SETTLEMENT MONITORING OF EARTHEN DAMS OPERATED BY THE FCI

Joe Tram - FCD

From: Marilyn DeRosa - FCD
To: Greg Rodzenko - FCD; Joe Tram - FCD
Subject: Land Subsidence Steering Committee
Date: Monday, March 17, 1997 12:15PM

I met with the Steering Committee for Land Subsidence and Earth Fissures last Thursday, including members from ADWR, Arizona Geological Survey (AGS), USGS, CAWCD, ADEQ, and FCD. I gave them a brief report on the Dysart Drain and White Tanks #3 projects, and our ongoing maintenance program involving the collection of periodic elevation data.

I told them we were basing much of our engineering design on subsidence problems slowing as ADWR's plan for groundwater balance by 2025 was implemented, and implored them to strive for full implementation of their so-called "safe yield" plan. In addition, I assured them the elevation data collected from our structures would be tied to an immovable control point (such as bedrock).

The USGS is continuing to do subsidence related studies, but is NOT actively re-mapping the Phoenix valley at the 1:24,000 scale (no funding). The only support AGS can provide is through their information "clearing house" (CLASEFI=Center for Land-Subsidence and Earth-Fissure Information). They collect whatever data is available and provide it to folks who call asking for info. in a certain area. They would like us to share with them any info. we collect regarding subsidence during our maintenance/elevation work. The only thing ADWR can do is slow groundwater overpumping through their rules/regulations (and they are not terribly effective).

So, we're basically on our own.

I'll be writing a letter to ADWR to reiterate our desire to see their "safe yield" plan for 2025 fully implemented. In addition, I'd like to talk to the planners and project managers (via an IPR? Maybe via a P&PM staff meeting?) about ground subsidence, susceptable valley locations, the AGS clearing house, and project planning/design.

Any comments, questions or suggestions? Let me know. Thanks.

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SETTLEMENT MONITORING OF EARTHEN DAMS OPERATED BY THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

DRAFT

Prepared by

Jan M. Staedicke
Civil Engineering Technician III
Flood Control District of Maricopa County

June 1, 1995

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Purpose

The purpose of this report is to:

a) Compile settlement monitoring data that has been acquired to date.

b) Recommend refinements to the monitoring procedure.

c) Recommend a schedule of continued monitoring.

d) Recommend that the settlement monitoring procedure be supplemented with:

    a) earth fissure monitoring procedure

    b) Periodic inspection using a team of specialists (geologist, structural engineer, etc.)

Introduction

Beginning in 1977 survey monuments were installed on the crest and downstream toe of the Flood Control District's (FCD's) earthen dams to monitor the settlement of these structures. It is assumed that changing elevations of monuments at the downstream toe of the structures indicate subsidence, and changing elevations of the crest monuments are the sum of subsidence plus expansion/contraction of the embankment fill. The difference between these two is then the apparent expansion/contraction of the fill material.

Subsidence is the downward movement or sinking of the Earth's surface caused by removal of underlying support (typically the withdrawal of groundwater). The estimated groundwater pumpage in the Salt River Valley basin area peaked in the 1950's. Due to an abundance of rainfall and surface water supply between 1976 and 1982, pumpage was greatly reduced and water levels rose over much of the basin during that time.[1] The Phoenix Active Management Area (AMA) was created by the Groundwater Management Act of 1980. Although groundwater levels have stabilized throughout much of the valley, they continue to decline in the area of Luke Air Force Base, so structures in this vicinity warrant greatest concern (White Tanks and McMicken).

The crest monuments are typically placed about 6" below the crest. Since the distance from the crest to the monument isn't constant, variation from the design crest of less than 1 foot is probably not significant. A more telling number is the settlement between years surveyed. Because groundwater pumping peaked in the 1950's, and our earliest survey data is 1977, we lack data for the most critical time period. Structures which should have the highest priority for continued monitoring are those in which the minimum elevation is more than 1 foot below design crest, or those which show the greatest settlement in the years surveyed.

Data Analysis

Appendix A contains a summary table that lists each structure and shows the maximum settlement between years surveyed, and the difference between the design crest and the minimum crest elevation. The table appears twice, sorted first by greatest settlement, and then by greatest change from the design crest.

Appendix B contains detailed comments regarding each structure.

Appendix C contains the following detailed information for each structure:

1) Data table showing survey elevations, incremental and total settlement

2) Plot of the crest settlement monuments

3) Plot of the change in crest over the years surveyed.

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[1]Arizona Department of Water Resources Hydrologic Map Series Report No. 12 Sheet 1 of 3 Depth to Water and Altitude of the Water Level. Dated 1983

In each data table anomalies have been shaded. These have been checked from the plans, but they should also be checked from the survey notes. In cases where the error is obvious, it has been corrected and noted.

In addition to the data gathered in the settlement surveys, the District is in the process of conducting GPS surveys of each dam, to verify their capacities. The first of these surveys (Buckeye Structures 1,2,&3) has been submitted to the District, and the remaining surveys are to be submitted in late June. yr? This data should be analyzed before prioritizing and conducting future subsidence surveys. Although the GPS surveys don't have the same level of accuracy, and don't include elevations of the settlement monuments, they do include spot elevations on the dams, and provide ties to the benchmarks used in the subsidence surveys. This should help us confirm those locations where enough subsidence has occurred to cause concern and/or warrant increased monitoring.

Groundwater Withdrawal Induced Subsidence fissuring

An earth fissure is a crack at or near the Earth's surface that is caused by subsidence.[2] According to SH&B's study of McMicken Dam "This kind of crack would in all probability lead to very rapid failure of the unrepaired dam in the event of major runoff into the reservoir."[3] SH&B's 1983 study of McMicken Dam states "it is considered highly probable that at least several earth fissures will form through the dam in the next few decades. The central vertical drain concept of repair yields...the only positive defence against subsidence induced fissuring through the dam."[4] It is recommended that we supplement our program of settlement monitoring with a program of monitoring fissures near FCD Dams. Fissures are known to exist in the vicinity of McMicken and Powerline Dams, and we would be wise to determine if fissures are present near other dams, and monitor their progression. The SH&B report has numerous references to publications regarding fissures, and this would be a good place to start.

Recommendations:

Recommended refinements to the settlement monitoring procedure:

1) Surveys should be tied into a grid of USC&GS monuments established in rock.
2) Surveys should include elevations of the crest, if monuments are below the surface.
3) Surveys should include the elevation of the emergency spillway.
4) Water levels in the vicinity should be checked at timing close to that of the surveys.
5) Establish monuments at the downstream toe, if they don't exist (McMicken)

Recommended schedule of continued monitoring:

ADWR has stated that after several surveys have been completed, surveys can be delayed indefinitely unless a trend of settlement has been established. The recommended survey interval is approximately 5 years, but this varies depending on the sponsor of the project. Table 1 shows the survey record and proposed schedule (assumes 5 year interval)

Corps Structures

Corps regulation no. 1110-2-100 states that their structures should be monitored at a 5 year interval.

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[2]Steven Slaff, Land Subsidence and Earth Fissures in Arizona, Arizona Geological Survey, 1993, p.11.

[3]SH&B, p. 66.

[4]Sergent, Hauskins & Beckwith, Design Report, McMicken Dam Restoration Study, 1983, Pages 2 and 3.

The last survey of a Corps dam was in 1985, so these need to be brought up to date. The Corps has indicated that in cases where extensive monitoring has revealed no significant settlement, it may be possible to extend the survey interval to 10 years upon their written concurrence. Dreamy Draw Dam may fall into this category.

District Structures

a)McMicken Dam should be surveyed at 1 year intervals, and after significant retention occurs. Significant is defined as 6' of water behind the dam or continuous outflow through the controlled outlet in excess of 24 hours.

b)Cassandro Wash Dam has not been constructed, but the plans provide for the installation of settlement monuments. Because there is no history of extensive groundwater pumping or subsidence, SCS has never surveyed the Sunset and Sunnycove structures which are also in the Wickenburg area. Because of its proximity to downstream structures, we would be wise to monitor settlement of Cassandro Wash Dam at the interval recommended in Corps regulation No 1110-3-100 (First 4 years 1 year interval, next 4 years 2 year interval, 5 year intervals thereafter, unless structural integrity warrants additional inspections. After 5 years, if there has been not significant settlement, it may be possible to discontinue surveys.

SCS Structures

It is this writer's opinion that all SCS structures except Harquahala and Spookhill should be surveyed this year. After we have one more data set, it may be possible to delay some of the surveys indefinitely. We should encourage SCS to submit the remaining data that is still being compiled (Saddleback, White Tanks #3, and Vineyard).

Both SCS and ADWR state that after several surveys have been completed, surveys can be delayed indefinitely unless a trend of settlement has been established. SCS surveys those structures in areas of known subsidence at an interval of approximately 5 years as resources are available. Past surveys of SCS structures have been conducted jointly by SCS and FCD, so we need to agree on priorities, funding, and a proposed schedule. Three SCS structures have never been surveyed, because they are not in areas of known subsidence (Sunset, Sunnycove, Guadalupe). The results of the GPS surveys should indicate if there are any significant variations in the crest of these three structures that should be monitored.

If we follow the five year interval, all SCS structures except for Harquahala need to be surveyed this year. White Tanks #3 & #4, Powerline, Vineyard, and Rittenhouse are all in areas of known subsidence and should be surveyed. Spookhill FRS has been surveyed three times over an 8 year span, and shown only 0.03 foot of settlement. Surveys on this structure could probably be delayed indefinitely. Signal Butte FRS has been surveyed twice over 2 years, and shown only +0.7 feet of settlement. We should probably survey this once again before discontinuing surveys.

Recommended Fissure Monitoring:

SH&B's study recommends the following fissure monitoring at McMicken Dam. FCD's engineering division should evaluate their recommendations in greater detail, and consider using the same procedures at Powerline Dam. We should also find out if fissures are known to exist near any other FCD dams.

1) Ground reconnaissance of fissures in the vicinity of the dam at 6 month intervals to monitor possible growth and progression toward the dam.

2) Low-sun-angle photography to identify possible fissures. This was recommended to be completed 3 years after the dam was restored (1988) with the schedule of additional photography to depend on the results.

Recommended Periodic inspection:

Although the dams are regularly inspected by FCD's maintenance division, the Corps has stated that for their own structures they normally conduct a more formal inspection (called Periodic) at five year intervals. The settlement surveys are completed about six months prior to the inspection, so their results can be studied by the inspection team. The inspection team consists of a geologist, a structural engineer, and other specialists. It may be worthwhile for us to use this procedure, especially for dams which are in areas of known subsidence and fissuring.

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SUBSIDENCE MONITORING

5/26/95

SORTED IN ORDER OF GREATEST SETTLEMENT

SPONSOR	STRUCTURE	MAX SETTLEMENT	AVE SETTLEMENT	YEARS SPACING	LAST SURVEY	CHANGE	COMMENTS
CORPS	CAVE BUTTES DAM	-0.30	-0.16	3	1983	0.34	CREST DESIGNED FOR 2' SETTLEMENT? CONFIRM.
CORPS	DREAMY DRAW DAM	-0.03	-0.02	7	1983	-1.37	
CORPS	ADOBE DAM	-0.03	-0.01	1	1983	-0.15	MAX SUBSIDENCE=.107/6YRS PER PRE-DAM SURVEY
CORPS	NEW RIVER DAM				1985	-0.26	CANNOT FIND ADDITIONAL SURVEY DATA
FCD	MCMICKEN DAM	-0.54	-0.32	6	1991	-0.62	ESTABLISH DOWNSTREAM TOE MONUMENTS
SCS	POWERLINE FRS	-0.60	-0.23	4	1990	-2.25	1991 CREST RESTORED, CENTER DRAIN ADDED.
SCS	HARQUAHALA FRS	-0.46	-0.19	7	1991	-1.11	
SCS	RITTENHOUSE FRS	-0.20	-0.12	4	1990	-1.52	
SCS	BUCKEYE FRS #1	-0.18	-0.12	9	1986	-1.55	SURVEYS BASED ON BENCHMARK WHICH SUBSIDED
SCS	SADDLEBACK FRS	-0.15	-0.02	3	1990	-1.11	1990 DATA STILL BEING COMPILED BY SCS
SCS	BUCKEYE FRS #2	-0.06	-0.04	9	1986	-0.88	SURVEYS BASED ON BENCHMARK WHICH SUBSIDED
SCS	SPOOKHILL FRS	-0.03	-0.02	8	1987	-0.48	
SCS	SIGNAL BUTTE FRS	0.07	-0.04	2	1989	-0.15	
SCS	BUCKEYE FRS #3	0.28	0.18	9	1986	-1.26	SURVEYS BASED ON BENCHMARK WHICH SUBSIDED.
SCS	WHITE TANKS #4 FRS	0.30	0.28	2	1991	-1.24	1990 &1991 DATA STILL BEING COMPILED BY SCS
SCS	WHITE TANKS #3 FRS	0.75	0.60	7	1991	-4.42	
SCS	VINEYARD FRS				1989	-1.18	1989 DATA STILL BEING COMPILED BY SCS
SCS	APACHE JCT FRS				1989		SCS PLANS TO SURVEY THIS YEAR
SCS	GUADALUPE FRS						
SCS	SUNNYCOVE FRS						
SCS	SUNSET FRS						

NOTES:

1) MAX SETTLEMENT = MAX SETTLEMENT BETWEEN YEARS SURVEYED, NOT SETTLEMENT FROM DESIGN CREST.

2) CHANGE = DESIGN CREST - MINIMUM ELEVATION

3) MONUMENTS ARE TYPICALLY INSTALLED APPROX 6" BELOW CREST, CHANGE LESS THAN 1' IS PROBABLY NOT SIGNIFICANT.

5) GUADALUPE, SUNSET, AND SUNNYCOVE WERE NOT SURVEYED BECAUSE THEY AREN'T IN AREAS OF KNOWN SUBSIDENCE.

6) SUBSIDENCE SURVEYS FOR WHITE TANKS & BUCKEYE STRUCTURES BASED ON BENCHMARK "DEAD" WHICH VARIES FROM USC&GS BY ABOUT 3.7'.

7) COLUMN "CHANGE" ADJUSTED BY 3.7' FOR BUCKEYE AND WHITE TANKS STRUCTURES.

SUBSIDENCE MONITORING

5/26/95

SORTED IN ORDER OF GREATEST CHANGE FROM DESIGN CREST

SPONSOR	STRUCTURE	MAX SETTLEMENT	AVE SETTLEMENT	YEARS SPACING	LAST SURVEY	CHANGE	COMMENTS
CORPS	DREAMY DRAW DAM	-0.03	-0.02	7	1983	-1.37	
CORPS	NEW RIVER DAM				1985	-0.26	CANNOT FIND ADDITIONAL SURVEY DATA
CORPS	ADOBE DAM	-0.03	-0.01	1	1983	-0.15	MAX SUBSIDENCE=.107/6YRS PER PRE-DAM SURVEY
CORPS	CAVE BUTTES DAM	-0.30	-0.16	3	1983	0.34	CREST DESIGNED FOR 2' SETTLEMENT? CONFIRM.
FCD	MCMICKEN DAM	-0.54	-0.32	6	1991	-0.62	ESTABLISH DOWNSTREAM TOE MONUMENTS
SCS	WHITE TANKS #3 FRS	0.75	0.60	7	1991	-4.42	
SCS	POWERLINE FRS	-0.60	-0.23	4	1990	-2.25	1991 CREST RESTORED, CENTER DRAIN ADDED.
SCS	BUCKEYE FRS #1	-0.18	-0.12	9	1986	-1.55	SURVEYS BASED ON BENCHMARK WHICH SUBSIDED
SCS	RITTENHOUSE FRS	-0.20	-0.12	4	1990	-1.52	
SCS	BUCKEYE FRS #3	0.28	0.18	9	1986	-1.26	SURVEYS BASED ON BENCHMARK WHICH SUBSIDED.
SCS	WHITE TANKS #4 FRS	0.30	0.28	2	1991	-1.24	1990 &1991 DATA STILL BEING COMPILED BY SCS
SCS	VINEYARD FRS				1989	-1.18	1989 DATA STILL BEING COMPILED BY SCS
SCS	HARQUAHALA FRS	-0.46	-0.19	7	1991	-1.11	
SCS	SADDLEBACK FRS	-0.15	-0.02	3	1990	-1.11	1990 DATA STILL BEING COMPILED BY SCS
SCS	BUCKEYE FRS #2	-0.06	-0.04	9	1986	-0.88	SURVEYS BASED ON BENCHMARK WHICH SUBSIDED
SCS	SPOOKHILL FRS	-0.03	-0.02	8	1987	-0.48	
SCS	SIGNAL BUTTE FRS	0.07	-0.04	2	1989	-0.15	
SCS	APACHE JCT FRS				1989		SCS PLANS TO SURVEY THIS YEAR
SCS	GUADALUPE FRS						
SCS	SUNNYCOVE FRS						
SCS	SUNSET FRS						

NOTES:

1) MAX SETTLEMENT = MAX SETTLEMENT BETWEEN YEARS SURVEYED, NOT SETTLEMENT FROM DESIGN CREST.

2) CHANGE = DESIGN CREST - MINIMUM ELEVATION

3) MONUMENTS ARE TYPICALLY INSTALLED APPROX 6" BELOW CREST, CHANGE LESS THAN 1' IS PROBABLY NOT SIGNIFICANT.

5) GUADALUPE, SUNSET, AND SUNNYCOVE WERE NOT SURVEYED BECAUSE THEY AREN'T IN AREAS OF KNOWN SUBSIDENCE.

6) SUBSIDENCE SURVEYS FOR WHITE TANKS & BUCKEYE STRUCTURES BASED ON BENCHMARK "DEAD" WHICH VARIES FROM USC&GS BY ABOUT 3.7'.

7) COLUMN "CHANGE" ADJUSTED BY 3.7' FOR BUCKEYE AND WHITE TANKS STRUCTURES.

SUBSIDENSE SURVEY RECORD AND SCHEDULE

5/30/95

					SURVEY SCHEDULE							
SPONSOR	**PROJECT**	**SURVEY RECORD**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**			
SCS	APACH JCT FRS	89	X					X				
SCS	BUCKEYE FRS1	77,79,84,86	X					X				
SCS	BUCKEYE FRS2	77,79,84,86	X					X				
SCS	BUCKEYE FRS3	77,79,84,86	X					X				
SCS	HARQUAHALA FRS	84,86,91		X					X			
SCS	POWERLINE FRS	86,90	X					X				
SCS	RITTENHOUSE FRS	86,90	X					X				
SCS	SADDLEBACK FRS	83,86,90	X					X				
SCS	SIGNAL BUTTE FRS	87,89	X					X				
SCS	SPOOKHILL FRS	79,84,87	X					X				
SCS	VINEYARD RD FRS	86,89	X					X				
SCS	WHITE TANKS FRS 3	84,86,90,91	X	X		X			X			
SCS	WHITE TANKS FRS 4	84,86,90,91	X					X				
CORPS	ADOBE DAM	82,83	X					X				
CORPS	CAVE BUTTES DAM	80,81,83	X					X				
CORPS	DREAMY DRAW DAM	74,75,76,81,83	X					X				
CORPS	NEW RIVER DAM	85	X					X				
FCD	MCMICKEN DAM	85, 91	X	X	X	X	X	X	X			
NOTES: THE FOLLOWING INFORMATION IS FROM "PERIODIC INSPECTION & CONTINUING EVALUATION OF COMPLETED CIVIL WORKS STRUCTURES"												
U.S. ARMY CORPS OF ENGINEERS, REGULATION NO. 1110-2-100, DATED 28 FEBRUARY 1983												
1) THE OPERATING ENTITY IS RESPONSIBLE FOR PERIODIC INSPECTION												
2) SETTLEMENT MONITORING IS PART OF THE INSPECTION PROGRAM												
3) INSPECTION INTERVALS												
FIRST 4 YRS-1 YR INTERVAL												
NEXT 4 YRS-2 YR INTERVAL												
5 YR INTERVALS THEREAFTER, UNLESS STRUCTURAL INTEGRITY WARRANTS ADDITIONAL INSPECTIONS												

APPENDIX B

Adobe Dam
Two surveys were performed over a one year period. Maximum settlement was -0.027. An additional subsidence survey was performed in 1977 (before dam construction). Using the data set from 1977, the maximum subsidence over a 6 year span was -0.107. The embankment was overbuilt by 1.83' to allow for post construction settlement.

The following information relates to anticipated settlement, and comes from Periodic Inspection Report No. 1, dated June 1982, Appendix III:
Page III-4, Embankment: " The embankment was overbuilt for estimated post construction settlements."
Page III-5, Dam foundation: "The foundation materials consist of non-homogeneous alluvial soils extending to a depth of at least 1,250 feet."

Apache Junction FRS
This dam was completed in 1989, and only one survey has been conducted. SCS plans to survey the structure this year.

Buckeye FRS #1
Five surveys have been performed over a nine year period. Maximum settlement over nine years is 0.187'. The minimum elevation varies from the design crest by 6 feet, but 3.7' of this difference is due to the surveys for the Buckeye and White Tanks structures being based on a benchmark which varies from other USC&GS monuments about 3.7 feet. It is unknown if the benchmark subsided, or if it was never correctly tied to the USC&GS survey grid.

In 1981 an embankment drain was added between stations 565+00 and 801+00 to correct a transverse cracking problem. Cracking was most severe between stations 590+00 and 720+00. This cracking may have been related to subsidence/settlement.

The subsidence plot shows spikes of -.3 at station B-18 and +.17 at station B-20. Both of these points are suspected to be erroneous because they are not consistent with the surrounding data points.

Buckeye FRS #2
Five surveys have been performed over a nine year period. Maximum settlement over nine years is -0.06 The minimum elevation is 0.88' below the design crest.

