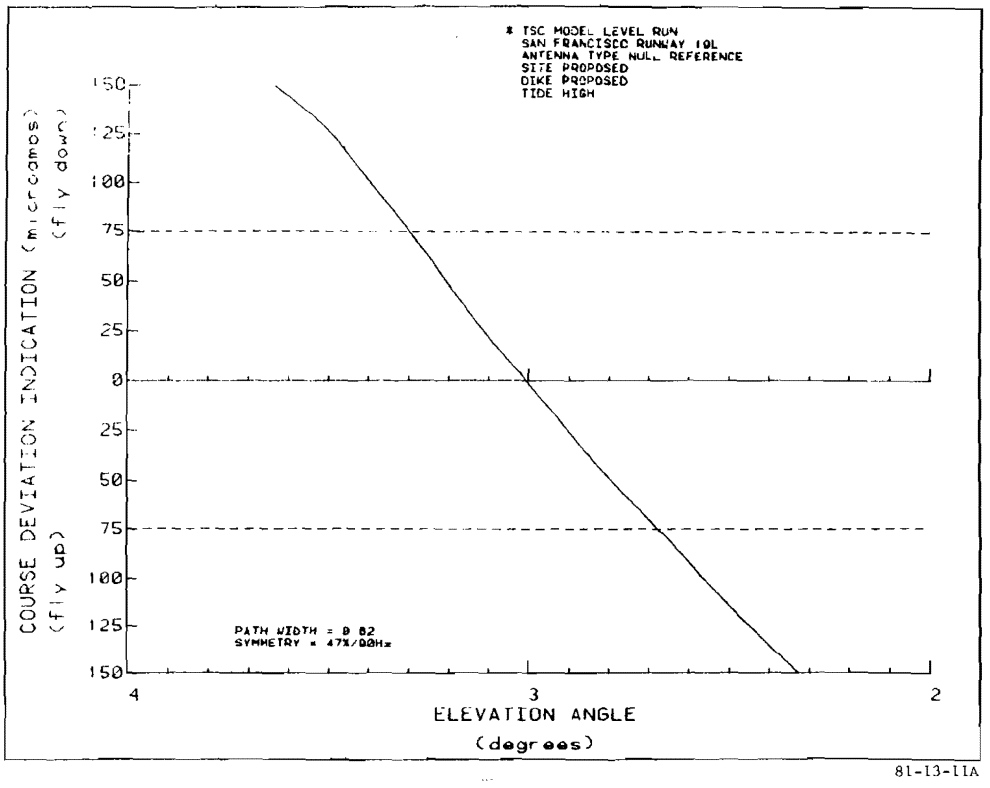


CAPTURE EFFECT ANTENNA, HIGH TIDE



CAPTURE EFFECT ANTENNA, LOW TIDE

FIGURE 10. LEVEL RUN PLOT, EXISTING SITE, EXISTING DIKE (Sheet 2 of 2)