Buckeye FRS #3
Five surveys have been performed over a nine year period. Maximum settlement over nine years is -0.19. The minimum elevation is 1.53' below the design crest.

Cave Buttes Dam
Three surveys have been performed over a 3 year period. The maximum settlement over 3 years was -0.30'. The minimum elevation is 0.34' above the design crest. The crest appears to be designed to allow for 2' of settlement.

Dreamy Draw Dam

Seven surveys were performed over a nine year period. The maximum settlement was -0.03'. The

minimum elevation was 1.37' below the design crest.

Harquahala FRS
Three surveys were performed over a seven year period. Maximum settlement is -0.46, and the minimum elevation is 1.1 feet' below the design crest.

Harquahala FRS is outside the Phoenix active management area (AMA). Extraction of groundwater may not be monitored as closely. This area is not included on the map of groundwater elevation changes that we have.

McMicken Dam
Two surveys were performed over a 6 year period. The maximum settlement was -0.54 feet. The average settlement was -0.32 feet. The minimum elevation is 0.62 feet below the design crest. It would be useful to establish monuments on the downstream toe of the structure, so that we could determine if changes in the crest are due to subsidence or expansion/contraction of the fill.

The following information is extracted from "McMicken Dam Restoration Study, 1982"
The Corps began investigating cracking of the dam as early as 1964. A 1972 investigation exposed transverse cracks which exceeded 14.5 feet in depth, and found that the cracks were predominantly located between stations 265+00 to 295+00 and 445+00 to 475+00.
A 1977 FCD report concluded that severe cracking probably was present throughout the northernmost two-thirds of the dam, and that the cracking was not totally caused by subsidence. The dam was breached in 1977.
SH&B's 1983 report concludes "The primary cause of embankment cracking was found to be settlement of a surface layer of collapsing embankment foundation soils. The moisture sensitive soils and observed cracking intensity are greater in the Trilby Wash area in the northerly one-half of the dam, though at least a thin layer of collapsing soil and isolated cracking is present over most of the length of the dam. Sufficient evidence exists to support the conclusion that the foundation soils have been wetted in the past due to ponding of water for extended periods behind the dam. It is thought that the probability for future settlement and cracking of the embankment is very low due to this past ponding.
Groundwater Withdrawal Induced Subsidence fissuring:
No evidence was found that earth fissures due to groundwater withdrawal cross the dam or contribute to embankment cracking. However, earth fissures were found near the southerly end of the dam. The history of pumpage of groundwater in the vicinity of the dam, the consequent groundwater declines and subsidence, and the anticipated future groundwater withdrawals and basin subsidence are such that the formation of numerous earth fissures in the vicinity of the dam is expected. Thus, *it is considered highly probable that at least several earth fissures will form through the dam in the next few decades. The central vertical drain concept of repair yields the least cost, as well as the only positive defense against subsidence induced fissuring through the dam.*"[1]

The SH&B study used low-sun-angle aerial photography to identify possible fissures. This method uses highlighting or shading effects to locate subtle geomorphic features. Suspected fissures were then field investigated.

The SH&B study also notes that in 1982, the crest elevation varies from 1362 to 1357 feet. Crest

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[1]Sergent, Hauskins & Beckwith, Design Report, McMicken Dam Restoration Study, 1983, Pages 2 and 3.

elevations in excess of 1360 feet occur along the southernmost segment of the alignment from stations 40+00 to 87+00. The remainder of the crest is generally at an elevation of 1358 to 1360 feet.

In 1985 the dam was restored and a central vertical drain was added. Crest settlement monuments were also added at this time.

SH&B's report outlines the following inspection & maintenance schedule:[2]
1) Yearly survey of crest elevation monuments.
2) Crest elevation survey approximately 1 month after significant retention occurs. Significant defined as 6' of water behind the dam or continuous outflow through the controlled outlet in excess of 24 hours.
3) Ground reconnaissance of fissures in vicinity of dam at 6 month intervals to monitor possible growth and progression toward the dam.
4)Low-sun-angle photography performed 3 years after completion of the repair. (This means it should have been done in 1988.) Future photographic monitoring based on the results.

New River Dam
One survey was conducted in 1985. The minimum crest elevation was 0.26 feet below the design crest. Unable to find records of additional surveys. New River Dam also has piezometer wells which should be monitored at the same time that the settlement surveys are performed. Recommendation--Survey.

The following information regarding foundation conditions and anticipated settlement comes from Periodic Inspection Report No. 1, dated March 1985, Appendix III (pages are not numbered)

Settlement and Subsidence
Dam Embankment:
"The estimated total settlement at the maximum embankment section and foundation is less than 2.6 feet. *Maximum post construction settlement was estimated to be less than 1.1 feet...Minor post-construction differential settlements that are due to the loading of the foundation are anticipated because of the abrupt changes in the bedrock profile existing below streambed in the west half of the valley.*

Dike No. 1
"The total settlement, therefore, is estimated to be 0.7 foot and the total post-construction settlement is estimated to be less than 0.16 foot. Post-construction differential settlements because of loading of the foundation are not anticipated due to the presence of bedrock and well indurated caliche."

Dike No. 2
" Foundation settlements and subsidence due to groundwater decline were not addressed because the embankment is founded on rock."

Powerline FRS
Two surveys were performed over a four year spacing. The maximum settlement was -0.60 feet. The minimum elevation is 2.25 feet below the design crest.

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[2]Sergent Hauskins & Beckwith, Geotechnical Investigation Report: McMicken Dam Restoration Study, For the Flood Control District of Maricopa County, Arizona, 1982, P.116.

A center drain was added to the dam in 1991. It is unknown if the drain was added to correct a transverse cracking problem (similar to other structures) which may have been partially caused by settlement/subsidence. As part of the 1991 modification, the crest was restored approximately to the design crest. For unknown reasons the crest wasn't restored level, with the new minimum elevation being 1588.90 at station 89+00.

There is an earth fissure approximately 1/4 mile west of Powerline Dam. The fissure, if projected eastward would intersect Powerline FRS at approximate station 125+00. The fissure would intersect the CAP before reaching the Dam. In the late 1980's, the Bureau of Reclamation installed sheet piling around the CAP at the location where the fissure would intersect. It is recommended that FCD's Engineering Division contact the Bureau to see what data they have gathered regarding the fissure. The eastward progression of the fissure should be monitored as part of the regular dam inspections. The District also has a series of photos taken along the fissure between 1985 and 1987.

SH&B's Report on McMicken Dam references the fissure near Powerline Dam on pages 57, 63, and 64. It is recommended that FCD's engineering Division review this information more carefully and consider a program of monitoring similar to that recommended for McMicken. See the discussion on McMicken that follows.

The maximum subsidence in the area of Queen Creek is 4.5 feet[3]. "A study of earth fissures near Baseline and Meridian Roads by the U.S. Geological Survey (USGS) and the U.S. Bureau of Reclamation (BuRec) is ongoing. Geophysical data again indicates that a shallow bedrock irregularity has caused localized differential consolidation and subsequent fissuring (Carpenter, 1982) "[4]
"An indication of the subsurface extent and erosion potential of some fissures, introduction of water at a rate of 550 gpm into the Meridian and Baseline Roads fissure system resulted in no overflow after five days of continuous pumping (Raymond, 1982)[5]

Rittenhouse FRS
Two surveys were performed over a 4 year spacing. The maximum settlement was -0.20 feet. The minimum elevation is 1.52 feet below the design crest.

Saddleback FRS
Three surveys have been performed over a seven year period. The maximum settlement over 4 years is -0.15 feet. The minimum elevation is 1.11 feet below the design crest. The third data set (1990) is still being compiled by SCS.

Signal Butte FRS
Two surveys have been performed over a two year period. The maximum settlement was +0.07'. The minimum elevation was 0.15' below the design crest.

Spookhill FRS
Three surveys have been performed over an eight year period. The maximum settlement was -0.03 feet. The minimum elevation was 0.48' below the design crest.

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[3]Sergent, Hauskins & Beckwith, p. 57.

[4]SH&B, p. 63.

[5]SH&B, p. 64.

Vineyard FRS
Two surveys have been performed over a 3 year period. The second data set is still being compiled by SCS. The minimum elevation is 1.18' below the design crest.

Structure embankment and drainfill repair was completed in 1990. It is unknown if the drain was added to correct a transverse cracking problem (similar to other structures) which may have been partially caused by settlement/subsidence.

White Tanks FRS #3
By all criteria this structure is of greatest concern. Maximum settlement over 7 years is +1.49 feet. The minimum crest elevation is 3.42 feet below design. The crest, which is supposed to be level, varies by 6.47 feet.

There is a data anomaly at station A-7 which shows that the monument increased by 0.428 feet while adjacent monuments decreased by 0.2 feet. Although the SCS plan sheet does not indicate that the monument has been reset, SCS's 1991 report states that it was on page 10 of appendix 8. For the purposes of this report it has been assumed that the monument has been reset. This should be confirmed from the survey notes.

There is also a data anomaly at marker B-4 for the July 1991 reading. The reading was adjusted by 3.769 rather than 3.679. When this correction was made, the anomaly disappeared.

The plot of subsidence data (change in downstream toe) indicates a change varying from +0.5 at station 10+00 to +0.8 at station 70+00. Consolidation of fill was negligible (varying from -0.015 to -0.047 feet. Between surveys in 1984 and 1986 all monuments rose by about 1 foot. Since subsidence is not supposed to be reversible, this cannot be explained.

A 1991 SCS report entitled "Proposal for Rehabilitation White Tank Mountains Flood Retarding Structures #3 and #4" describes this problem in more detail.

In 1979 both White Tanks #3 and #4 were found to have severe and extensive cracking which was corrected by a 1982 project. Corrective measures included excavating a centerline trench and adding a vertical filter. It was thought that transverse cracking was mostly a result of desiccation.

The 1991 report outlines the following improvements required:

1)Raise the dam crest to the elevation required to pass the full PMF without failure.
2)Enlarge the spillway, and add a mechanical spillway to prevent erosion.
3) Raise the crest to accommodate future subsidence.
4) Extend the dam as needed for catch point to reach the elevation of top of crest.
5) Provide gravel surface to embankment slopes to prevent rilling, gullying, and crack protection.

The White Tanks #3 vicinity is included in the area searched for fissures as part of the SH&B study, however, no fissures were found. Because this is in an area of known subsidence we should monitor for the formation and progression of fissures.

White Tanks #4
Four surveys were performed over a 7 year period. The maximum settlement was -0.29 feet in 2 years. The minimum crest elevation is 1.24 feet below the design crest. The third and fourth data sets are still being compiled by SCS.

The 1991 report recommends raising the crest of the dam to a uniform elevation to allow the freeboard storm to pass safely through the emergency spillways without overtopping. The report states that there is some settlement of the crest of the dam which causes a 0.34 foot overflow of the crest by the one-half PMF.

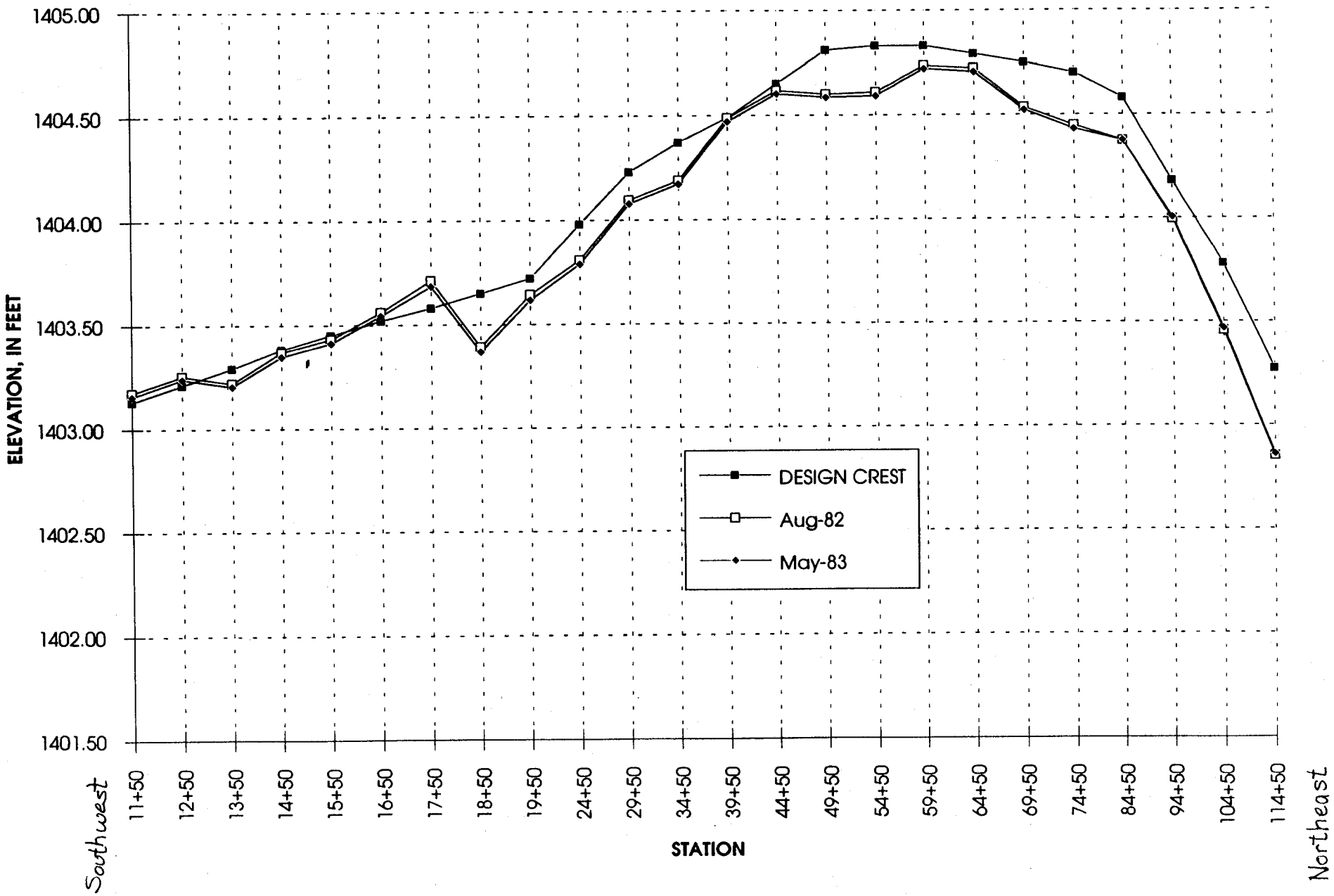
4/26/95

ADOBE DAM SUBSIDENCE MONITORING					FEET	FEET	FEET	FEET	FEET	FEET
NORTH	EAST	MARKER	STATION	DESIGN	Aug-82	May-83	1977	1977-1982	1982-1983	1977-1983
974021.619	428122.204	SM-2	11+50	1403.13	1403.173	1403.156			-0.017	
974077.062	428204.135	SM-3	12+50	1403.21	1403.254	1403.239			-0.016	
974133.141	428287.217	SM-4	13+50	1403.29	1403.219	1403.204			-0.015	
974190.055	428371.053	SM-6	14+50	1403.38	1403.368	1403.346			-0.022	
974243.888	428450.798	SM-7	15+50	1403.45	1403.430	1403.411			-0.019	
974301.216	428536.041	SM-8	16+50	1403.52	1403.560	1403.542			-0.018	
974358.115	428620.544	SM-9	17+50	1403.58	1403.711	1403.685			-0.027	
974411.205	428698.834	SM-10	18+50	1403.65	1403.393	1403.367			-0.025	
974469.894	428785.180	SM-11	19+50	1403.72	1403.643	1403.617			-0.027	
974749.687	429197.772	SM-12	24+50	1403.98	1403.808	1403.788			-0.020	
975027.967	429608.511	SM-14	29+50	1404.23	1404.095	1404.077			-0.018	
975308.835	430022.346	SM-15	34+50	1404.37	1404.188	1404.170			-0.017	
975590.581	430439.646	SM-16	39+50	1404.49	1404.487	1404.469			-0.017	
975871.818	430854.210	SM-18	44+50	1404.65	1404.618	1404.602			-0.016	
976149.726	431264.667	SM-19	49+50	1404.81	1404.601	1404.585			-0.015	
976429.599	431678.488	SM-20	54+50	1404.83	1404.610	1404.591			-0.019	
976713.425	432096.917	SM-22	59+50	1404.83	1404.735	1404.719			-0.015	
976991.067	432506.831	SM-23	64+50	1404.79	1404.721	1404.705			-0.016	
977272.687	432923.670	SM-24	69+50	1404.75	1404.535	1404.522			-0.013	
977551.047	433334.250	SM-25	74+50	1404.70	1404.448	1404.432			-0.016	
978113.416	434164.715	SM-27	84+50	1404.58	1404.375	1404.375			0.000	
978674.204	434992.805	SM-28	94+50	1404.18	1403.996	1404.004			0.008	
979234.558	435819.815	SM-29	104+50	1403.78	1403.456	1403.469			0.012	
979795.447	436648.144	SM-30	114+50	1403.27	1402.851	1402.859			0.008	
AVERAGE ELEVATION CHANGE									**-0.014**	
MAXIMUM ELEVATION LOSS									**-0.027**	
MAXIMUM ELEVATION GAIN									**0.012**	
		SM-1	8+61.47		1422.083	1422.080			-0.003	
		SM-1A			1408.894	1408.892			-0.002	
		SM-5	13+50		1376.537	1376.535			-0.002	
		SM-13	24+50		1381.174	1381.160			-0.013	
		SM-17	39+50		1383.649	1383.638			-0.010	
		SM-21	54+50		1383.679	1383.670			-0.010	
		SM-26	74+50		1391.878	1391.868			-0.010	
		SM-31	122+19.52			1420.115				
		SM-31A			1408.488	1408.493			0.005	
SUBSIDENCE MONUMENTS										
		SB-1	11		1365.854	1365.854	1365.854	0.000	0.000	0.000
		SB-2	12		1368.875	1368.874	1368.875	0.000	0.000	0.000

		SB-3					1341.217	XXXX	XXXX	XXXX
		SB-4			1342.311	1342.312	1342.313	-0.003	0.001	-0.002
		SB-5	25		1345.154	1345.158	1345.163	-0.010	0.004	-0.005
		SB-6					1346.824	XXXX	XXXX	XXXX
		SB-7					1352.380	XXXX	XXXX	XXXX
		SB-8					1356.248	XXXX	XXXX	XXXX
		SB-9	58		1362.061	1362.045	1362.054	0.007	-0.015	-0.009
		SB-10	65		1365.957	1365.949	1365.989	-0.032	-0.008	-0.040
		SB-11	75		1372.539	1372.543	1372.564	-0.025	0.005	-0.021
		SB-12	85		1379.367	1379.373	1379.474	-0.107	0.006	-0.101
		SB-13	95		1386.049	1386.046	1386.077	-0.028	-0.003	-0.031
		SB-14	105		1389.554	1389.558	1389.529	0.026	0.003	0.029
		SB-15	115		1393.084	1393.092	1393.022	0.062	0.008	0.070
		SB-16			1407.815	1407.826	1407.815	0.000	0.011	0.011
		SB-17			1410.748	1410.759	1410.748	0.000	0.010	0.010
		SB-18					1329.780	XXXX	XXXX	XXXX
AVERAGE ELEVATION CHANGE								**-0.009**	**0.002**	**-0.007**
MAXIMUM ELEVATION LOSS								**-0.107**	**-0.015**	**-0.101**
MAXIMUM ELEVATION GAIN								**0.062**	**0.011**	**0.070**
NOTES:										
1) CONSTRUCTION COMPLETED 1982										
2) DESIGN CREST ELEVATION = 1403.0. THIS DOES NOT INCLUDE 1.83' SETTLEMENT ALLOWANCE.										
3) DESIGN SPILLWAY CREST= 1377.8										
4) MAXIMUM HEIGHT = 63'										
5) FREEBOARD = 5.5'										

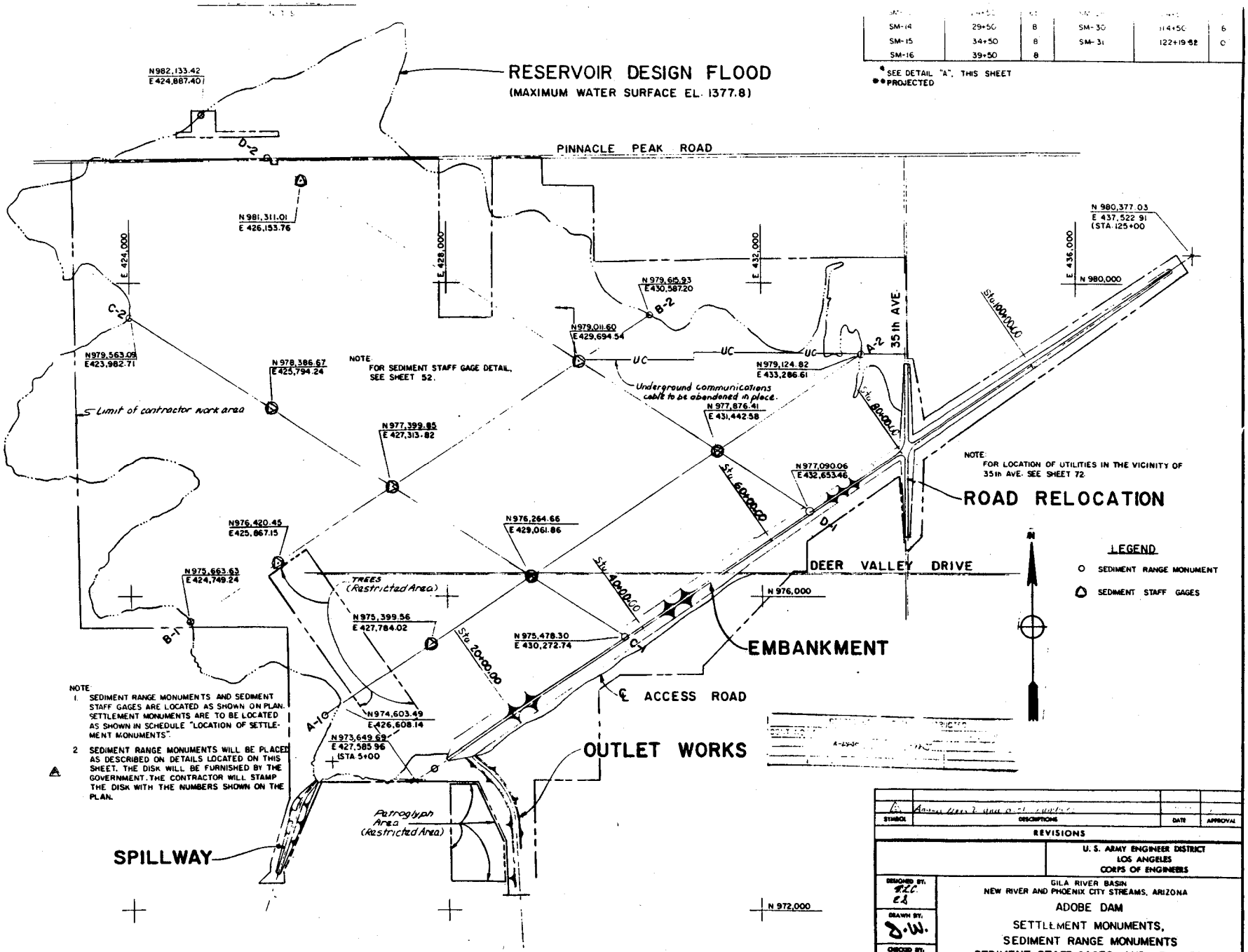
4/6/95

ADOBE DAM CREST SETTLEMENT MONUMENTS



SM-14	29+50	8	SM-30	114+50	6
SM-15	34+50	8	SM-31	122+19.52	0
SM-16	39+50	8			

* SEE DETAIL "A", THIS SHEET
** PROJECTED



NOTE:
FOR SEDIMENT STAFF GAGE DETAIL, SEE SHEET 52.

NOTE:
FOR LOCATION OF UTILITIES IN THE VICINITY OF 35th AVE. SEE SHEET 72.

NOTE:
1. SEDIMENT RANGE MONUMENTS AND SEDIMENT STAFF GAGES ARE LOCATED AS SHOWN ON PLAN. SETTLEMENT MONUMENTS ARE TO BE LOCATED AS SHOWN IN SCHEDULE "LOCATION OF SETTLEMENT MONUMENTS".
2. SEDIMENT RANGE MONUMENTS WILL BE PLACED AS DESCRIBED ON DETAILS LOCATED ON THIS SHEET. THE DISK WILL BE FURNISHED BY THE GOVERNMENT. THE CONTRACTOR WILL STAMP THE DISK WITH THE NUMBERS SHOWN ON THE PLAN.

SEDIMENT RANGE MONUMENT AND SEDIMENT STAFF GAGE PLACEMENT—PLAN
SCALE: 1 IN. = 600 FT.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

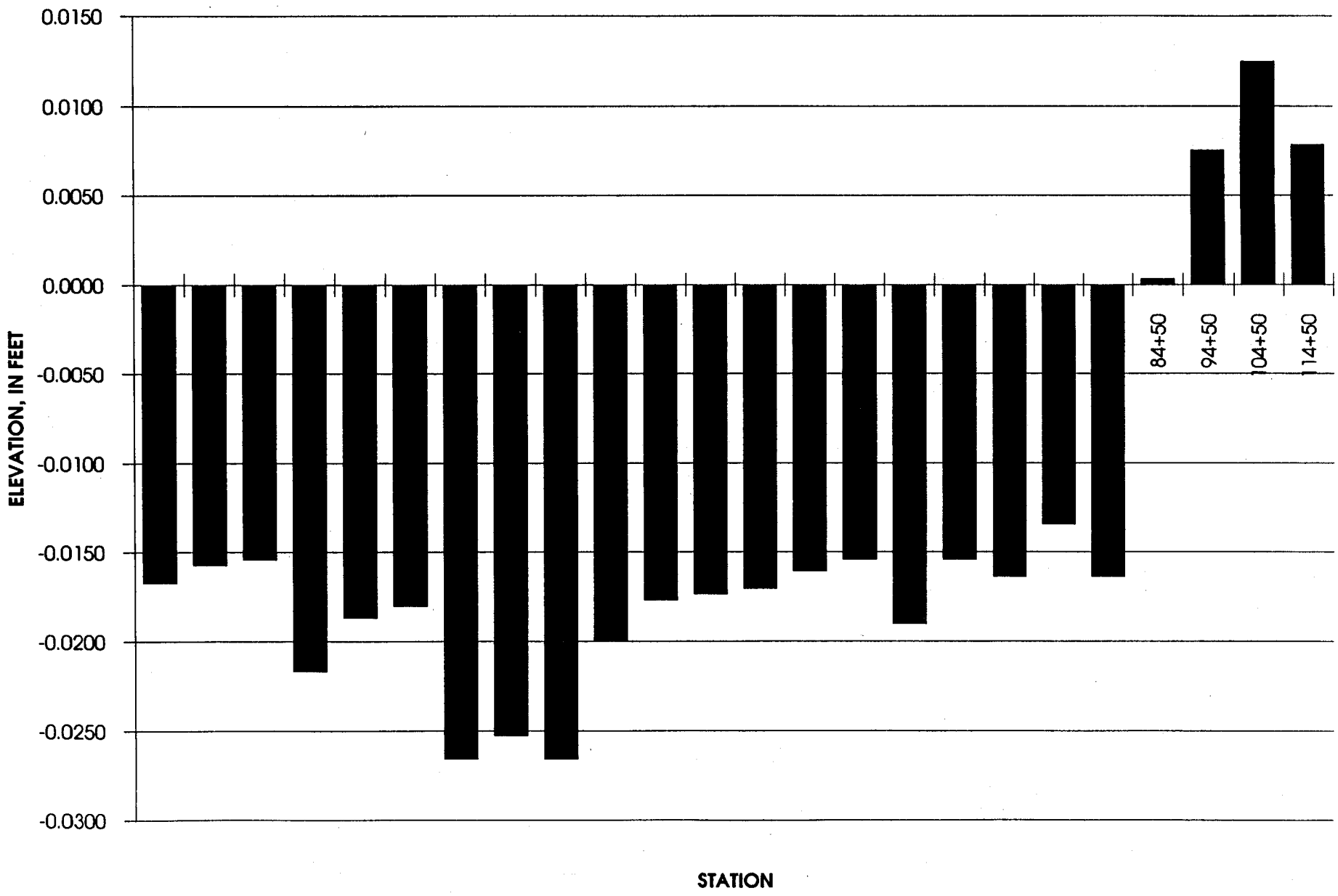
DESIGNED BY: R.L.C. E.A.
DRAWN BY: D.W.
CHECKED BY: CWF

GILA RIVER BASIN
NEW RIVER AND PHOENIX CITY STREAMS, ARIZONA
ADOBE DAM
SETTLEMENT MONUMENTS,
SEDIMENT RANGE MONUMENTS
SEDIMENT STAFF GAGES, AND UTILITIES
GENERAL PLAN AND DETAILS

SUBMITTED BY: DATE APPROVED: AUG 1980
SPEC. NO. DACW09-80-B-0036
DISTRICT FILE NO. 262/71
SHEET 71 OF 72

4/6/95

ADOBE DAM, CHANGE IN CREST ELEVATION AUG 82 TO MAY 83

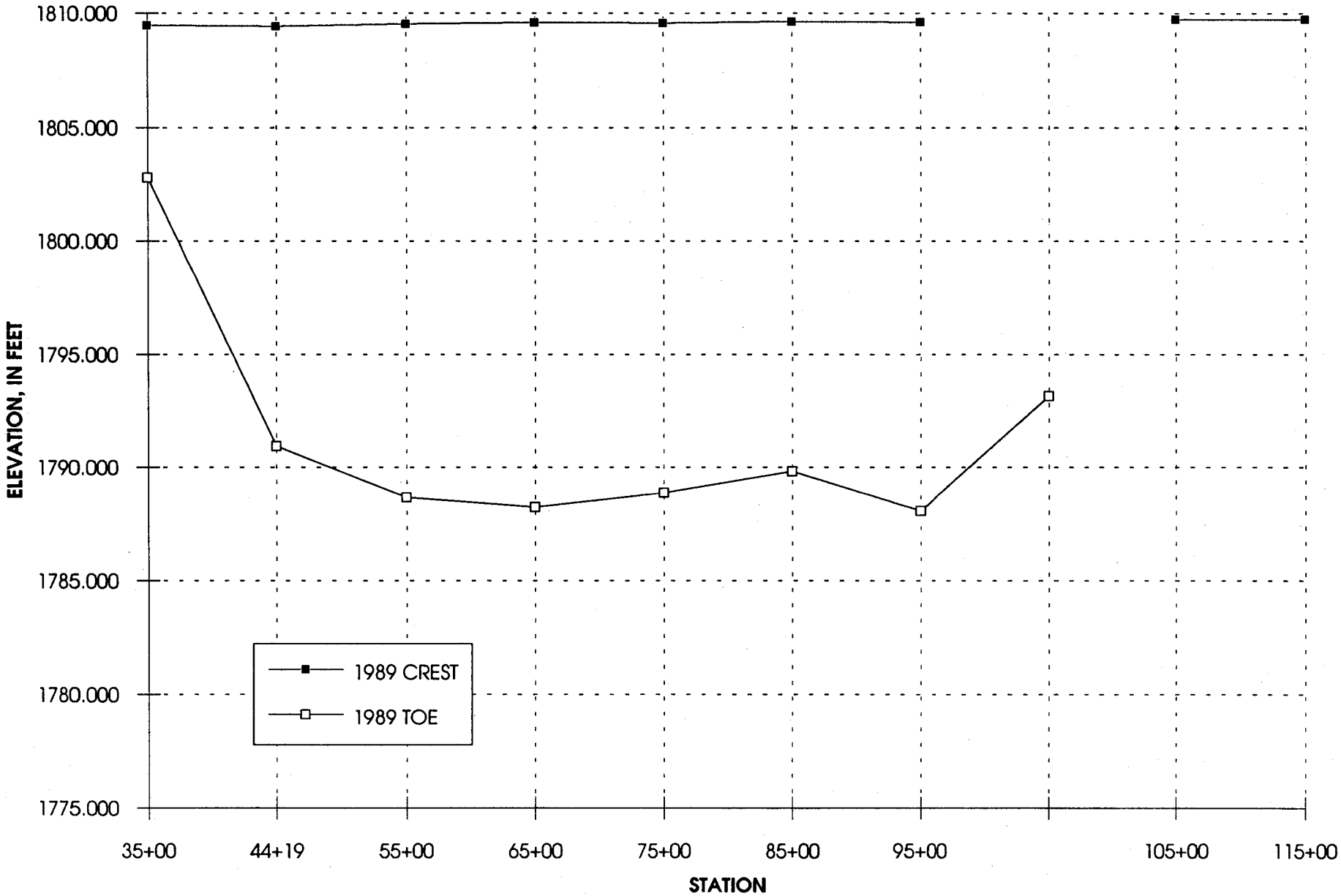


APACHE JUNCTION FRS SUBSIDENCE MONITORING			
MARKER	STATION	1989	
A-1	35+00	1809.459	
A-2	44+19	1809.435	
A-3	55+00	1809.522	
A-4	65+00	1809.594	
A-5	75+00	1809.576	
A-6	85+00	1809.643	
A-7	95+00	1809.607	
A-8			
A-9	105+00	1809.732	
A-10	115+00	1809.739	
MINIMUM		1809.435	
MAXIMUM		1809.739	
B-1	35+00	1802.794	
B-2	44+19	1790.941	
B-3	55+00	1788.669	
B-4	65+00	1788.238	
B-5	75+00	1788.874	
B-6	85+00	1789.811	
B-7	95+00	1788.062	
B-8	105+00	1793.136	
	29+86.95	1808.110	
	35+00	1801.190	
	40+00	1795.890	
	44+18.33	1790.580	
	44+19.07		
	47+39.79	1789.870	
	50+00	1788.480	
	55+00	1788.360	
	60+00	1787.050	
	65+00	1787.380	
	70+00	1787.300	
	75+00	1787.700	
	80+00	1789.680	
	85+00	1788.790	
	90+00	1788.460	
	95+00	1788.420	
	99+37.48	1784.940	
	99+38.16		

	102+21.62	1790.580	
	105+00	1791.710	
	110+00	1801.000	
	115+00	1806.260	
	117+00	1808.770	
APACHE JUNCTION FLOODWAY			
	12+00	1812.150	
	15+00	1811.640	
	20+00	1818.480	
	25+00	1807.500	
	25+88.03	1808.110	
	28+70	1805.200	
	30+67.19	1803.490	
	35+00	1800.290	
	40+00	1796.750	
APACHE JUNCTION FRS OUTLET			
	105+00	1781.330	
	110+00	1775.610	
	115+00	1769.210	
	120+00	1763.700	
	125+00	1759.360	
	129+23.99	1752.220	
NOTES:			
1) CONSTRUCTION COMPLETED 1987			
2) DESIGN CREST ELEVATION =			
3) DESIGN SPILLWAY CREST =			

4/26/95

APACHE JUNCTION FRS CREST SETTLEMENT MONITORING



5/23/95

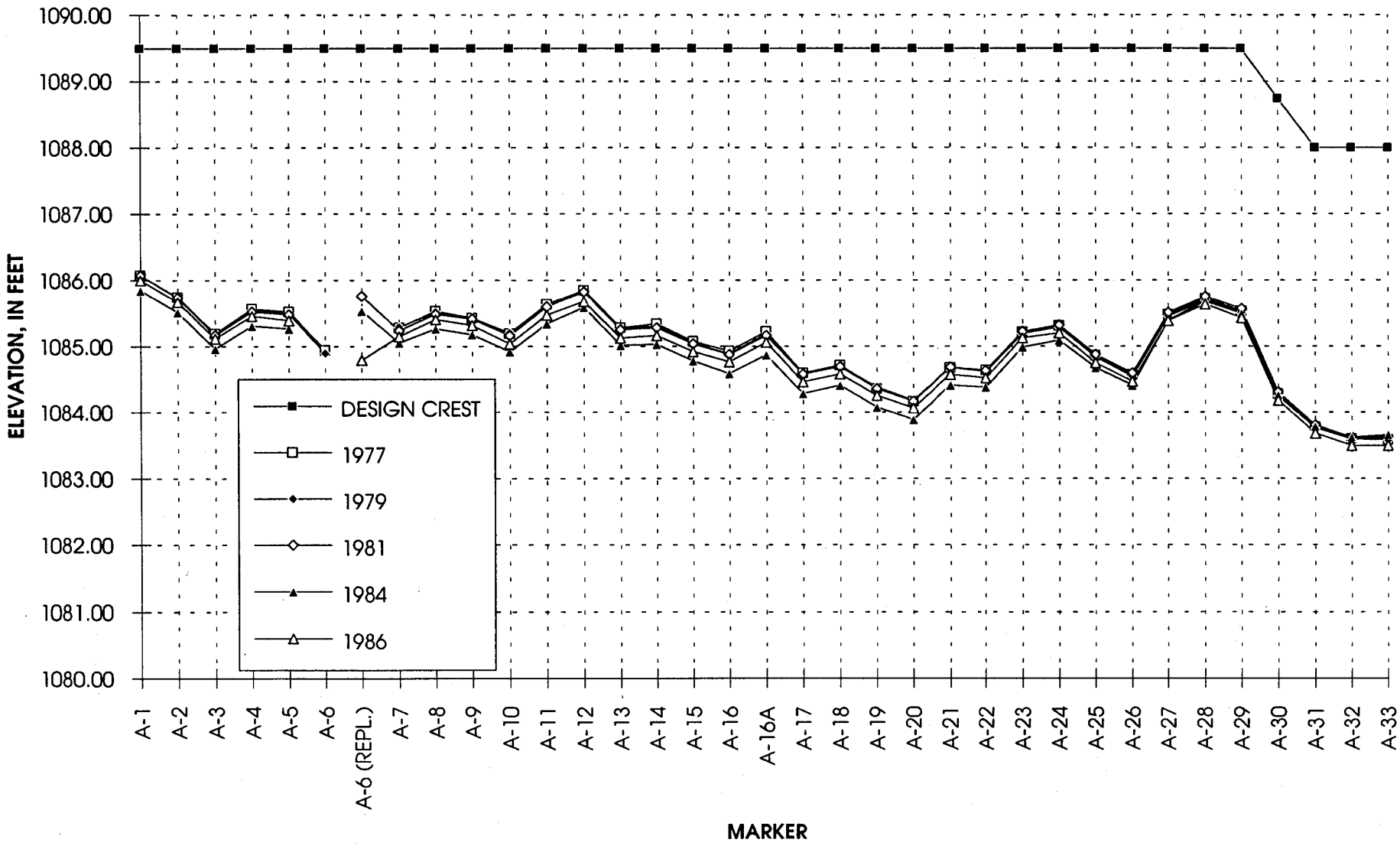
	BUCKEYE FRS #1 SETTLEMENT/SUBSIDENCE MONITORING														
STATION	MARKE	BEDROCK	DESIGN	1977	1979	1981	1984	1986	1994	77-79	79-81	81-84	84-86	77-86	74-94
534+10	A-1		1089.50	1086.072	1086.072	1086.072	1085.848	1086.002		0.000	0.000	-0.224	0.154	-0.070	
546+45	A-2		1089.50	1085.742	1085.744	1085.735	1085.511	1085.669		0.002	-0.009	-0.224	0.158	-0.073	
557+00	A-3		1089.50	1085.192	1085.180	1085.169	1084.964	1085.116		-0.012	-0.011	-0.205	0.152	-0.076	
570+25	A-4		1089.50	1085.564	1085.544	1085.524	1085.304	1085.456		-0.020	-0.020	-0.220	0.152	-0.108	
581+70	A-5		1089.50	1085.519	1085.489	1085.477	1085.264	1085.392		-0.030	-0.012	-0.213	0.128	-0.127	
592+70	A-6	1072	1089.50	1084.941	1084.898					-0.043	XXXX	XXXX	XXXX	XXXX	
592+70	A-6	(REPL.)	1089.50			1085.760	1085.530	1084.789		XXXX	XXXX	-0.230	-0.741	XXXX	
604+65	A-7	1068	1089.50	1085.281	1085.285	1085.237	1085.050	1085.146		0.004	-0.048	-0.187	0.096	-0.135	
616+35	A-8	1068	1089.50	1085.528	1085.515	1085.484	1085.264	1085.403		-0.013	-0.031	-0.220	0.139	-0.125	
627+15	A-9	1066	1089.50	1085.429	1085.424	1085.409	1085.176	1085.313		-0.005	-0.015	-0.233	0.137	-0.116	
637+60	A-10	1064	1089.50	1085.190	1085.197	1085.160	1084.916	1085.033		0.007	-0.037	-0.244	0.117	-0.157	
640+00			1089.50						1091.34						1.84
648+50	A-11	1062	1089.50	1085.634	1085.626	1085.597	1085.339	1085.469		-0.008	-0.029	-0.258	0.130	-0.165	
659+15	A-12	1064	1089.50	1085.845	1085.832	1085.820	1085.584	1085.679		-0.013	-0.012	-0.236	0.095	-0.166	
671+55	A-13	1062	1089.50	1085.278	1085.266	1085.248	1085.012	1085.126		-0.012	-0.018	-0.236	0.114	-0.152	
680+00			1089.50						1090.52						1.02
683+15	A-14	1058	1089.50	1085.339	1085.303	1085.276	1085.025	1085.163		-0.036	-0.027	-0.251	0.138	-0.176	
693+90	A-15	1060	1089.50	1085.071	1085.043	1085.031	1084.774	1084.920		-0.028	-0.012	-0.257	0.146	-0.151	
704+40	A-16	1060	1089.50	1084.927	1084.878	1084.872	1084.588	1084.760		-0.049	-0.006	-0.284	0.172	-0.167	
716+20	A-16A	1056	1089.50	1085.222	1085.179	1085.164	1084.868	1085.054		-0.043	-0.015	-0.296	0.186	-0.168	
727+20	A-17	1052	1089.50	1084.589	1084.580	1084.580	1084.288	1084.457		-0.009	0.000	-0.292	0.169	-0.132	
738+60	A-18	1050	1089.50	1084.708	1084.698	1084.692	1084.406	1084.577		-0.010	-0.006	-0.286	0.171	-0.131	
749+25	A-19	1056	1089.50	1084.360	1084.378	1084.358	1084.078	1084.253		0.018	-0.020	-0.280	0.175	-0.107	
750+00			1089.50						1090.52						1.02
760+00	A-20	1056	1089.50	1084.167	1084.179	1084.168	1083.887	1084.060		0.012	-0.011	-0.281	0.173	-0.107	
771+55	A-21	1052	1089.50	1084.674	1084.671	1084.678	1084.409	1084.574		-0.003	0.007	-0.269	0.165	-0.100	
783+20	A-22	1052	1089.50	1084.634	1084.612	1084.632	1084.376	1084.521		-0.022	0.020	-0.256	0.145	-0.113	
790+00			1089.50						1090.40						0.90
795+50	A-23	1052	1089.50	1085.210	1085.189	1085.219	1084.985	1085.127		-0.021	0.030	-0.234	0.142	-0.083	
806+16	A-24	1060	1089.50	1085.305	1085.285	1085.315	1085.089	1085.200		-0.020	0.030	-0.226	0.111	-0.105	
815+86			1089.50						1090.94						1.44
816+93	A-25	1060	1089.50	1084.860	1084.835	1084.872	1084.671	1084.751		-0.025	0.037	-0.201	0.080	-0.109	
827+83	A-26	1050	1089.50	1084.571	1084.540	1084.589	1084.410	1084.471		-0.031	0.049	-0.179	0.061	-0.100	
839+78	A-27	1058	1089.50	1085.475	1085.447	1085.504	1085.388	1085.384		-0.028	0.057	-0.116	-0.004	-0.091	
851+34	A-28	1060	1089.50	1085.722	1085.688	1085.752	1085.673	1085.631		-0.034	0.064	-0.079	-0.042	-0.091	
862+47	A-29	1070	1089.50	1085.532	1085.497	1085.562	1085.492	1085.424		-0.035	0.065	-0.070	-0.068	-0.108	
865+01			1089.50						1091.02						1.52
873+05	A-30	1068	1088.74	1084.275	1084.248	1084.306	1084.265	1084.180		-0.027	0.058	-0.041	-0.085	-0.095	
884+45	A-31	1054	1088.00	1083.778	1083.761	1083.808	1083.779	1083.683		-0.017	0.047	-0.029	-0.096	-0.095	
895+53	A-32	1048	1088.00	1083.595	1083.590	1083.620	1083.622	1083.499		-0.005	0.030	0.002	-0.123	-0.096	
906+40			1088.00						1088.96						0.96