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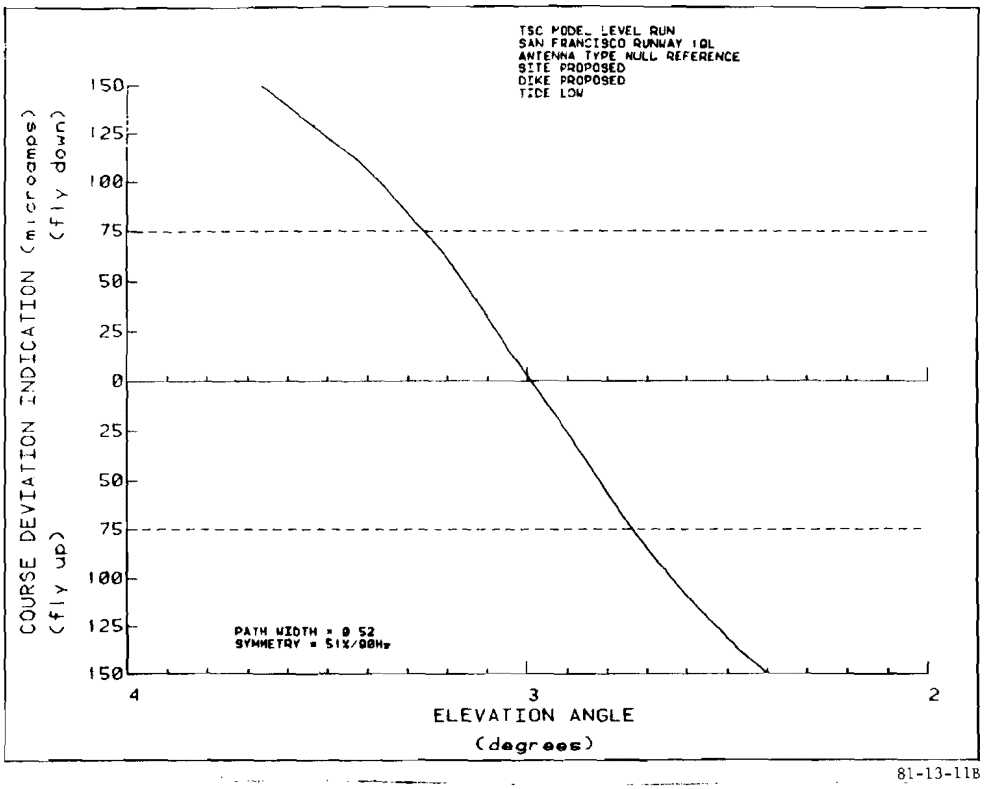