907+40	A-33	1064	1088.00	1083.588	1083.578	1083.619	1083.658	1083.495		-0.010	0.041	0.039	-0.163	-0.093	
CP58 NE COR SPILLWAY									1081.21						
CP59 NW COR SPILLWAY									1076.80						
AVERAGE CHANGE										**-0.017**	**0.006**	**-0.200**	**0.067**	**-0.118**	
MINIMUM				**1083.588**	**1083.578**	**1083.619**	**1083.622**	**1083.495**		**-0.049**	**-0.048**	**-0.296**	**-0.741**	**-0.176**	
MAXIMUM				**1086.072**	**1086.072**	**1086.072**	**1085.848**	**1086.002**		**0.018**	**0.065**	**0.039**	**0.186**	**-0.070**	
DOWNSTREAM TOE MONUMENTS															
534+10	B-1			1074.973	1074.972	1074.972	1074.689	1074.820		-0.001	0.000	-0.283	0.131	-0.153	
546+33	B-2			1079.410	1079.419	1079.405	1079.109	1079.273		0.009	-0.014	-0.296	0.164	-0.137	
556+95	B-3			1082.511	1082.514	1082.540	1082.202	1082.387		0.003	0.026	-0.338	0.185	-0.124	
570+25	B-4			1079.433	1079.430	1079.424	1079.116	1079.324		-0.003	-0.006	-0.308	0.208	-0.109	
581+70	B-5			1075.202	1075.194	1075.173	1074.869	1075.070		-0.008	-0.021	-0.304	0.201	-0.132	
592+70	B-6			1073.582	1073.581					-0.001	XXXX	XXXX	XXXX	XXXX	
592+70	B-6	(rep.)						1074.170		XXXX	XXXX	XXXX	XXXX	XXXX	
604+65	B-7			1071.965	1071.973	1071.949				0.008	0.024	XXXX	XXXX	XXXX	
604+65	B-7	(rep.)						1071.863		XXXX	XXXX	XXXX	XXXX	XXXX	
616+35	B-8			1070.622	1070.623	1070.599	1070.263	1070.522		0.001	-0.024	-0.336	0.259	-0.100	
627+15	B-9			1068.862	1068.861	1068.848	1068.486	1068.769		-0.001	-0.013	-0.362	0.283	-0.093	
637+68	B-10			1068.055	1068.054	1068.045	1067.680	1067.956		-0.001	-0.009	-0.365	0.276	-0.099	
648+55	B-11			1067.934	1068.938	1068.932	1067.575	1067.842		1.004	-0.006	-1.357	0.267	-0.092	
659+20	B-12			1065.534	1065.530	1065.445	1065.087	1065.362		-0.004	-0.085	-0.358	0.275	-0.172	
671+55	B-13			1063.108	1063.108	1063.084	1062.730	1063.003		0.000	-0.024	-0.354	0.273	-0.105	
683+10	B-14			1062.443	1062.477	1062.424	1062.149	1062.359		0.034	-0.053	-0.275	0.210	-0.084	
693+70	B-15			1062.903	1062.920	1062.873	1062.606	1062.809		0.017	-0.047	-0.267	0.203	-0.094	
704+30	B-16			1062.870	1062.879	1062.852	1062.574	1062.783		0.009	-0.027	-0.278	0.209	-0.087	
715+96	B-16A			1061.386	1061.401	1061.365	1061.091	1061.293		0.015	-0.036	-0.274	0.202	-0.093	
727+20	B-17			1061.543	1061.555	1061.537	1061.253	1061.460		0.012	-0.018	-0.284	0.207	-0.083	
738+52	B-18			1060.824	1060.834	1060.580	1060.302	1060.486		0.010	-0.254	-0.278	0.184	-0.338	
749+32	B-19			1061.246	1061.246	1061.244	1060.964	1061.160		0.000	-0.002	-0.280	0.196	-0.086	
759+85	B-20			1058.342	1058.356	1058.666	1058.325	1058.514		0.014	0.310	-0.341	0.189	0.172	
771+45	B-21			1058.273	1058.283	1058.359	1058.016	1058.198		0.010	0.076	-0.343	0.182	-0.075	
782+90	B-22			1058.494	1058.506	1058.577	1058.251	1058.425		0.012	0.071	-0.326	0.174	-0.069	
795+20	B-23			1060.219	1060.213	1060.279	1060.690	1060.136		-0.006	0.066	0.411	-0.554	-0.083	
806+22	B-24			1062.170	1062.151	1062.226	1062.616	1062.089		-0.019	0.075	0.390	-0.527	-0.081	
816+43	B-25			1059.290	1059.263	1059.340	1059.696	1059.193		-0.027	0.077	0.356	-0.503	-0.097	
827+98	B-26			1060.832	1060.807	1060.880	1061.181	1060.733		-0.025	0.073	0.301	-0.448	-0.099	
839+66	B-27			1068.468	1068.432	1068.511	1068.790	1068.373		-0.036	0.079	0.279	-0.417	-0.095	
851+34	B-28			1068.583	1068.536	1068.631	1068.814	1068.496		-0.047	0.095	0.183	-0.318	-0.087	
862+42	B-29			1073.226	1073.178	1073.273	1073.444	1073.150		-0.048	0.095	0.171	-0.294	-0.076	
873+00	B-30			1072.622	1072.575	1072.664	1072.814	1072.547		-0.047	0.089	0.150	-0.267	-0.075	
884+29	B-31			1067.348	1067.319	1067.386	1067.514	1067.267		-0.029	0.067	0.128	-0.247	-0.081	
895+22	B-32			1063.692	1063.660	1063.725	1063.801	1063.594		-0.032	0.065	0.076	-0.207	-0.098	

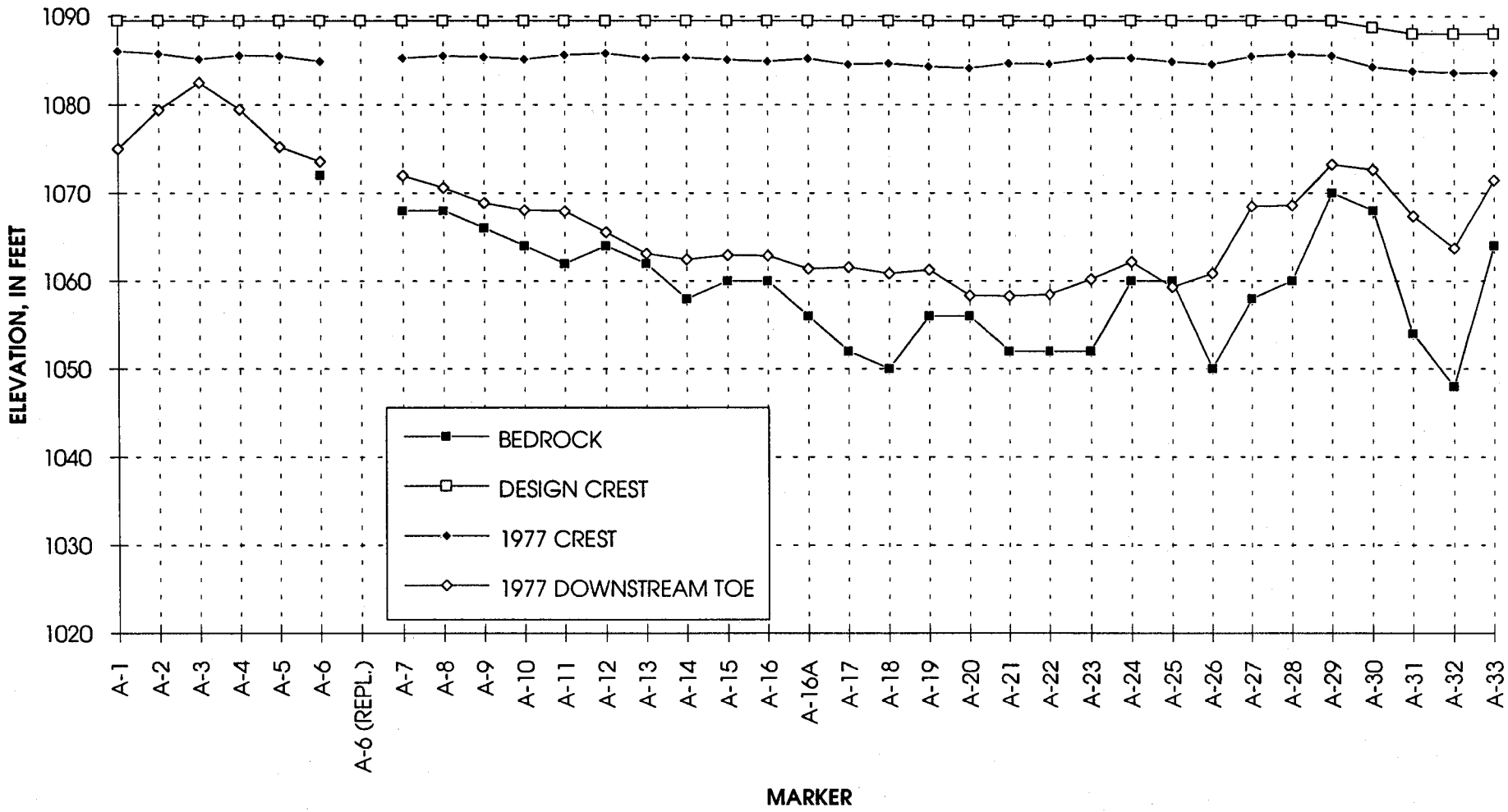
907+40	B-33			1071.408	1071.384	1071.425	1071.494	1071.300		-0.024	0.041	0.069	-0.194	-0.108	
AVERAGE CHANGE										**0.024**	**0.019**	**-0.159**	**0.016**	**-0.098**	
MINIMUM				**1058.273**	**1058.283**	**1058.359**	**1058.016**	**1058.198**		**-0.048**	**-0.254**	**-1.357**	**-0.554**	**-0.338**	
MAXIMUM				**1082.511**	**1082.514**	**1082.540**	**1082.202**	**1082.387**		**1.004**	**0.310**	**0.411**	**0.283**	**0.172**	
STATION	**MARKER**	**BEDROCK**	**DESIGN**	**1977**	**1979**	**1981**	**1984**	**1986**	**1994**	**77-79**	**79-81**	**81-84**	**84-86**	**77-86**	**74-94**
BENCHMARKS															
	DEAD-1			1419.000			1419.000	1419.000		######	0.000	######	0.000	######	
	DEAD-2				1193.291					######	######	0.000	0.000	######	
	R-1			1114.722	1114.722	1114.722	1114.533	1114.685		0.000	0.000	-0.189	0.152	######	
	R-2			1130.681	1130.681	1129.991	1129.854	1129.998		0.000	-0.690	-0.137	0.144	######	
	R-3					1225.786				0.000	######	######	0.000	0.000	
	R-3A							1201.281		0.000	0.000	0.000	######	######	
	L264		1093.10		1089.557	1089.546	1097.184	1089.545	1095.22	######	-0.011	7.638	-7.639	0.012	2.12
NOTES:															
1) CONSTRUCTION COMPLETED 1974															
2) DESIGN CREST ELEVATION = 1089.5															
3) DESIGN SPILLWAY CREST = 1079.8															
4) MAXIMUM HEIGHT = 31.5 FEET.															
5) EMBANKMENT DRAIN ADDED IN 1981 BETWEEN STATIONS 565+00 AND 801+00 TO CORRECT TRANSVERSE CRACKING PROBLEM.															
6) CRACKING PROBLEM WAS MOST SEVERE BETWEEN STATIONS 590+00 AND 720+00.															
7) SHADED AREAS INDICATE DATA ANOMOLIES. THESE HAVE BEEN RECHECKED FROM SCS PLAN SHEETS, BUT ERROR IS SUSPECTED.															
8) SURVEYS OF BUCKEYE STRUCTURES BASED ON BENCHMARK "DEAD" WHICH HAS SUBSIDED ABOUT 3.7'.															
9) ALL CONTROL POINTS MEASURED IN 1979 WERE 3.5' TO 3.6' LOWER THAN THEIR RECORDED ELEVATIONS (1974?).															

5/30/95

BUCKEYE FRS #1 CREST SETTLEMENT MONUMENTS

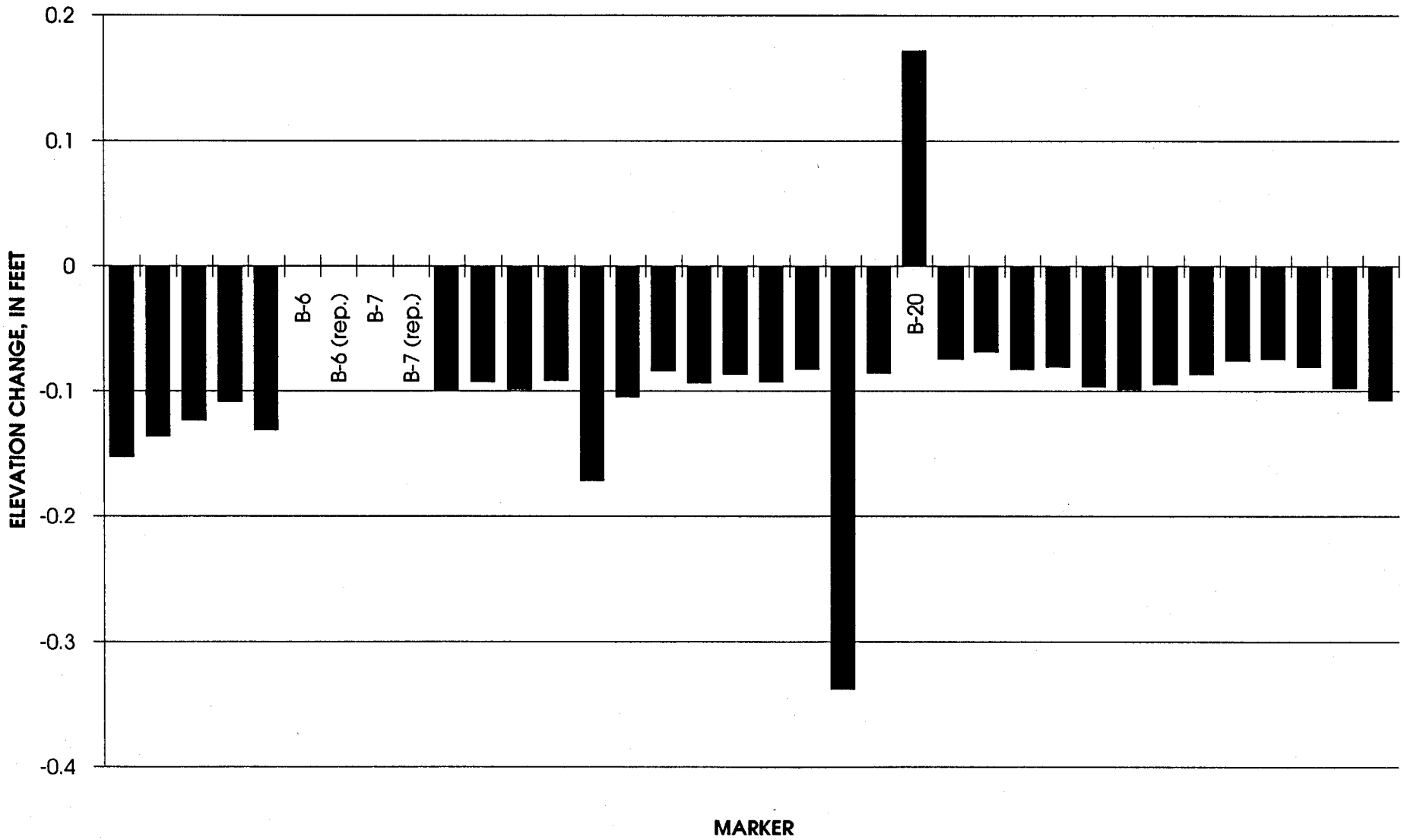


BUCKEYE FRS #1

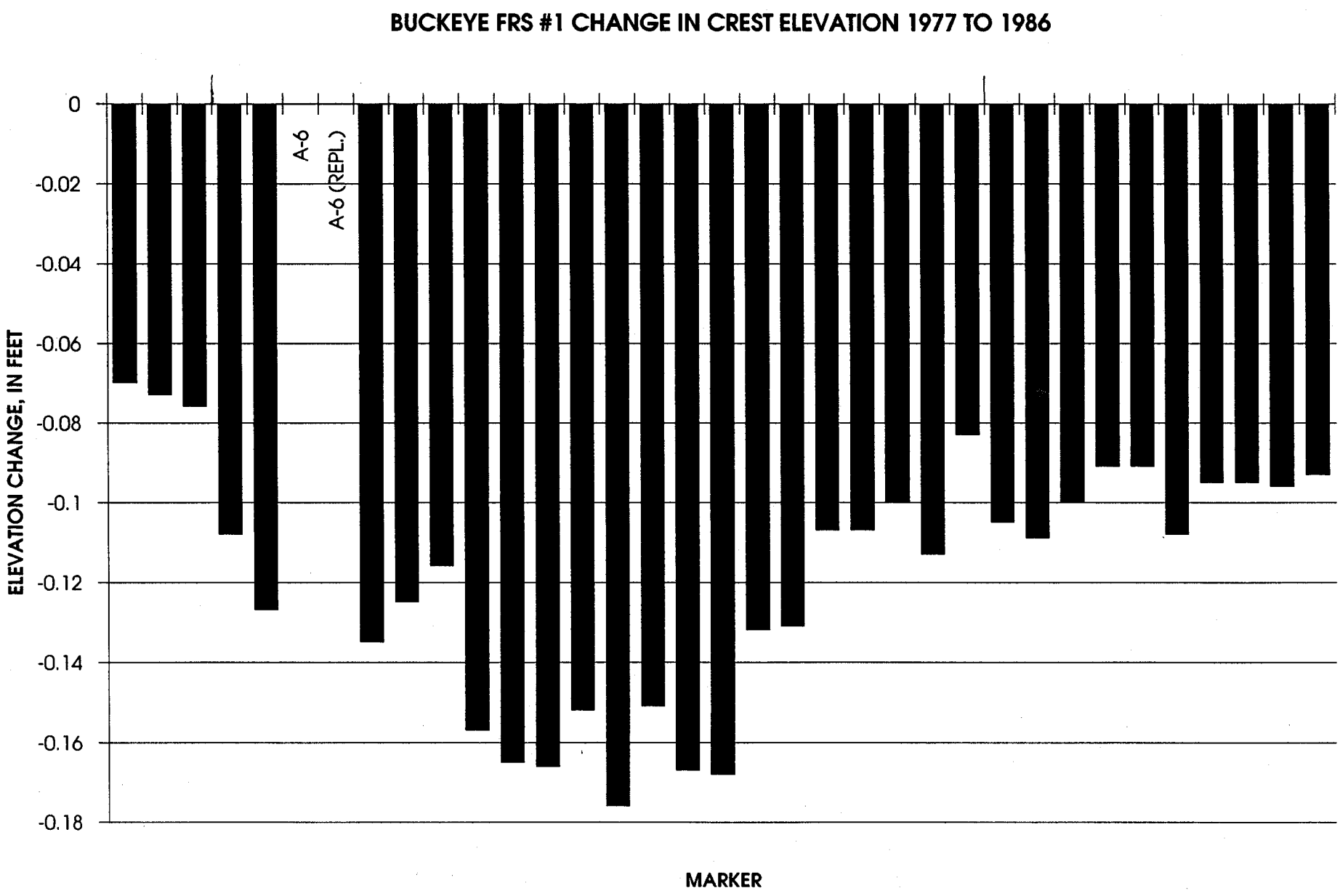


4/27/95

BUCKEYE FRS #1 CHANGE IN DOWNSTREAM TOE ELEVATION 1977 TO 1986



5/11/95


BUCKEYE FRS #1 CHANGE IN CREST ELEVATION 1977 TO 1986
ELEVATION CHANGE, IN FEET
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
A-6
A-6 (REPL.)
MARKER

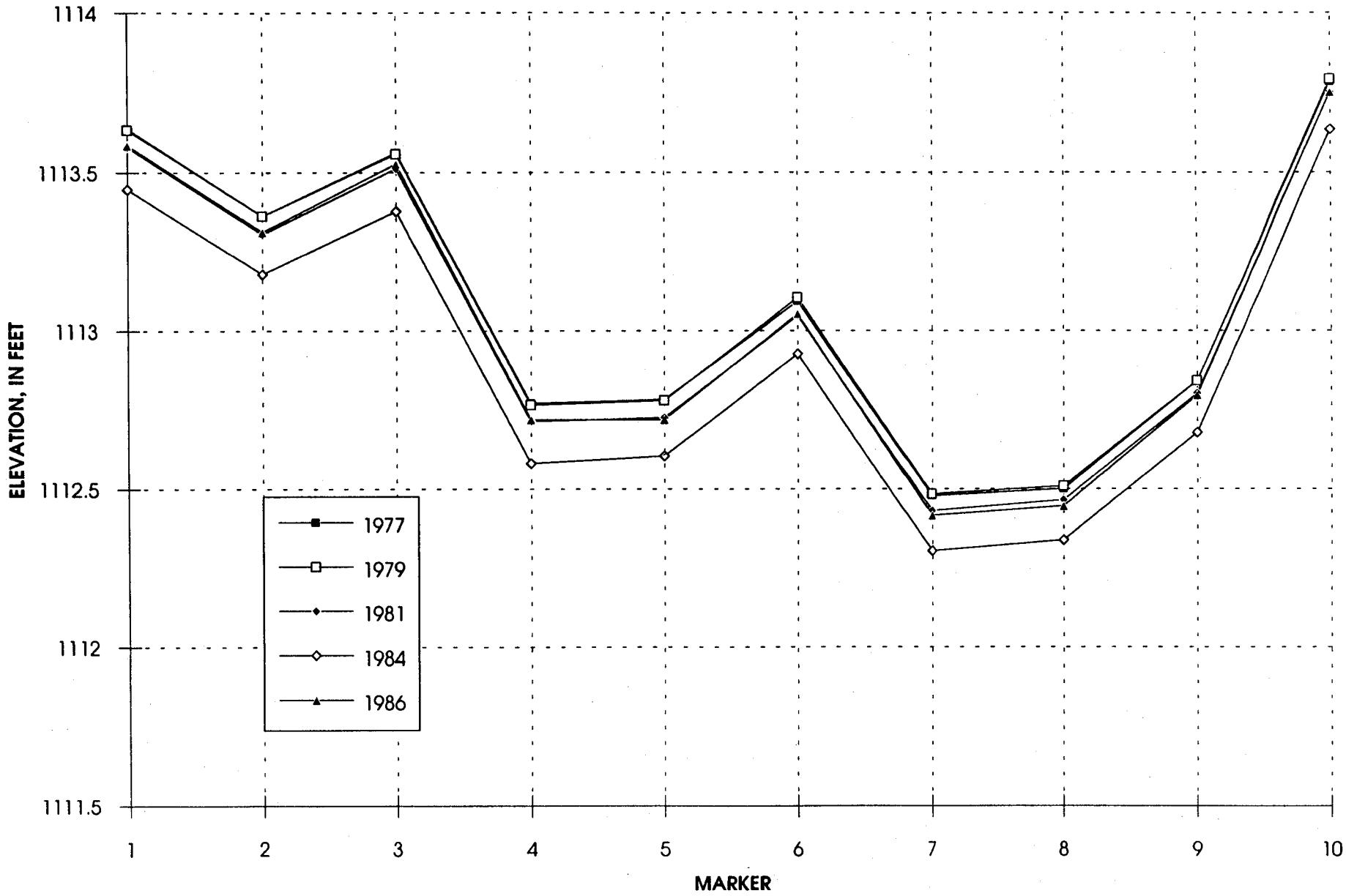
5/30/95

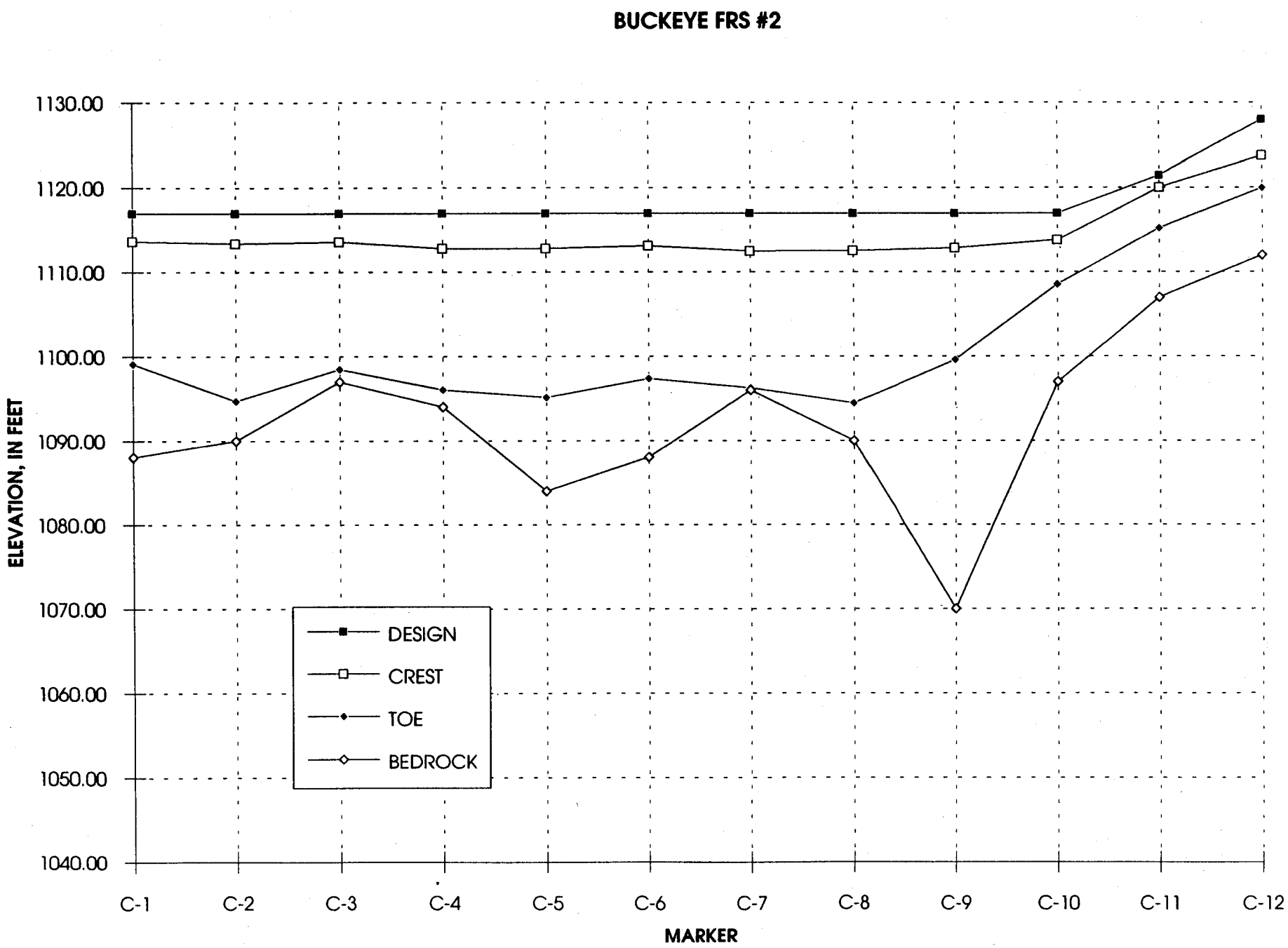
BUCKEYE FRS #2 SETTLEMENT/SUBSIDENCE MONITORING													
MARKER	**STATION**	**DESIGN**	**BEDROCK**	**1977**	**1979**	**1981**	**1984**	**1986**	**1977-1979**	**1979-1981**	**1981-1984**	**1984-1986**	**1977-1986**
C-1	323+52	1117.00	1102	1113.638	1113.633	1113.579	1113.446	1113.585	-0.005	-0.054	-0.133	0.139	-0.053
C-2	310+95	1117.00	1088	1113.362	1113.362	1113.306	1113.178	1113.312	0.000	-0.056	-0.128	0.134	-0.050
C-3	297+58	1117.00	1098	1113.562	1113.557	1113.512	1113.378	1113.526	-0.005	-0.045	-0.134	0.148	-0.036
C-4	287+90	1117.00	1092	1112.771	1112.764	1112.713	1112.580	1112.719	-0.007	-0.051	-0.133	0.139	-0.052
C-5	277+18	1117.00	1085	1112.782	1112.780	1112.725	1112.605	1112.719	-0.002	-0.055	-0.120	0.114	-0.063
C-6	267+85	1117.00	1092	1113.093	1113.105	1113.047	1112.927	1113.053	0.012	-0.058	-0.120	0.126	-0.040
C-7	258+42	1117.00	1096	1112.478	1112.484	1112.431	1112.304	1112.416	0.006	-0.053	-0.127	0.112	-0.062
C-8	248+30	1117.00	1090	1112.500	1112.509	1112.464	1112.337	1112.446	0.009	-0.045	-0.127	0.109	-0.054
C-9	238+40	1117.00	1070	1112.841	1112.842	1112.802	1112.678	1112.796	0.001	-0.040	-0.124	0.118	-0.045
C-10	228+34	1117.00	1099	1113.784	1113.792	1113.751	1113.635	1113.752	0.008	-0.041	-0.116	0.117	-0.032
C-11	217+78	1123.72	1109	1120.000	1120.014	1119.980	1119.879	1119.986	0.014	-0.034	-0.101	0.107	-0.014
C-12	210+31	1127.83	1112	1123.680	1123.691	1123.656	1123.552	1123.679	0.011	-0.035	-0.104	0.127	-0.001
AVERAGE CHANGE									**0.003**	**-0.047**	**-0.122**	**0.124**	**-0.042**
MINIMUM				**1112.478**	**1112.484**	**1112.431**	**1112.304**	**1112.416**	**-0.007**	**-0.058**	**-0.134**	**0.107**	**-0.063**
MAXIMUM									**0.014**	**-0.034**	**-0.101**	**0.148**	**-0.001**
DOWNSTREAM TOE													
D-1	323+32			1099.082	1099.082	1099.022	1098.887	1099.001	0.000	-0.060	-0.135	0.114	-0.081
D-2	310+89			1094.692	1094.702	1094.653	1094.497	1094.618	0.010	-0.049	-0.156	0.121	-0.074
D-3	297+36			1098.470	1098.477	1098.433	1098.284	1098.415	0.007	-0.044	-0.149	0.131	-0.055
D-4	287+77			1096.031	1096.061	1096.013	1095.852	1096.002	0.030	-0.048	-0.161	0.150	-0.029
D-5	277+13			1095.102	1095.112	1095.064	1094.903	1095.036	0.010	-0.048	-0.161	0.133	-0.066
D-6	268+11			1097.336	1097.349	1097.294	1097.138	1097.280	0.013	-0.055	-0.156	0.142	-0.056
D-7	258+46			1096.236	1096.252	1096.197	1096.041	1096.190	0.016	-0.055	-0.156	0.149	-0.046
D-8	248+51			1094.427	1094.437	1094.398	1094.243	1094.387	0.010	-0.039	-0.155	0.144	-0.040
D-9	238+37			1099.601	1099.612	1099.567	1099.438	1099.558	0.011	-0.045	-0.129	0.120	-0.043
D-10	227+67			1108.558	1108.567	1108.535	1108.398	1108.534	0.009	-0.032	-0.137	0.136	-0.024
D-11	217+78			1115.244	1115.272	1115.235	1115.106	1115.263	0.028	-0.037	-0.129	0.157	0.019
D-12	210+40			1119.927	1119.946	1119.908	1119.802	1119.936	0.019	-0.038	-0.106	0.134	0.009
AVERAGE CHANGE									**0.014**	**-0.046**	**-0.144**	**0.136**	**-0.041**
MINIMUM									**-0.007**	**-0.060**	**-0.161**	**0.107**	**-0.081**
MAXIMUM									**0.030**	**-0.032**	**-0.101**	**0.157**	**0.019**
C1-D1	323+52								-0.005	0.006	0.002	0.025	0.028
C2-D2	310+95								-0.010	-0.007	0.028	0.013	0.024
C3-D3	297+58								-0.012	-0.001	0.015	0.017	0.019
C4-D4	287+90								-0.037	-0.003	0.028	-0.011	-0.023
C5-D5	277+18								-0.012	-0.007	0.041	-0.019	0.003
C6-D6	267+85								-0.001	-0.003	0.036	-0.016	0.016
C7-D7	258+42								-0.010	0.002	0.029	-0.037	-0.016
C8-D8	248+30								-0.001	-0.006	0.028	-0.035	-0.014

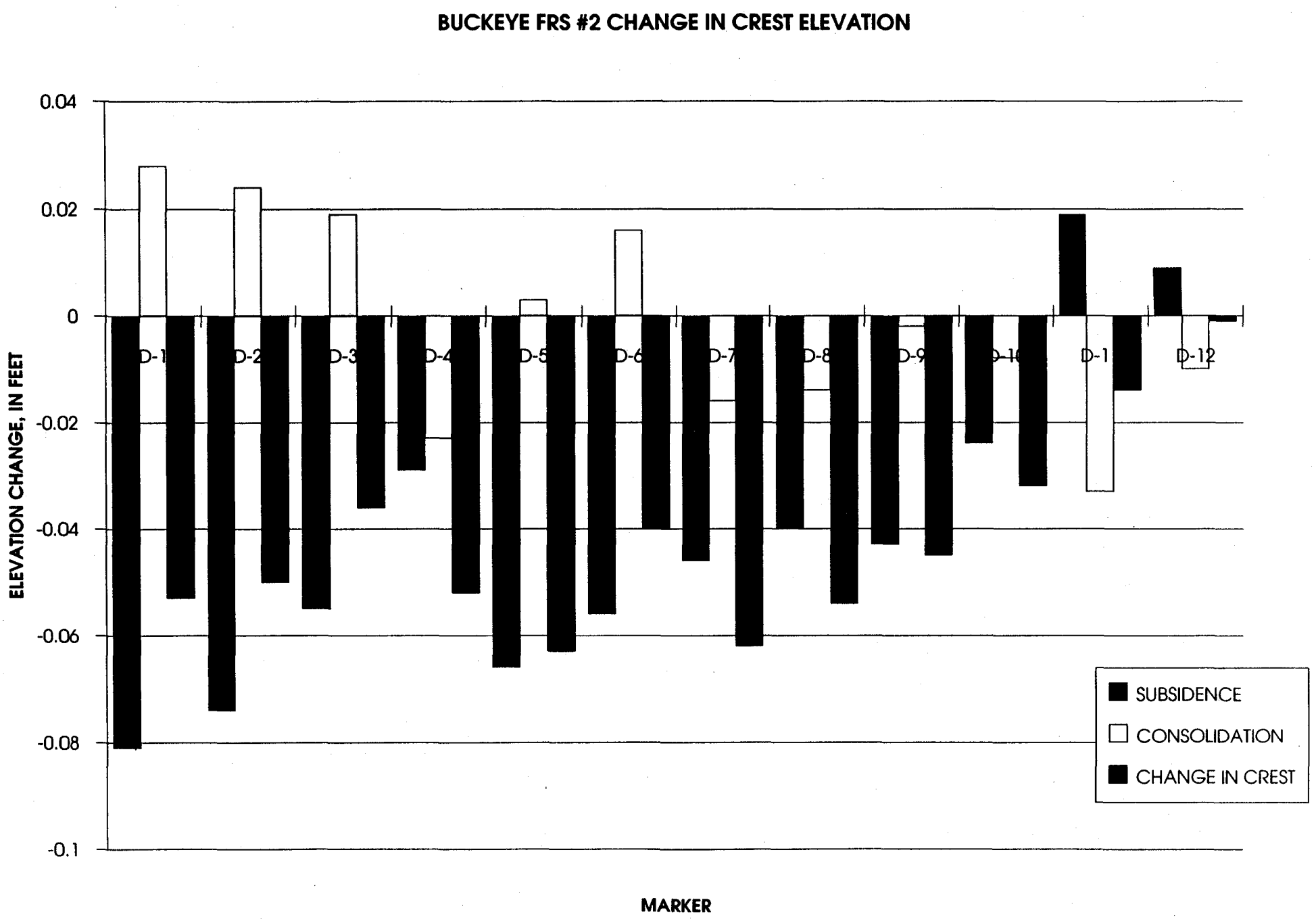
C9-D9	238+40								-0.010	0.005	0.005	-0.002	-0.002
C10-D10	228+34								-0.001	-0.009	0.021	-0.019	-0.008
C11-D11	217+78								-0.014	0.003	0.028	-0.050	-0.033
C12-D12	210+31								-0.008	0.003	0.002	-0.007	-0.010
AVERAGE CHANGE									**-0.010**	**-0.001**	**0.022**	**-0.012**	**-0.001**
MINIMUM									**-0.037**	**-0.009**	**0.002**	**-0.050**	**-0.033**
MAXIMUM									**-0.001**	**0.006**	**0.041**	**0.025**	**0.028**
NOTES:													
1) CONSTRUCTION COMPLETED 1974													
2) DESIGN CREST = 1117.0 BETWEEN STATIONS 230+00 AND 325													
3) DESIGN CREST VARIES FROM 1131.58 TO 1117.0 BETWEEN STATIONS 203+50 AND 230+00													
4) DESIGN SPILLWAY CREST = 1111.2													
5) MAXIMUM HEIGHT = 26'													
4) "BEDROCK" INDICATES ELEVATION OF SILTSTONE AS NOTED ON THE CONSTRUCTION PLANS													

5/17/95

BUCKEYE FRS #2 CREST SETTLEMENT MONUMENTS

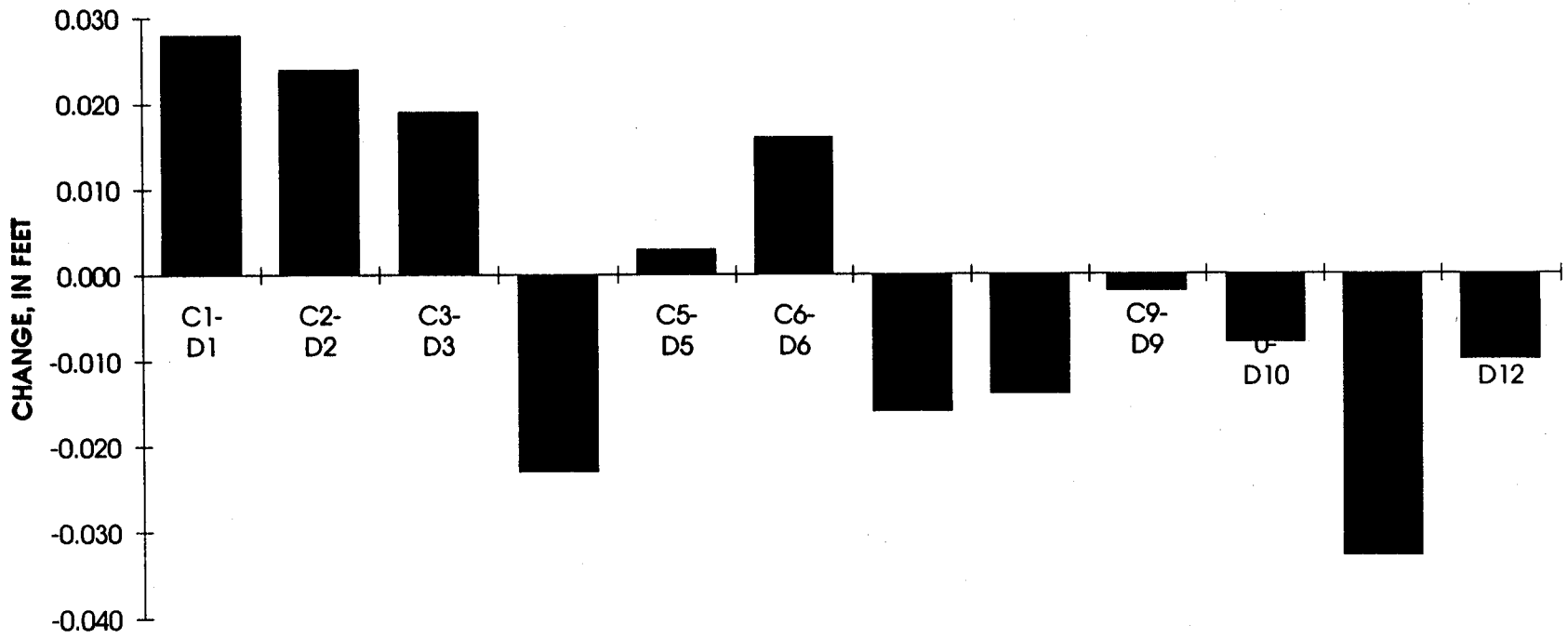


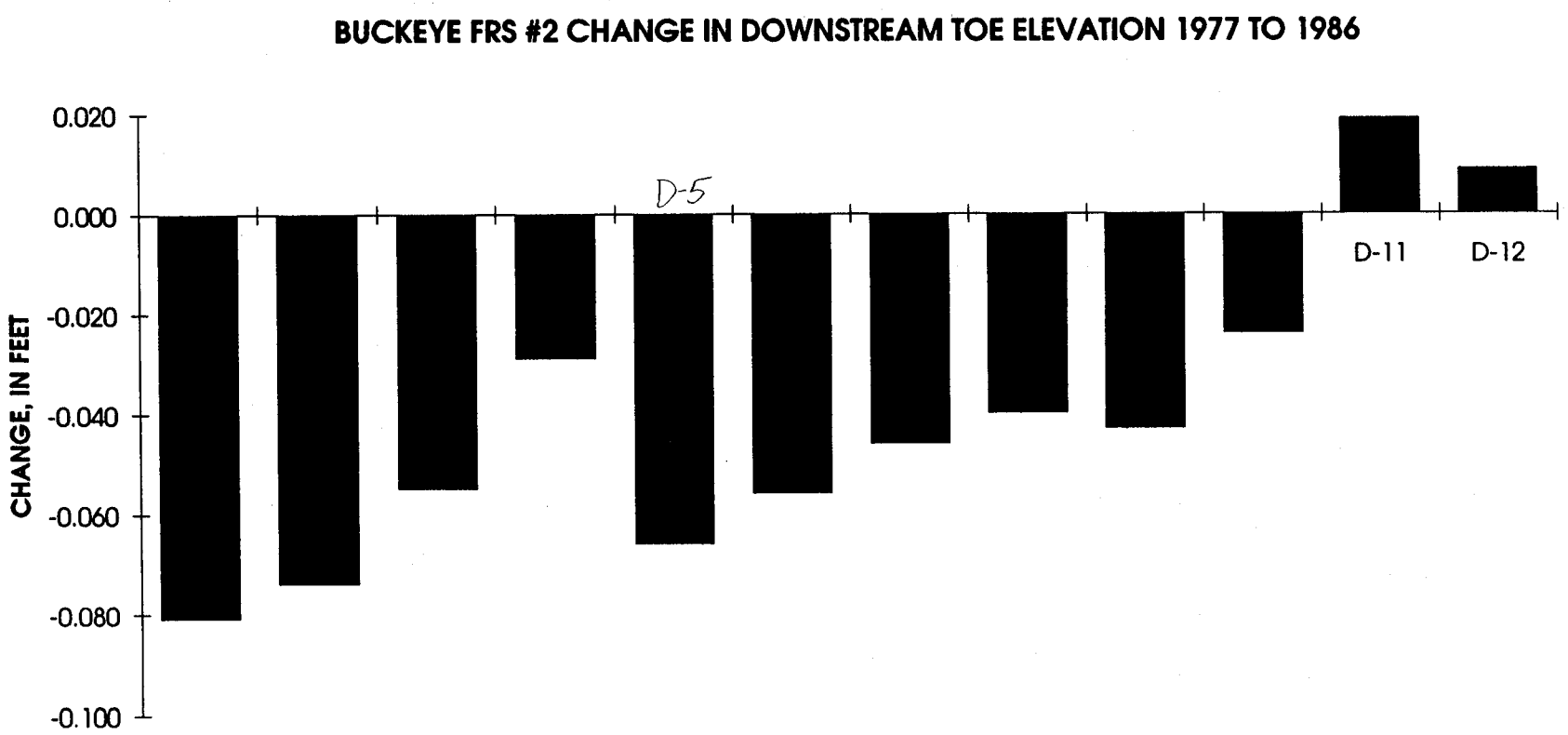

BUCKEYE FRS #2
1130.00
1120.00
1110.00
1100.00
1090.00
1080.00
1070.00
1060.00
1050.00
1040.00
ELEVATION, IN FEET
C-1
C-2
C-3
C-4
C-5
C-6
C-7
C-8
C-9
C-10
C-11
C-12
MARKER
DESIGN
CREST
TOE
BEDROCK