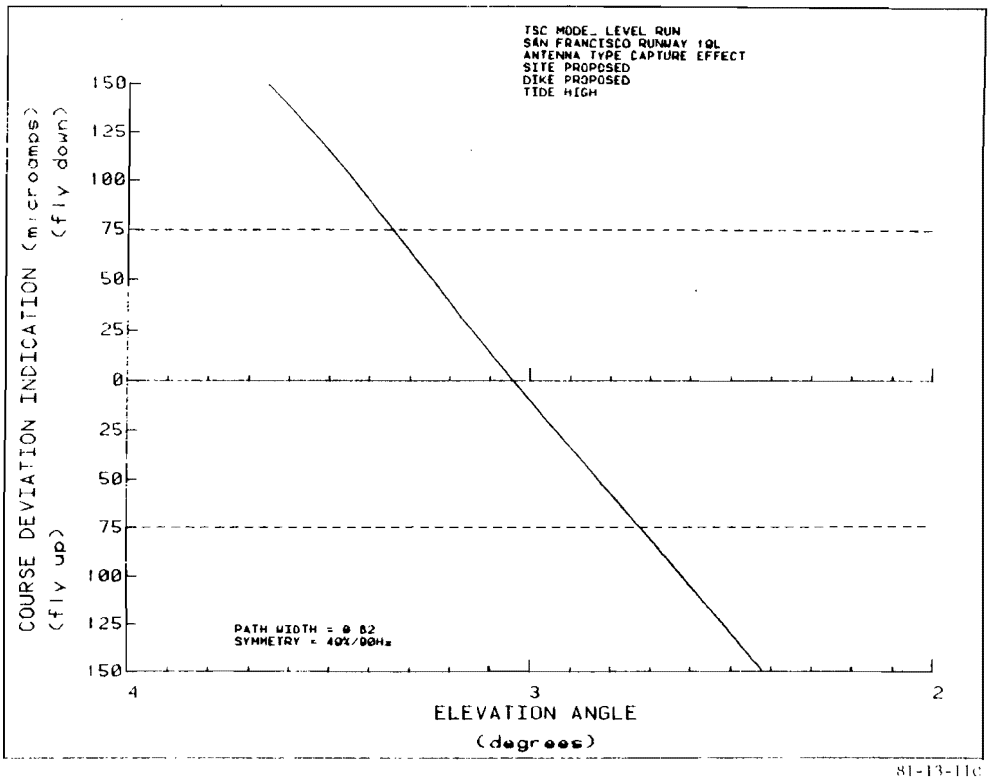
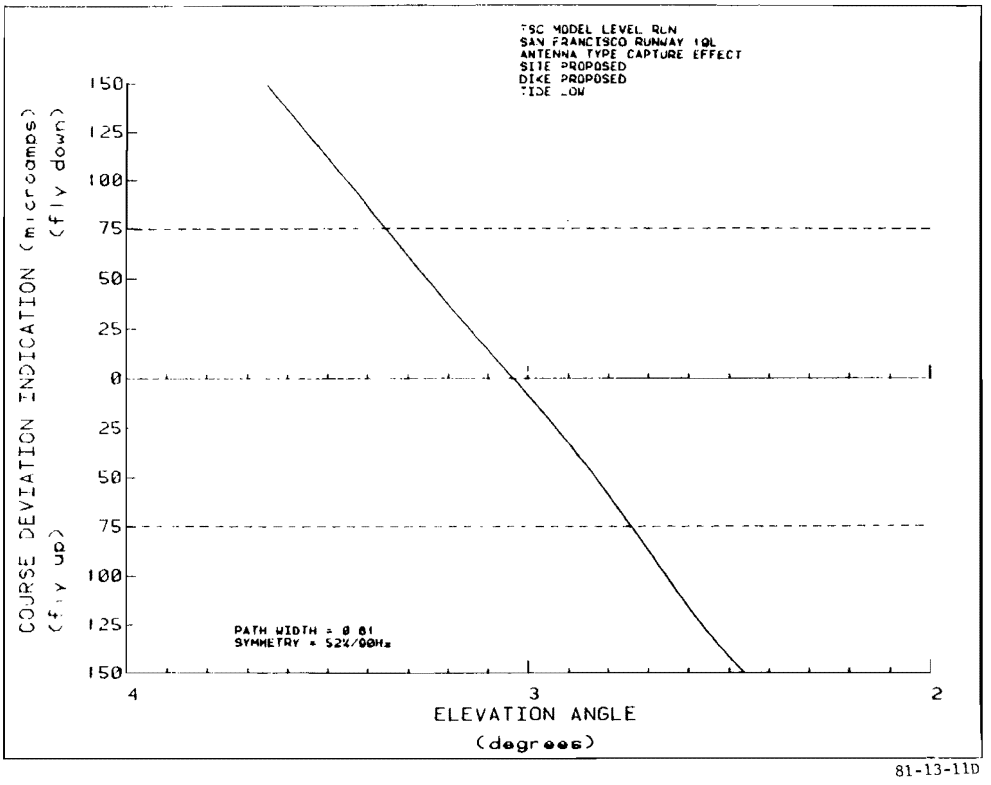