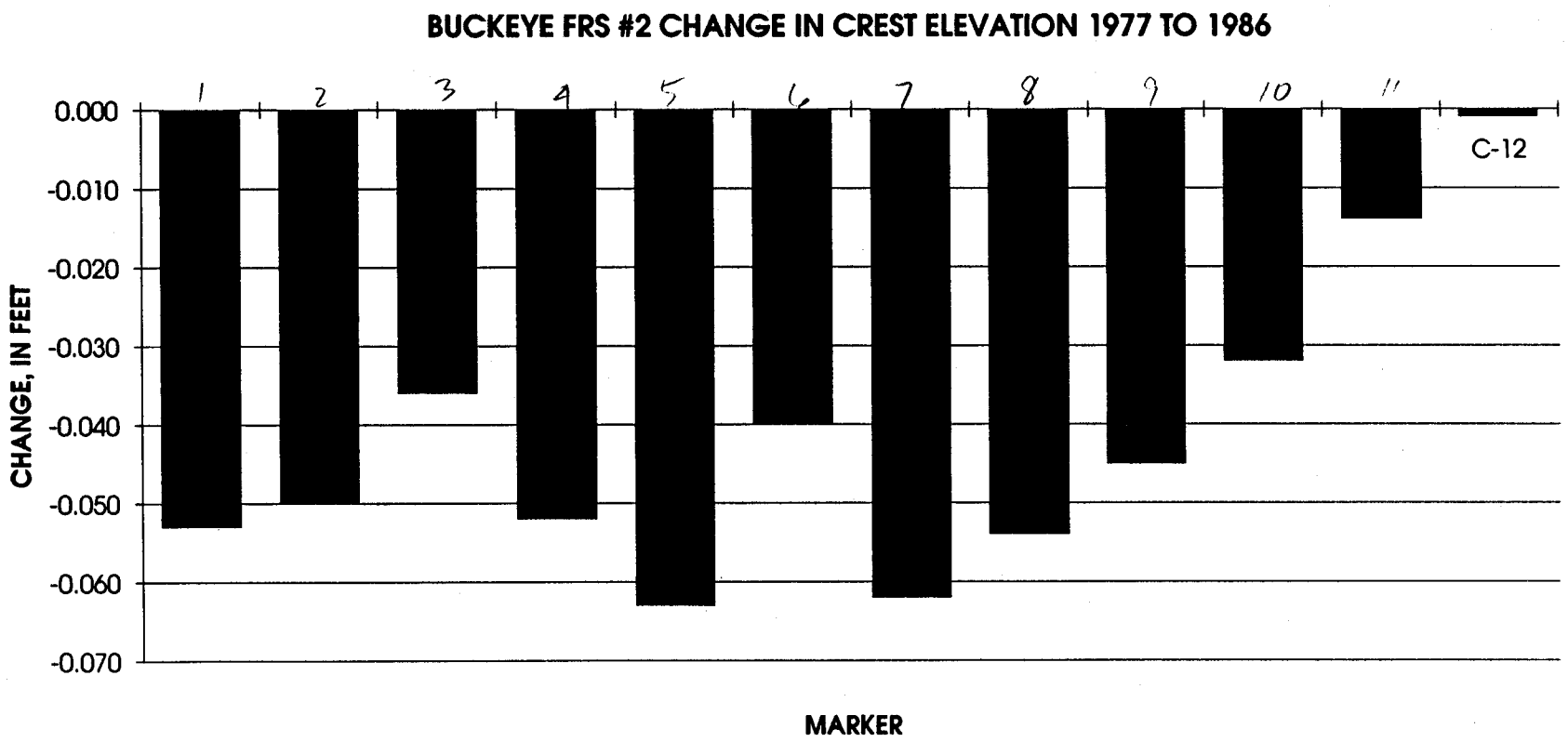

BUCKEYE FRS #2 CHANGE IN CREST ELEVATION
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
ELEVATION CHANGE, IN FEET
D-1
D-2
D-3
D-4
D-5
D-6
D-7
D-8
D-9
D-10
D-11
D-12
SUBSIDENCE
CONSOLIDATION
CHANGE IN CREST
MARKER

Consolidation of Fill

BUCKEYE FRS #2 CHANGE IN CREST MINUS TOE ELEVATION 1977 TO 1986




BUCKEYE FRS #2 CHANGE IN DOWNSTREAM TOE ELEVATION 1977 TO 1986
CHANGE, IN FEET
0.020
0.000
-0.020
-0.040
-0.060
-0.080
-0.100
D-5
D-11
D-12


BUCKEYE FRS #2 CHANGE IN CREST ELEVATION 1977 TO 1986
CHANGE, IN FEET
0.000
-0.010
-0.020
-0.030
-0.040
-0.050
-0.060
-0.070
1
2
3
4
5
6
7
8
9
10
11
C-12
MARKER

5/30/95

BUCKEYE FRS #3 SUBSIDENCE MONITORING													
MARKER	**STATION**	**DESIGN**	**BEDROCK**	**1977**	**1979**	**1981**	**1984**	**1986**	**1977-1979**	**1979-1981**	**1981-1984**	**1984-1986**	**1977-1986**
E-1	192+50	1170.00	1157	1166.388	1166.422	1166.437	1166.286	1166.483	0.034	0.015	-0.151	0.197	0.095
E-2	179+28	1170.00	1145	1165.267	1165.288	1165.322	1165.141	1165.361	0.021	0.034	-0.181	0.220	0.094
E-3	167+62	1170.00	1145	1166.440	1166.456	1166.499	1166.318	1166.541	0.016	0.043	-0.181	0.223	0.101
E-4	154+81	1170.00	1144	1165.499	1165.526	1165.580	1165.388	1165.606	0.027	0.054	-0.192	0.218	0.107
E-5	143+64	1170.00	1144	1165.241	1165.264	1165.299	1165.113	1165.331	0.023	0.035	-0.186	0.218	0.090
E-6	131+85	1170.00	1140	1166.437	1166.469	1166.505	1166.328	1166.558	0.032	0.036	-0.177	0.230	0.121
E-7	122+40	1170.00	1145	1165.814	1165.849	1165.890	1165.722	1165.961	0.035	0.041	-0.168	0.239	0.147
E-8	112+07	1170.00	1148	1165.883	1165.920	1165.963	1165.777	1166.051	0.037	0.043	-0.186	0.274	0.168
E-9	100+85	1170.00	1148	1166.136	1166.175	1166.225	1166.046	1166.320	0.039	0.050	-0.179	0.274	0.184
E-10	90+43	1170.00	1146	1165.773	1165.822	1165.871	1165.701	1165.993	0.049	0.049	-0.170	0.292	0.220
E-11	79+98	1170.00	1148	1166.243	1166.292	1166.334	1166.207	1166.475	0.049	0.042	-0.127	0.268	0.232
E-12	70+62	1170.00	1139	1165.748	1165.813	1165.851	1165.744	1166.002	0.065	0.038	-0.107	0.258	0.254
E-13	61+08	1170.00	1148	1164.785	1164.838	1164.882	1164.767	1165.038	0.053	0.044	-0.115	0.271	0.253
E-14	50+60	1170.00	1146	1165.551	1165.610	1165.654	1165.549	1165.828	0.059	0.044	-0.105	0.279	0.277
E-15	41+24	1170.00	1148	1165.088	1165.149	1165.182	1165.075	1165.361	0.061	0.033	-0.107	0.286	0.273
E-16	30+92	1170.00	1147	1166.934	1167.020	1167.073	1166.911	1167.201	0.086	0.053	-0.162	0.290	0.267
AVERAGE CHANGE									**0.043**	**0.041**	**-0.156**	**0.252**	**0.180**
MINIMUM				**1164.785**	**1164.838**	**1164.882**	**1164.767**	**1165.038**	**0.016**	**0.015**	**-0.192**	**0.197**	**0.090**
MAXIMUM				**1166.934**	**1167.020**	**1167.073**	**1166.911**	**1167.201**	**0.086**	**0.054**	**-0.105**	**0.292**	**0.277**
F-1	192+50			1159.270	1159.311	1159.326	1159.180	1159.435	0.041	0.015	-0.146	0.255	0.165
F-2	179+07			1143.686	1143.710	1143.739	1143.603	1143.828	0.024	0.029	-0.136	0.225	0.142
F-3	167+62			1145.643	1145.670	1145.702	1145.553	1145.785	0.027	0.032	-0.149	0.232	0.142
F-4	154+70			1147.220	1147.247	1147.294	1147.132	1147.395	0.027	0.047	-0.162	0.263	0.175
F-5	143+55			1148.129	1148.162	1148.200	1148.065	1148.316	0.033	0.038	-0.135	0.251	0.187
F-6	131+95			1146.825	1146.860	1146.894	1146.750	1147.179	0.035	0.034	-0.144	0.429	0.354
F-7	122+50			1147.755	1147.793	1147.810	1147.684	1147.965	0.038	0.017	-0.126	0.281	0.210
F-8	112+12			1148.187	1148.243	1148.282	1148.147	1148.425	0.056	0.039	-0.135	0.278	0.238
F-9	100+92			1148.842	1148.895	1148.928	1148.784	1149.042	0.053	0.033	-0.144	0.258	0.200
F-10	90+73			1147.592	1147.655	1147.689	1147.543	1147.806	0.063	0.034	-0.146	0.263	0.214
F-11	80+03			1147.645	1147.712	1147.727	1147.576	1147.863	0.067	0.015	-0.151	0.287	0.218
F-12	70+49			1148.391	1148.478	1148.269	1148.114	1148.406	0.087	-0.209	-0.155	0.292	0.015
F-13	60+94			1146.863	1146.950	1147.041	1146.897	1147.179	0.087	0.091	-0.144	0.282	0.316
F-14	50+40			1147.278	1147.376	1147.377	1147.254	1147.539	0.098	0.001	-0.123	0.285	0.261
F-15	41+24			1147.587	1147.685	1147.685	1147.555	1147.859	0.098	0.000	-0.130	0.304	0.272
F-16	31+04			1151.988	1152.081	1152.138	1151.951	1152.269	0.093	0.057	-0.187	0.318	0.281
AVERAGE CHANGE									**0.058**	**0.017**	**-0.145**	**0.281**	**0.212**
MINIMUM									**0.024**	**-0.209**	**-0.187**	**0.225**	**0.015**
MAXIMUM									**0.098**	**0.091**	**-0.123**	**0.429**	**0.354**
E1-F1									-0.007	0.000	-0.005	-0.058	-0.070
E2-F2									-0.003	0.005	-0.045	-0.005	-0.048

E3-F3									-0.011	0.011	-0.032	-0.009	-0.041
E4-F4									0.000	0.007	-0.030	-0.045	-0.068
E5-F5									-0.010	-0.003	-0.051	-0.033	-0.097
E6-F6									-0.003	0.002	-0.033	-0.199	-0.233
E7-F7									-0.003	0.024	-0.042	-0.042	-0.063
E8-F8									-0.019	0.004	-0.051	-0.004	-0.070
E9-F9									-0.014	0.017	-0.035	0.016	-0.016
E10-F10									-0.014	0.015	-0.024	0.029	0.006
E11-F11									-0.018	0.027	0.024	-0.019	0.014
E12-F12									-0.022	0.247	0.048	-0.034	0.239
E13-F13									-0.034	-0.047	0.029	-0.011	-0.063
E14-F14									-0.039	0.043	0.018	-0.006	0.016
E15-F15									-0.037	0.033	0.023	-0.018	0.001
E16-F16									-0.007	-0.004	0.025	-0.028	-0.014
AVERAGE CHANGE									**-0.015**	**0.024**	**-0.011**	**-0.029**	**-0.032**
MINIMUM									**-0.039**	**-0.047**	**-0.051**	**-0.199**	**-0.233**
MAXIMUM									**0.000**	**0.247**	**0.048**	**0.029**	**0.239**
NOTES:													
1) CONSTRUCTION COMPLETED 1975													
2) DESIGN CREST ELEVATION = 1170.0													
3) DESIGN SPILLWAY ELEVATION = 1162.2													
4) MAXIMUM HEIGHT = 34'													

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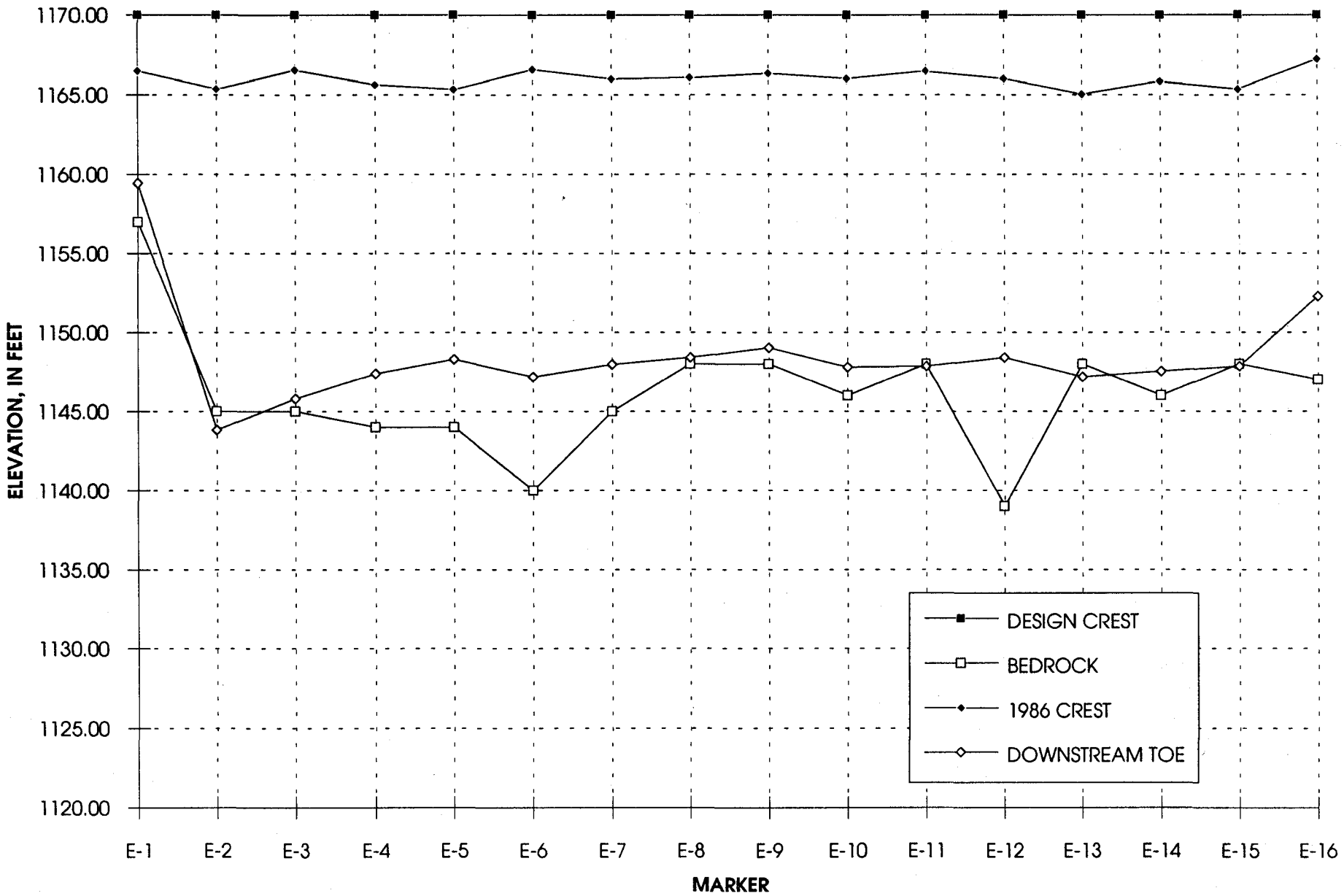
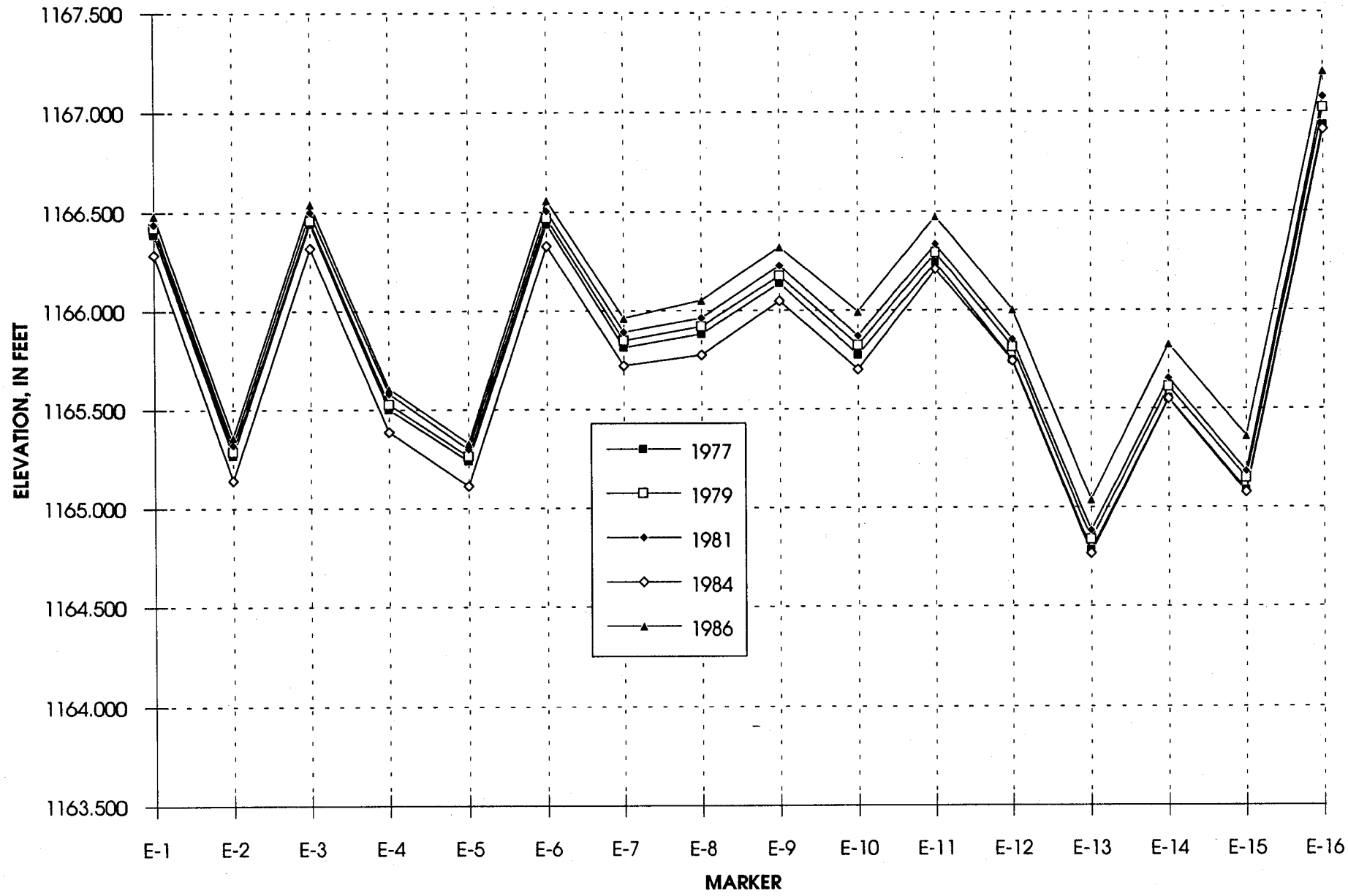
BUCKEYE FRS #3