NULL REFERENCE ANTENNA, LOW TIDE

FIGURE 11. LEVEL RUN PLOT, PROPOSED SITE, PROPOSED DIKE (Sheet 1 of 2)

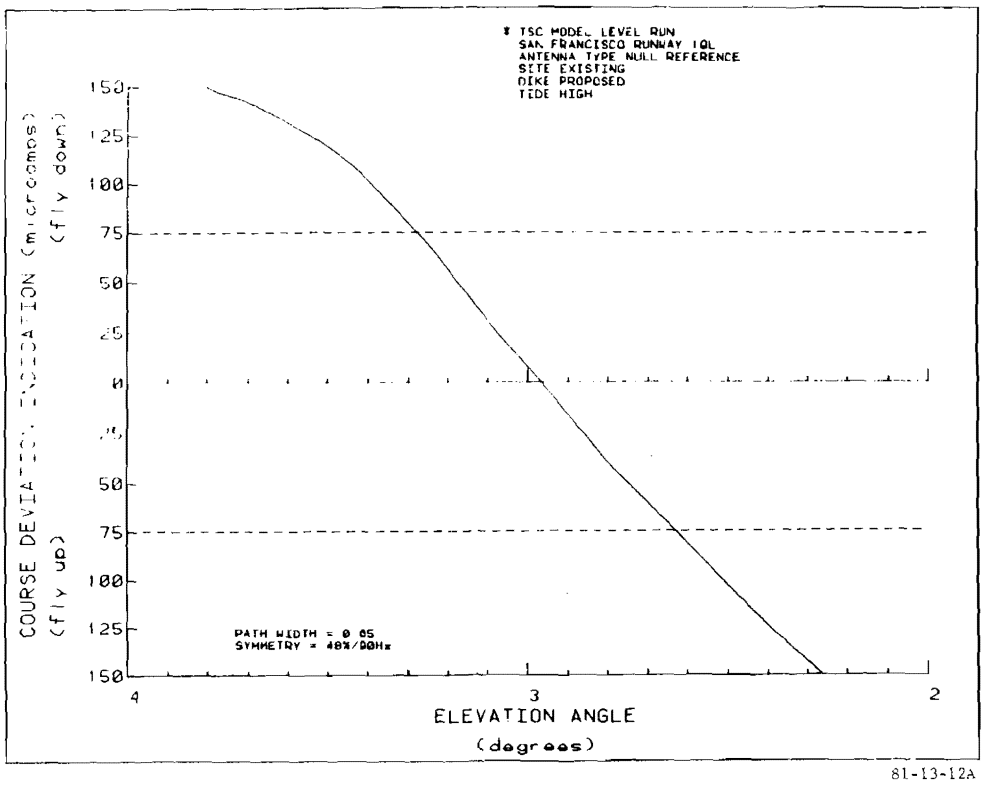


CAPTURE EFFECT ANTENNA, HIGH TIDE



CAPTURE EFFECT ANTENNA, LOW TIDE

FIGURE 11. LEVEL RUN PLOT, PROPOSED SITE, PROPOSED DIKE (Sheet 2 of 2)



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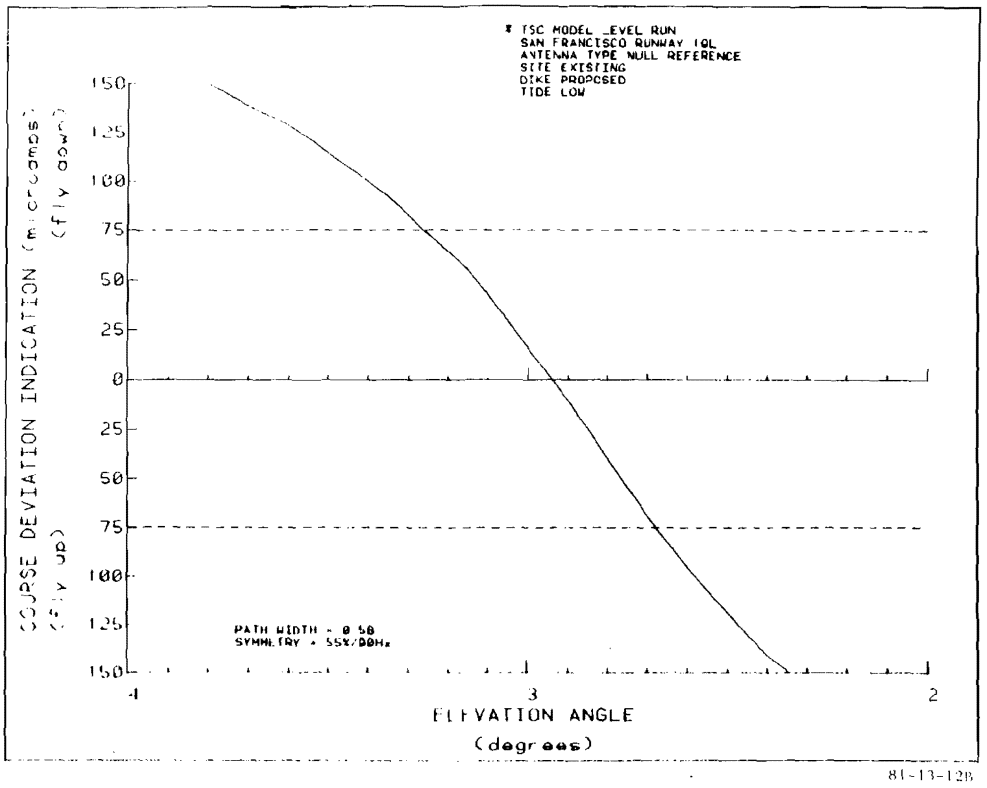