BUCKEYE FRS #3 CREST SETTLEMENT MONUMENTS



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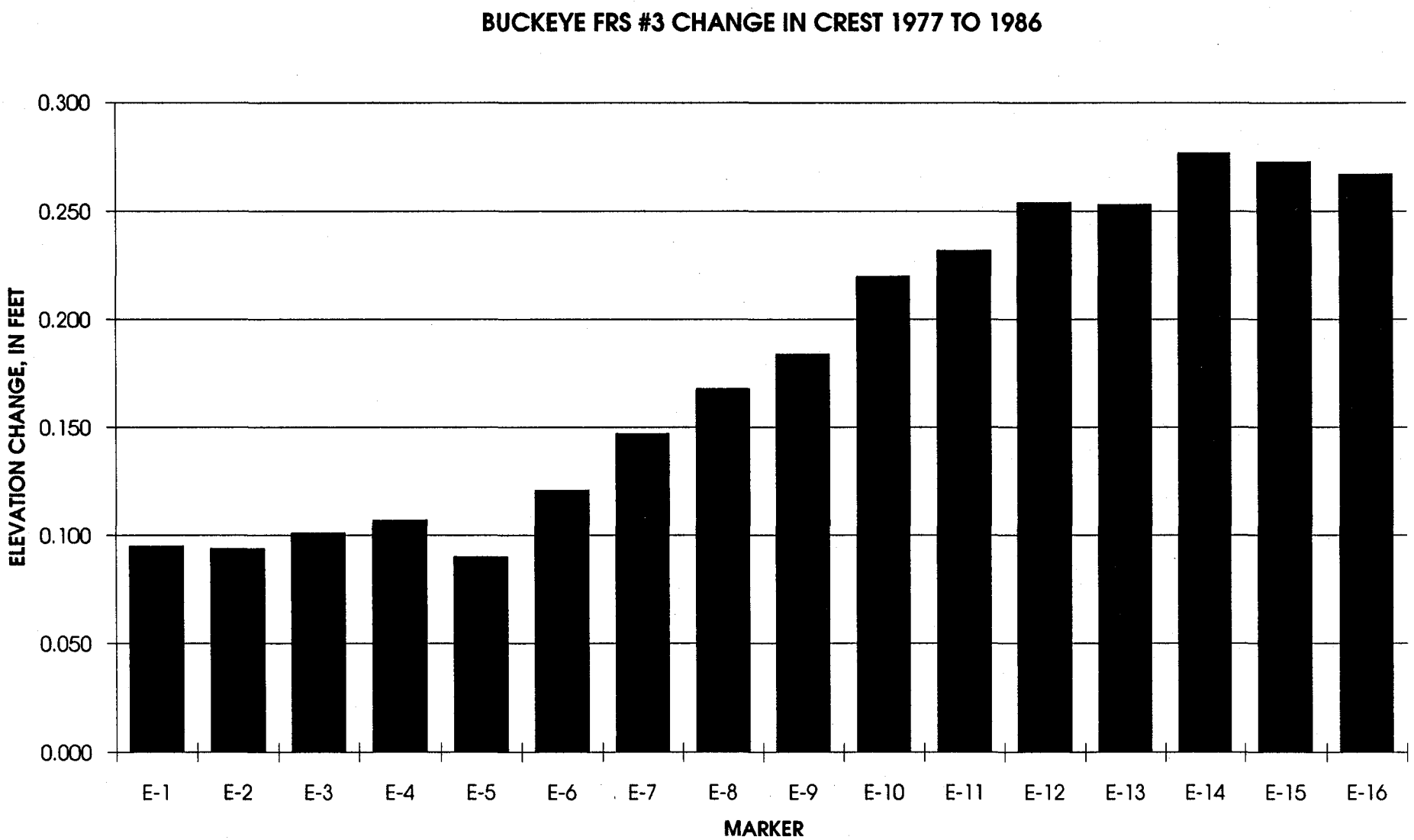
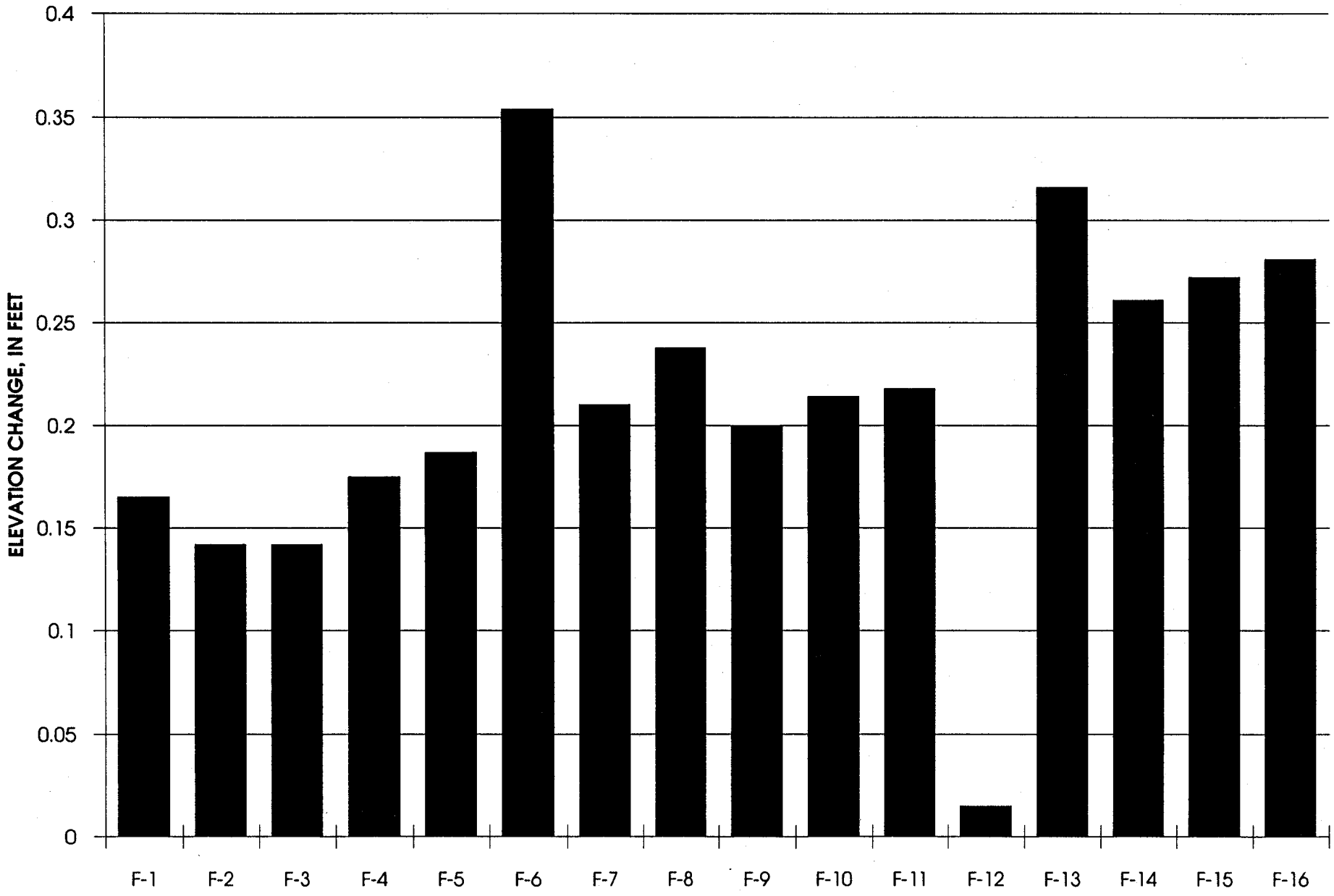

BUCKEYE FRS #3 CHANGE IN CREST 1977 TO 1986
ELEVATION CHANGE, IN FEET
0.300
0.250
0.200
0.150
0.100
0.050
0.000
E-1
E-2
E-3
E-4
E-5
E-6
E-7
E-8
E-9
E-10
E-11
E-12
E-13
E-14
E-15
E-16
MARKER

4/27/95

BUCKEYE FRS #3 CHANGE IN DOWNSTREAM TOE 1977 TO 1986



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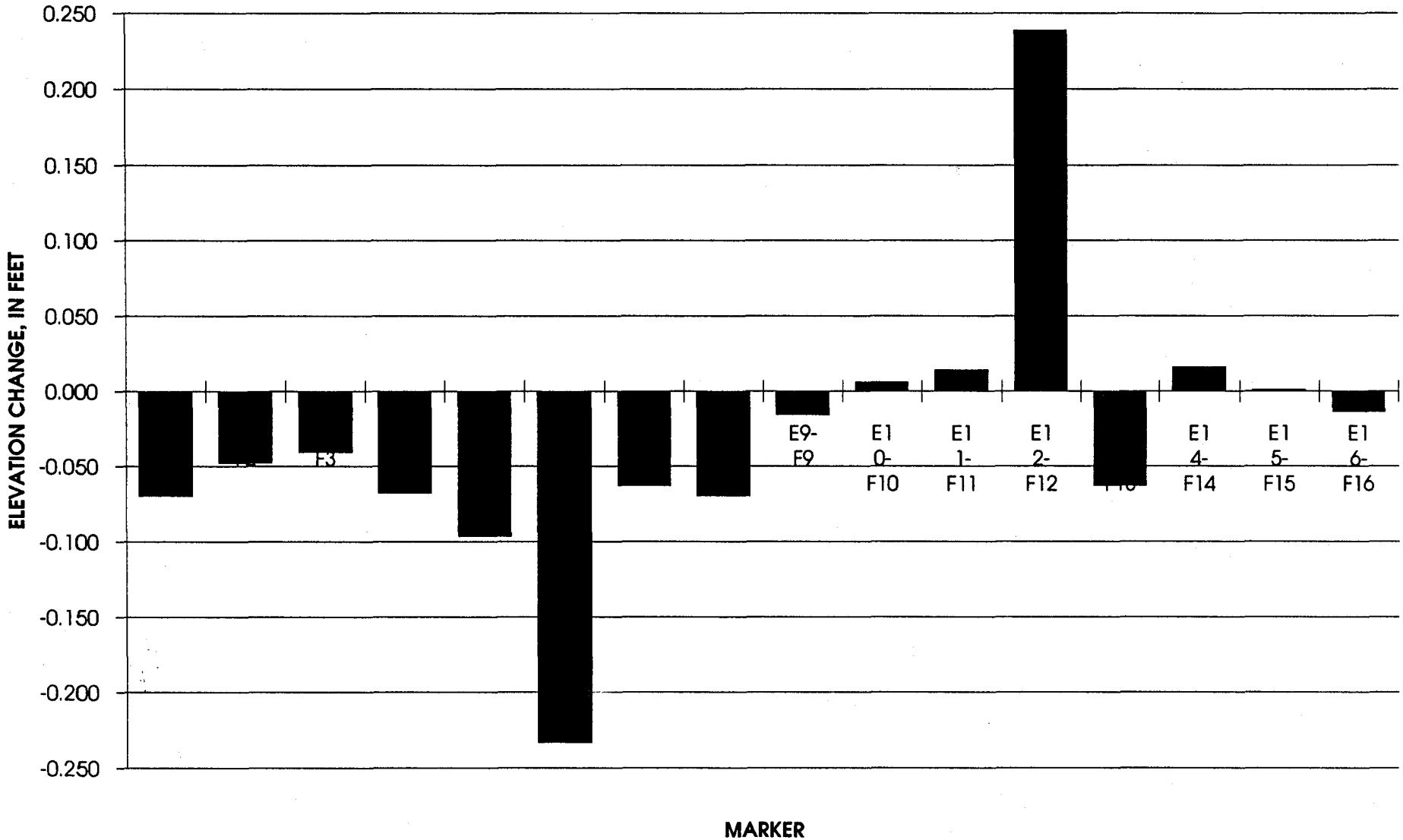
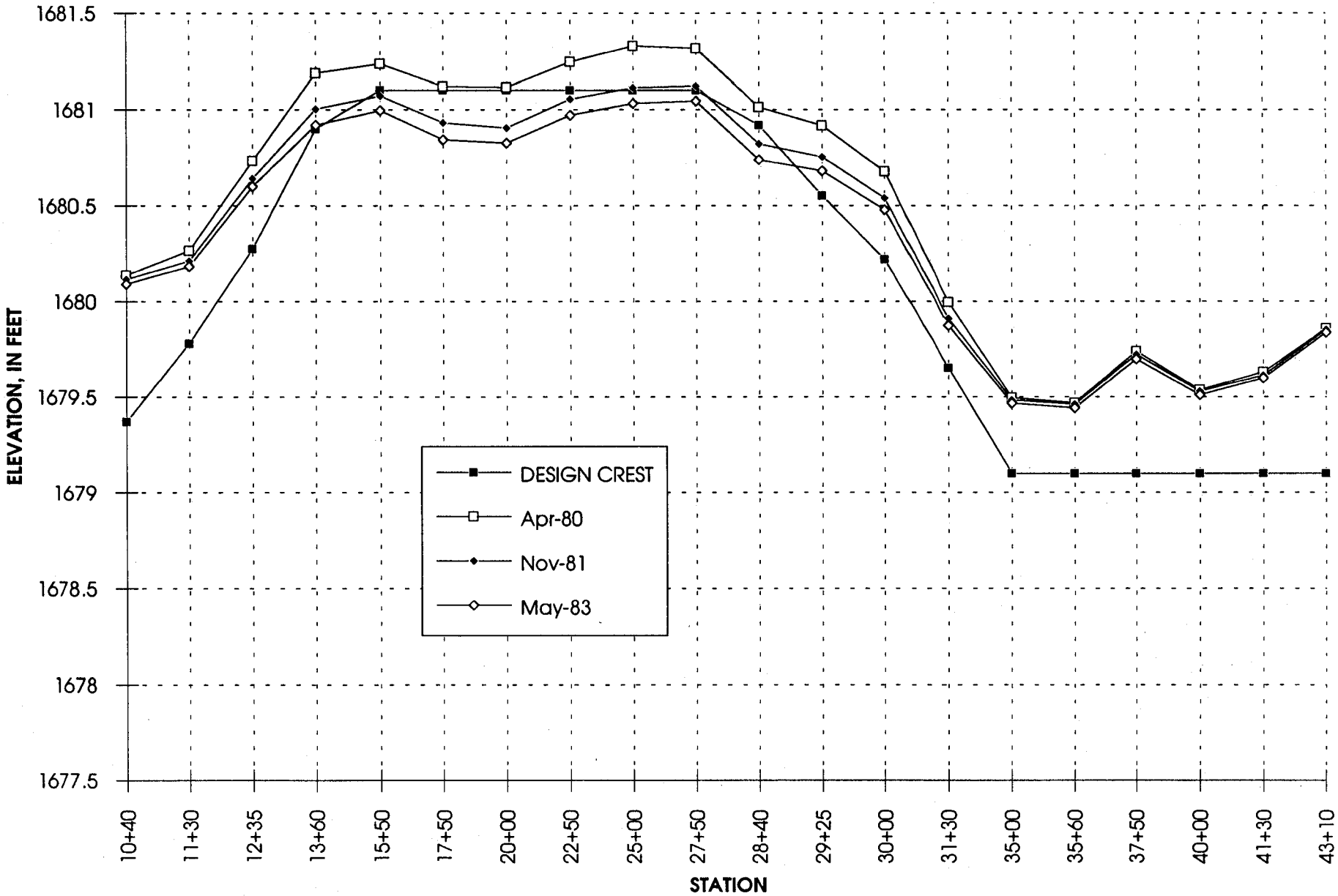
BUCKEYE FRS #3 CONSOLIDATION/EXPANSION

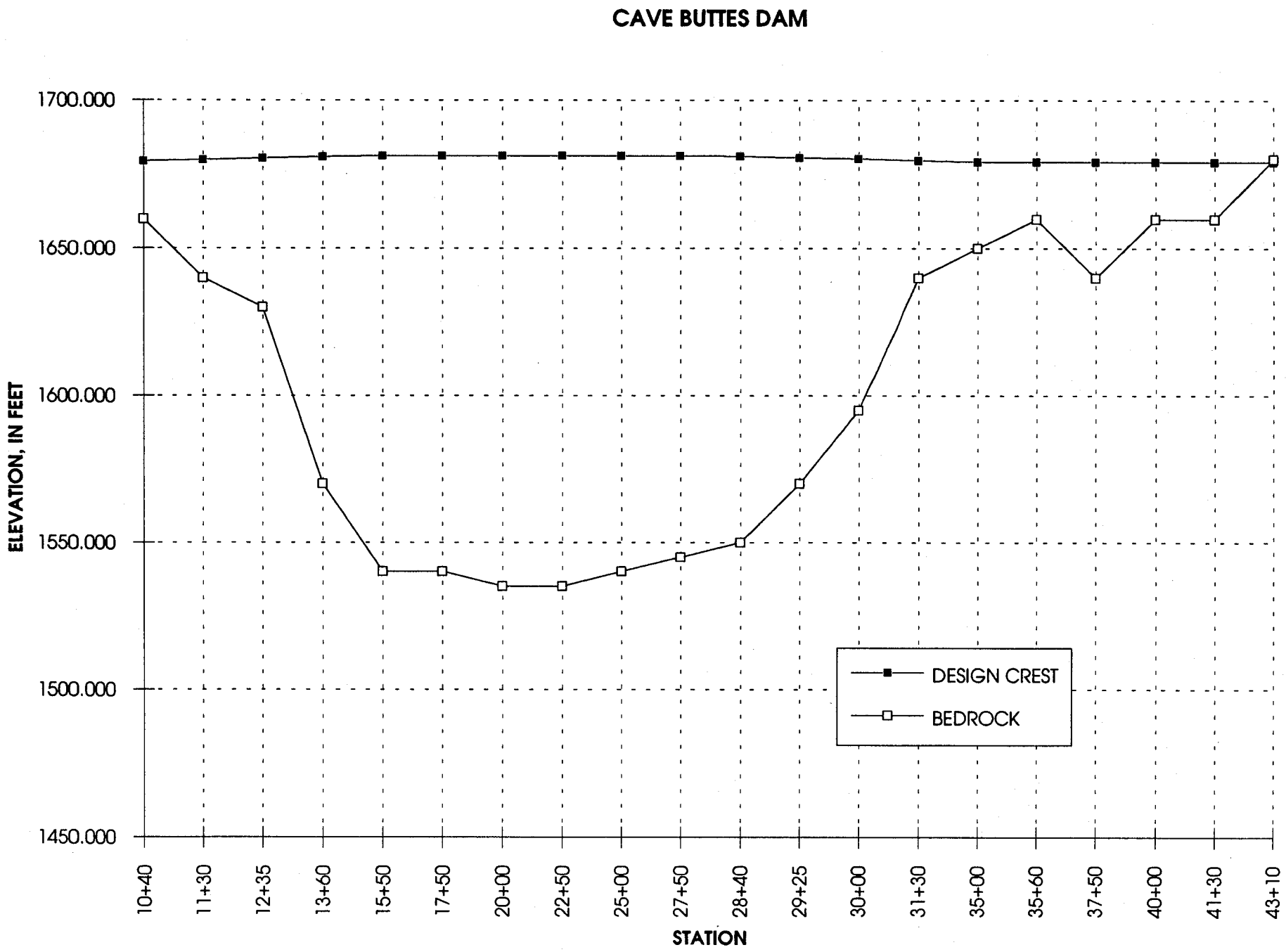


CAVE BUTTES DAM & DIKE #1 SUBSIDENCE MONITORING									
MARKER	**STATION**	**DESIGN**	**BEDROCK**	**Apr-80**	**Nov-81**	**May-83**	**1980-1981**	**1981-1983**	**1980-1983**
SM-1	10+40	1679.370	1660	1680.136	1680.115	1680.090	-0.021	-0.025	-0.046
SM-2	11+30	1679.780	1640	1680.266	1680.213	1680.182	-0.053	-0.031	-0.084
SM-3	12+35	1680.275	1630	1680.733	1680.642	1680.599	-0.091	-0.043	-0.134
SM-4	13+60	1680.900	1570	1681.187	1681.003	1680.921	-0.184	-0.082	-0.266
SM-5	15+50	1681.100	1540	1681.236	1681.070	1680.996	-0.166	-0.074	-0.240
SM-6	17+50	1681.100	1540	1681.121	1680.933	1680.845	-0.188	-0.088	-0.276
SM-7	20+00	1681.100	1535	1681.114	1680.906	1680.826	-0.208	-0.080	-0.288
SM-8	22+50	1681.100	1535	1681.246	1681.054	1680.972	-0.192	-0.082	-0.274
SM-9	25+00	1681.100	1540	1681.329	1681.112	1681.031	-0.217	-0.081	-0.298
SM-10	27+50	1681.100	1545	1681.317	1681.122	1681.045	-0.195	-0.077	-0.272
SM-11	28+40	1680.920	1550	1681.012	1680.821	1680.740	-0.191	-0.081	-0.272
SM-12	29+25	1680.550	1570	1680.918	1680.753	1680.681	-0.165	-0.072	-0.237
SM-13	30+00	1680.220	1595	1680.678	1680.539	1680.479	-0.139	-0.060	-0.199
SM-14	31+30	1679.650	1640	1679.996	1679.910	1679.874	-0.086	-0.036	-0.122
SM-15	35+00	1679.100	1650	1679.496	1679.483	1679.466	-0.013	-0.017	-0.030
SM-16	35+60	1679.100	1660	1679.468	1679.460	1679.441	-0.008	-0.019	-0.027
SM-17	37+50	1679.100	1640	1679.740	1679.721	1679.698	-0.019	-0.023	-0.042
SM-18	40+00	1679.100	1660	1679.537	1679.528	1679.509	-0.009	-0.019	-0.028
SM-19	41+30	1679.100	1660	1679.628	1679.612	1679.597	-0.016	-0.015	-0.031
RM-4	43+10	1679.100	1680	1679.859	1679.850	1679.836	-0.009	-0.014	-0.023
AVERAGE CHANGE							**-0.109**	**-0.051**	**-0.159**
MINIMUM				**1679.468**	**1679.460**	**1679.441**	**-0.217**	**-0.088**	**-0.298**
MAXIMUM				**1681.329**	**1681.122**	**1681.045**	**-0.008**	**-0.014**	**-0.023**
DIKE #2									
SM-20	51+10			1679.395	1679.386	1679.383	-0.009	-0.003	-0.012
SM-21	52+20			1679.451	1679.435	1679.428	-0.016	-0.007	-0.023
SM-22	53+50			1679.537	1679.518	1679.509	-0.019	-0.009	-0.028
SM-23	55+00			1679.471	1679.447	1679.437	-0.024	-0.010	-0.034
SM-24	57+50			1679.552	1679.531	1679.521	-0.021	-0.010	-0.031
SM-25	60+00			1679.630	1679.608	1679.598	-0.022	-0.010	-0.032
SM-26	62+50			1679.462	1679.442	1679.437	-0.020	-0.005	-0.025
SM-27	65+00			1679.407	1679.397	1679.395	-0.010	-0.002	-0.012
SM-28	67+50			1679.613	1679.597	1679.601	-0.016	0.004	-0.012
SM-29	70+00			1679.434	1679.424	1679.422	-0.010	-0.002	-0.012
SM-30	72+50			1679.565	1679.560	1679.558	-0.005	-0.002	-0.007
SM-31	75+00			1679.574	1679.573	1679.570	-0.001	-0.003	-0.004
SM-32	77+50			1679.472	1679.471	1679.470	-0.001	-0.001	-0.002
SM-33	80+00			1679.520	1679.526	1679.523	0.006	-0.003	0.003
SM-34	82+80			1679.629	1679.632	1679.630	0.003	-0.002	0.001
SM-35	85+00			1679.755	1679.759	1679.756	0.004	-0.003	0.001