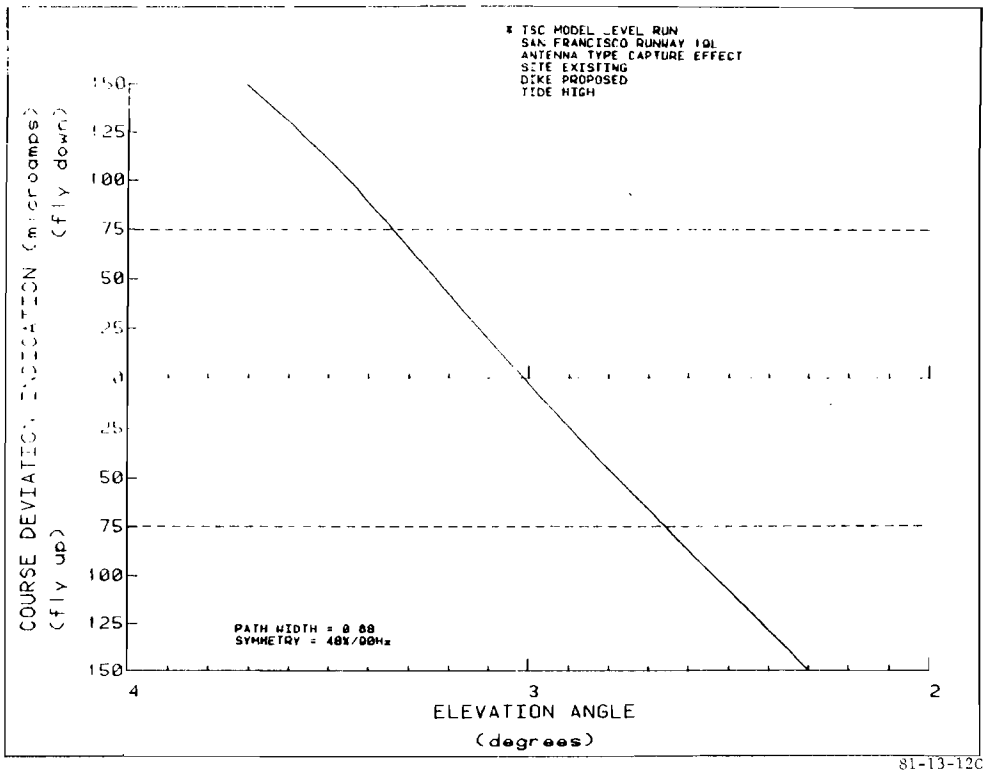
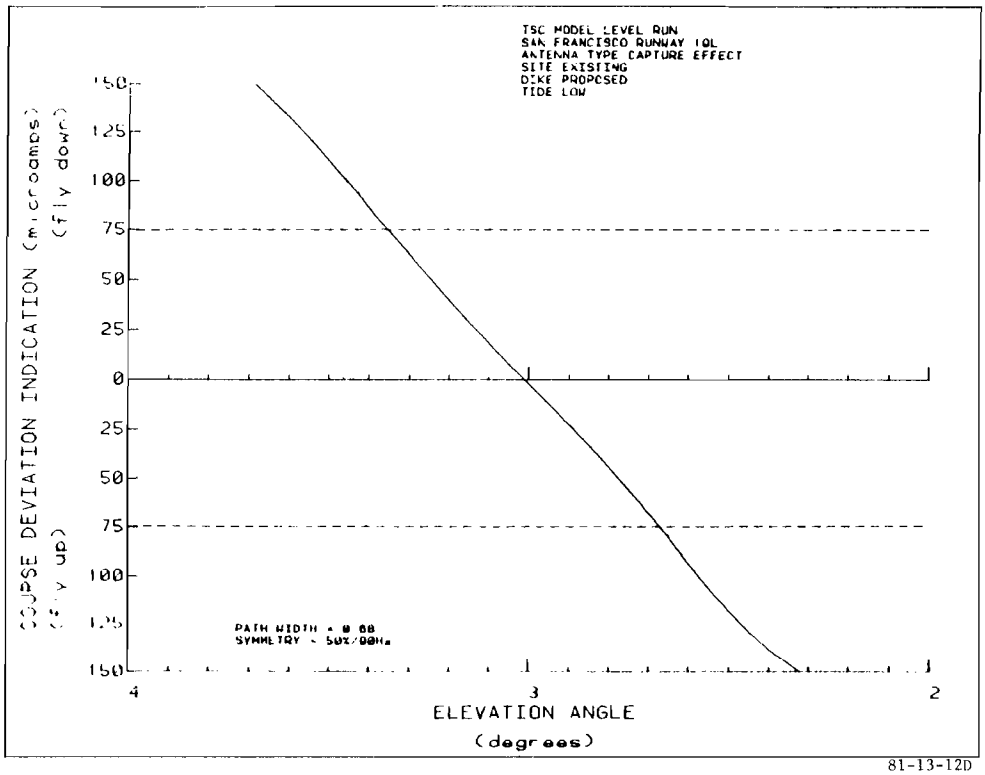


NULL REFERENCE ANTENNA, LOW TIDE

FIGURE 12. LEVEL RUN PLOT, EXISTING SITE, PROPOSED DIKE (Sheet 1 of 2)

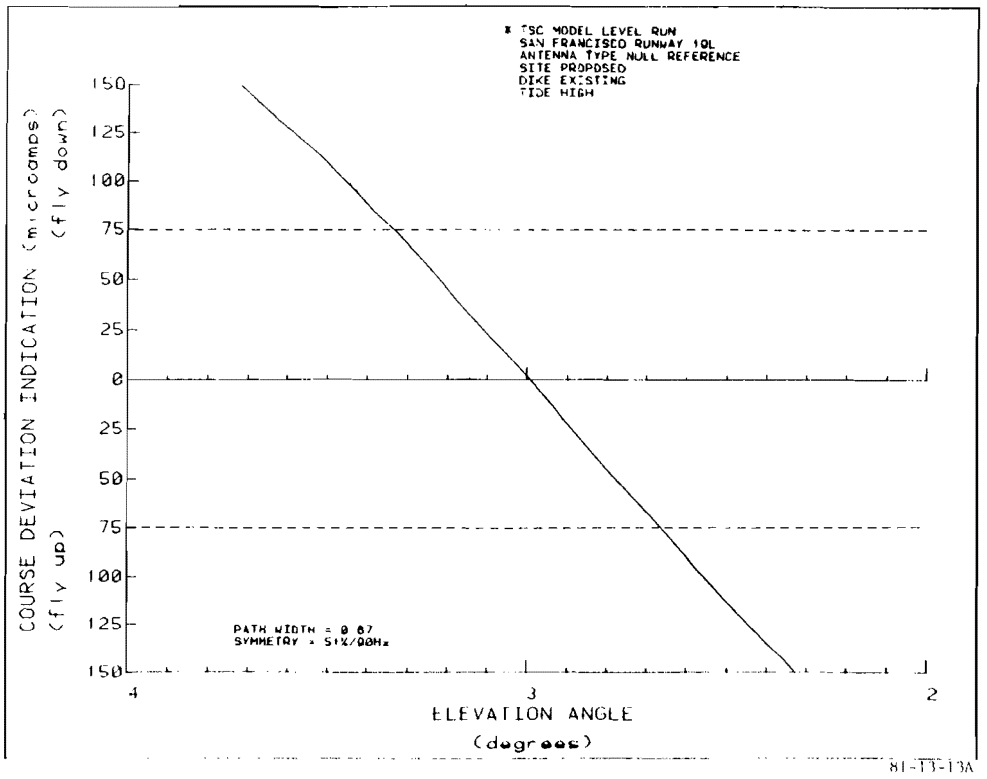


CAPTURE EFFECT ANTENNA, HIGH TIDE

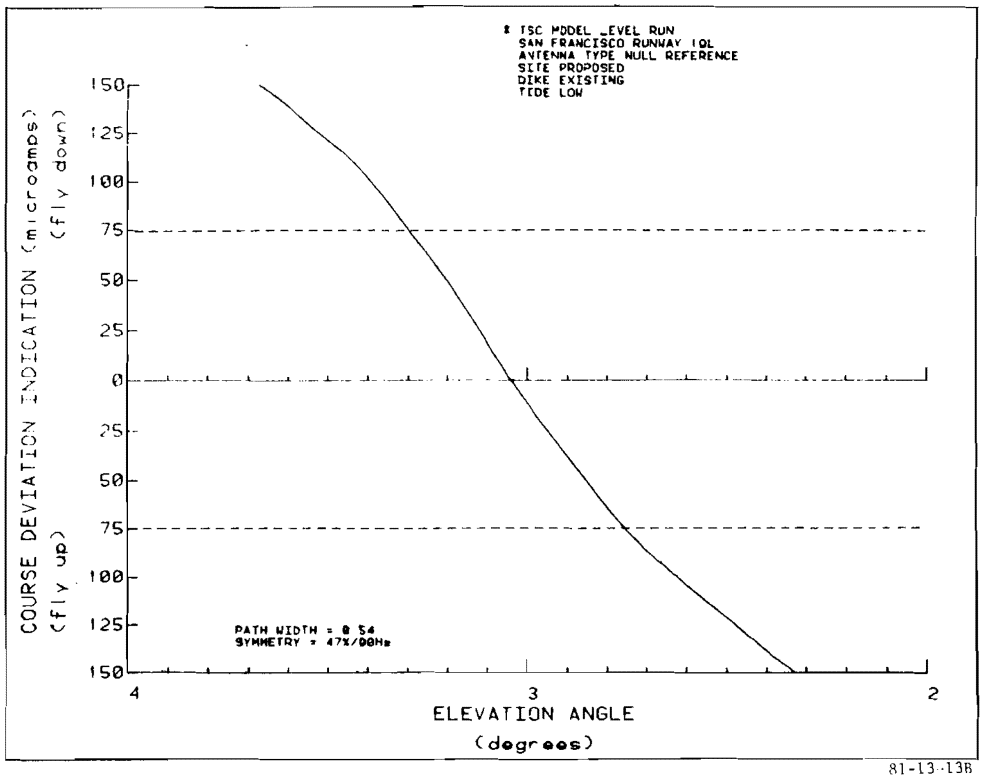


CAPTURE EFFECT ANTENNA, LOW TIDE

FIGURE 12. LEVEL RUN PLOT, EXISTING SITE, PROPOSED DIKE (Sheet 2 of 2)

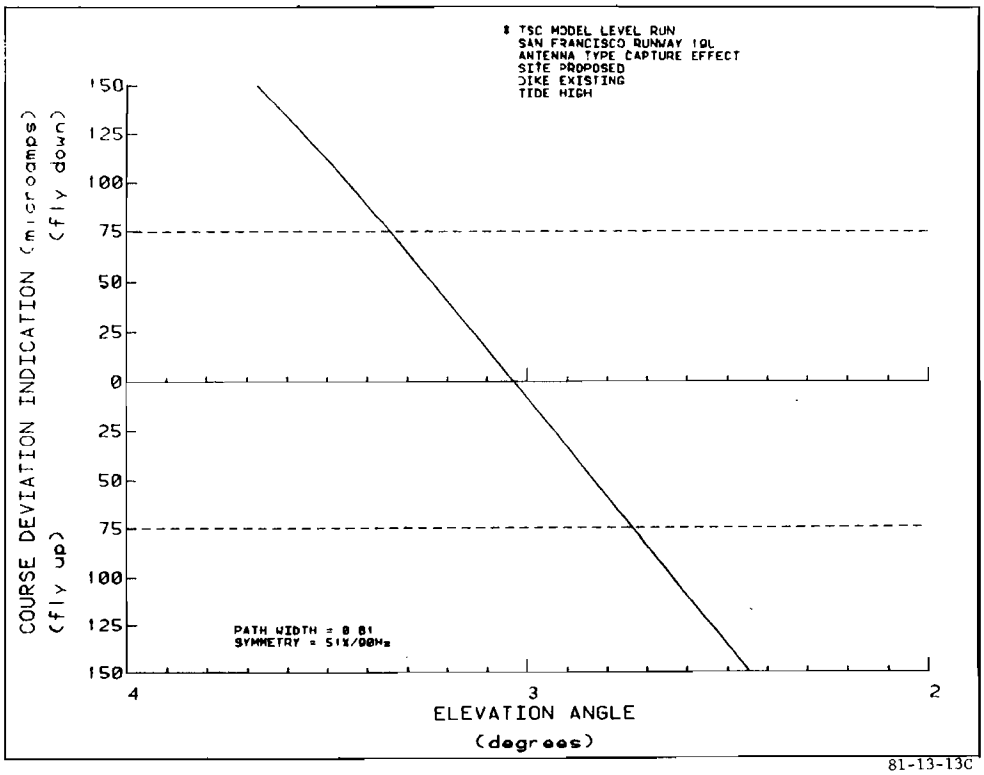


NULL REFERENCE ANTENNA, HIGH TIDE

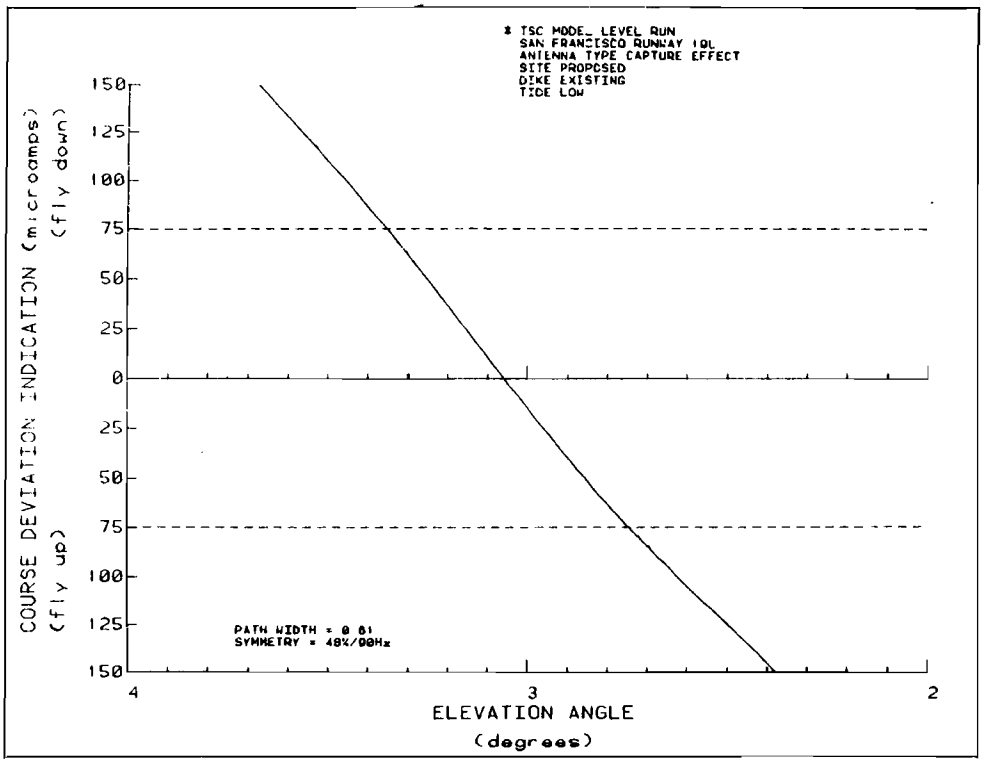


NULL REFERENCE ANTENNA, LOW TIDE

FIGURE 13. LEVEL RUN PLOT, PROPOSED SITE, EXISTING DIKE (Sheet 1 of 2)



CAPTURE EFFECT ANTENNA, HIGH TIDE



CAPTURE EFFECT ANTENNA, LOW TIDE

FIGURE 13. LEVEL RUN PLOT, PROPOSED SITE, EXISTING DIKE (Sheet 2 of 2)