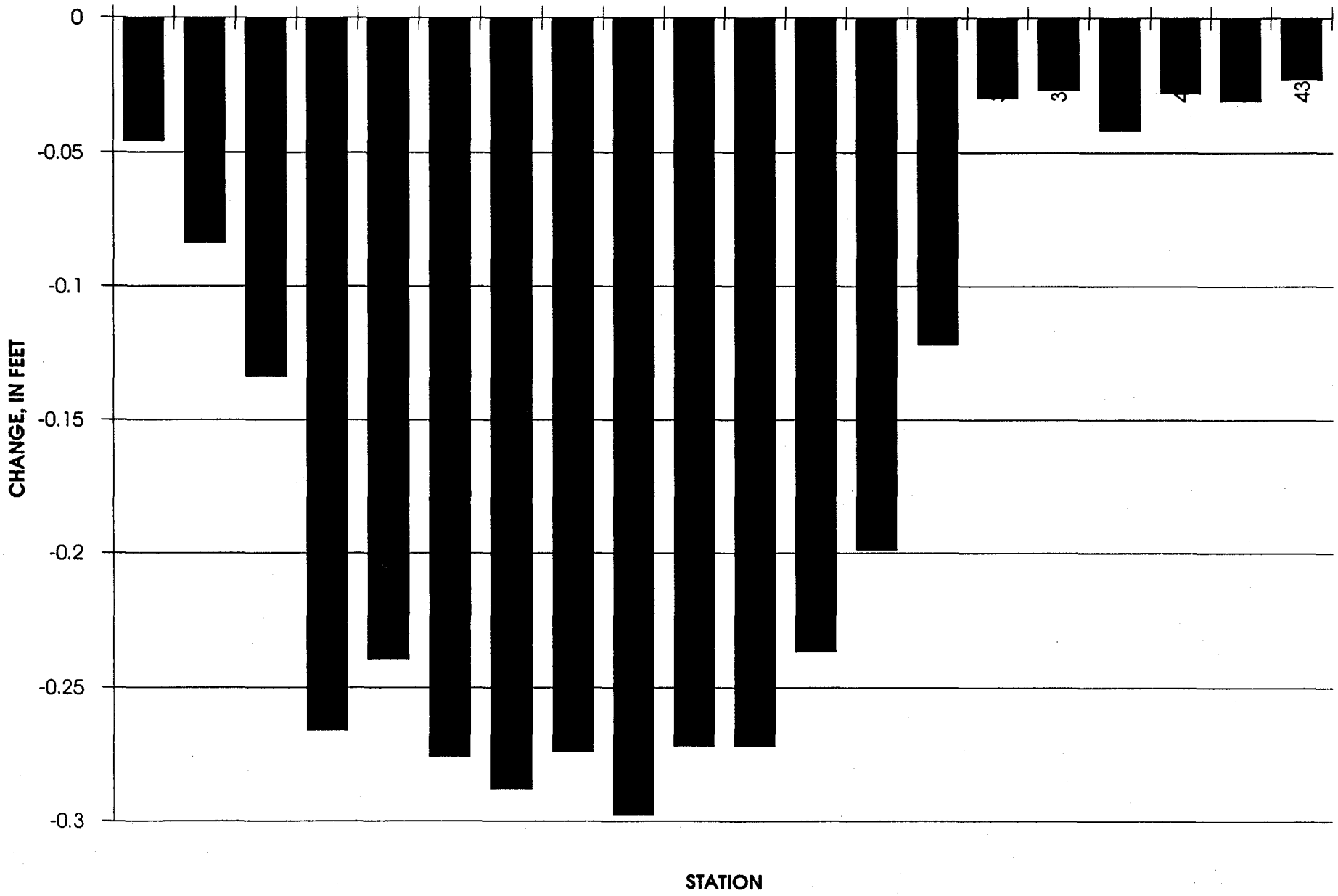
SM-36	87+50			1679.498	1679.502	1679.500	0.004	-0.002	0.002
SM-37	90+00			1679.593	1679.601	1679.598	0.008	-0.003	0.005
SM-38	95+00			1679.625	1679.622	1679.619	-0.003	-0.003	-0.006
SM-39	100+00			1679.514	1679.501	1679.498	-0.013	-0.003	-0.016
SM-40	105+00			1681.098	1681.085	1681.078	-0.013	-0.007	-0.020
SM-41	110+00			1686.104	1686.097	1686.091	-0.007	-0.006	-0.013
SM-42	115+00			1691.067	1691.067	1691.067	0.000	0.000	0.000
SM-43	120+00			1696.057	1696.055	1696.060	-0.002	0.005	0.003
SM-44	125+00			1700.788	1700.775	1700.780	-0.013	0.005	-0.008
SM-45	130+00			1706.064	1706.043	1706.050	-0.021	0.007	-0.014
SM-46	135+00			1710.975	1710.957	1710.966	-0.018	0.009	-0.009
SM-47	140+00			1715.990	1715.974	1715.977	-0.016	0.003	-0.013
AVERAGE CHANGE							**-0.009**	**-0.002**	**-0.011**
MINIMUM				**1679.395**	**1679.386**	**1679.383**	**-0.024**	**-0.010**	**-0.034**
MAXIMUM				**1715.990**	**1715.974**	**1715.977**	**0.008**	**0.009**	**0.005**
CREST MONUMENTS									
SM-23	55+00			1679.471	1679.447	1679.437	-0.024	-0.010	-0.034
SM-27	65+00			1679.407	1679.397	1679.395	-0.010	-0.002	-0.012
SM-31	75+00			1679.574	1679.573	1679.570	-0.001	-0.003	-0.004
SM-35	85+00			1679.755	1679.759	1679.756	0.004	-0.003	0.001
AVERAGE CHANGE							**-0.008**	**-0.005**	**-0.012**
DOWNSTREAM TOE									
SM-23D				1623.199	1623.189	1623.187	-0.010	-0.002	-0.012
SM-27D				1633.484	1633.482	1633.482	-0.002	0.000	-0.002
SM-31D				1639.472	1639.474	1639.475	0.002	0.001	0.003
SM-35D				1649.048	1649.051	1649.057	0.003	0.006	0.009
AVERAGE CHANGE							**-0.002**	**0.001**	**-0.001**
UPSTREAM TOE									
SM-23U				1627.937	1627.921	1627.920	-0.016	-0.001	-0.017
SM-27U				1636.260	1636.234	1636.232	-0.026	-0.002	-0.028
SM-31U				1643.531	1643.510	1643.519	-0.021	0.009	-0.012
SM-35U				1651.013	1650.967	1650.964	-0.046	-0.003	-0.049
AVERAGE CHANGE							**-0.027**	**0.001**	**-0.026**
NOTES:									
1) CONSTRUCTION COMPLETED 1980									
2) DESIGN CREST ELEVATION VARIES									
3) DESIGN SPILLWAY CREST = 1657.1									
4) MAXIMUM HEIGHT = 190'									

CAVE BUTTES DAM CREST SETTLEMENT MONUMENTS




CAVE BUTTES DAM
ELEVATION, IN FEET
1700.000
1650.000
1600.000
1550.000
1500.000
1450.000
10+40
11+30
12+35
13+60
15+50
17+50
20+00
22+50
25+00
27+50
28+40
29+25
30+00
31+30
35+00
35+60
37+50
40+00
41+30
43+10
STATION
DESIGN CREST
BEDROCK

CAVE BUTTES DAM CHANGE IN CREST ELEVATION 1980 TO 1983



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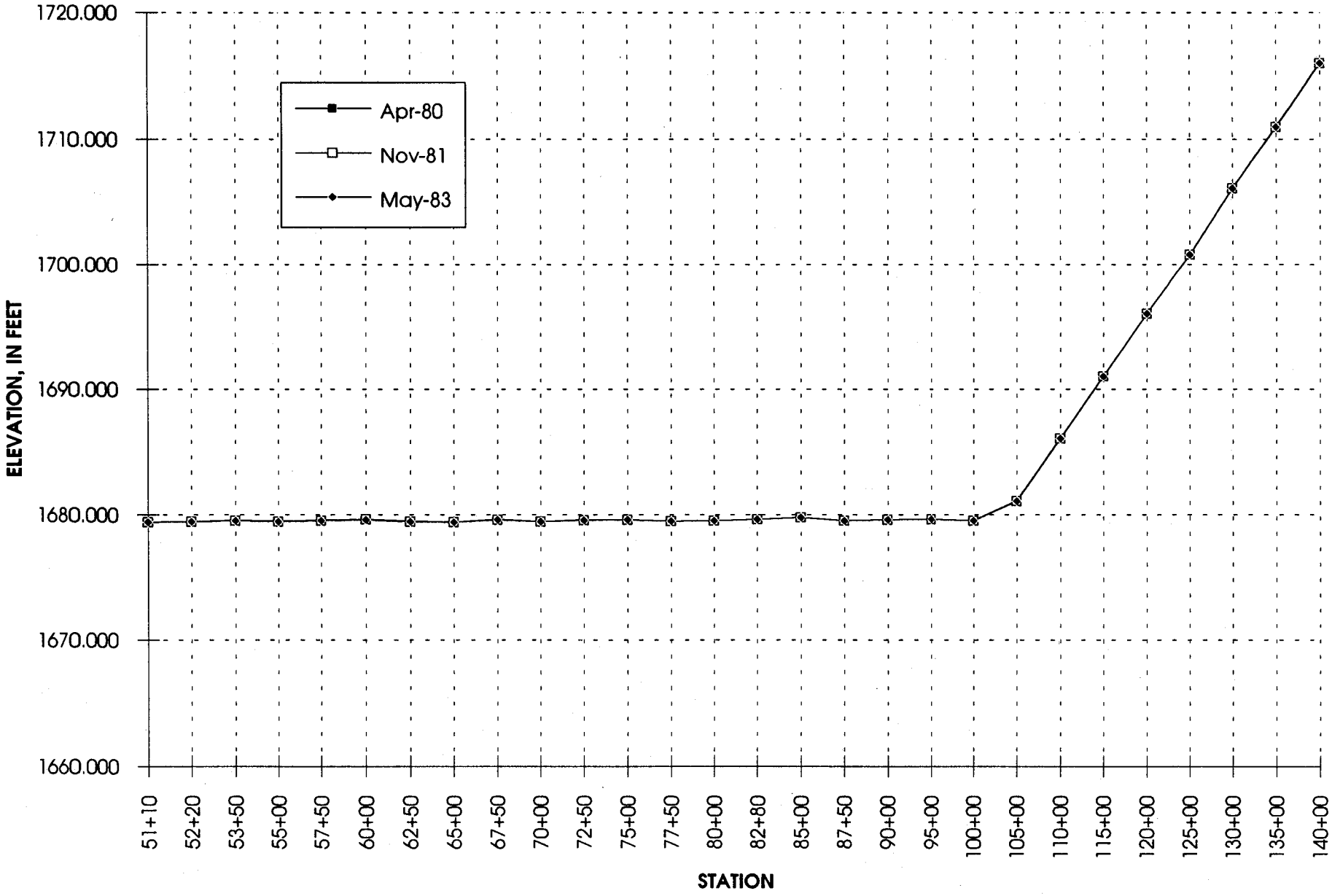
CAVE BUTTES DAM DIKE #2 SUBSIDENCE MONITORING



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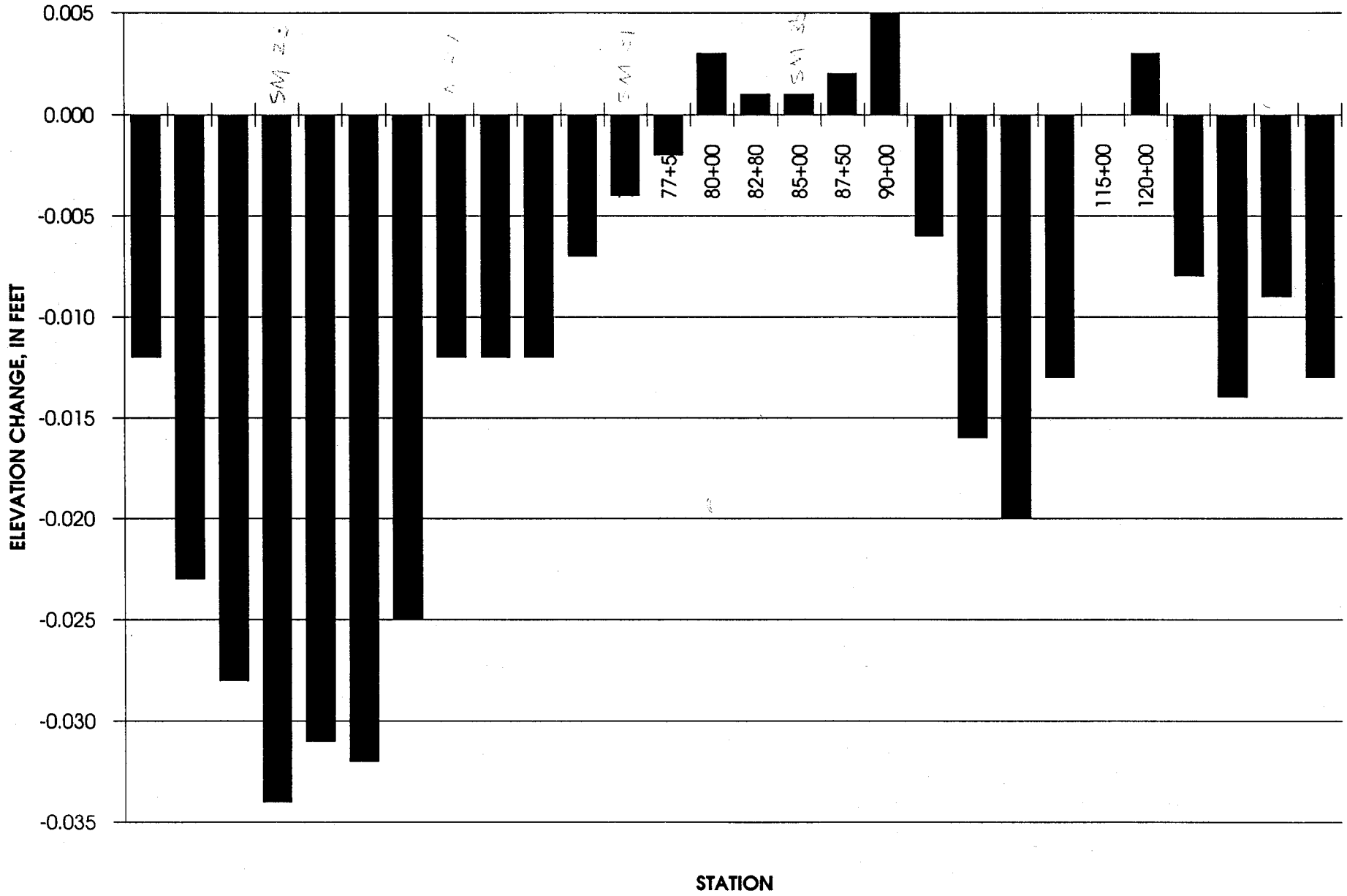
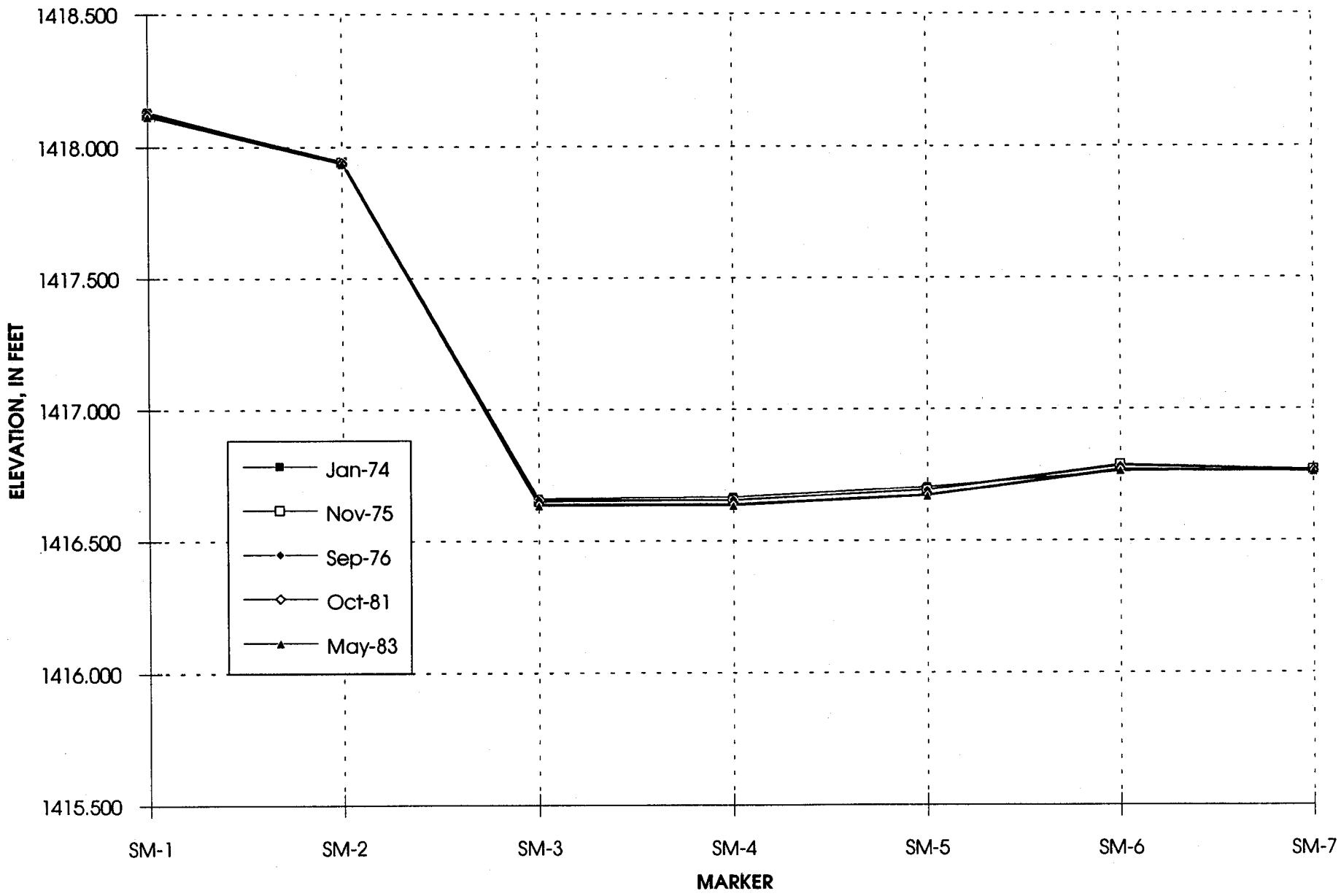
CAVE BUTTES DAM DIKE #2 CHANGE IN CREST, 1980 TO 1983

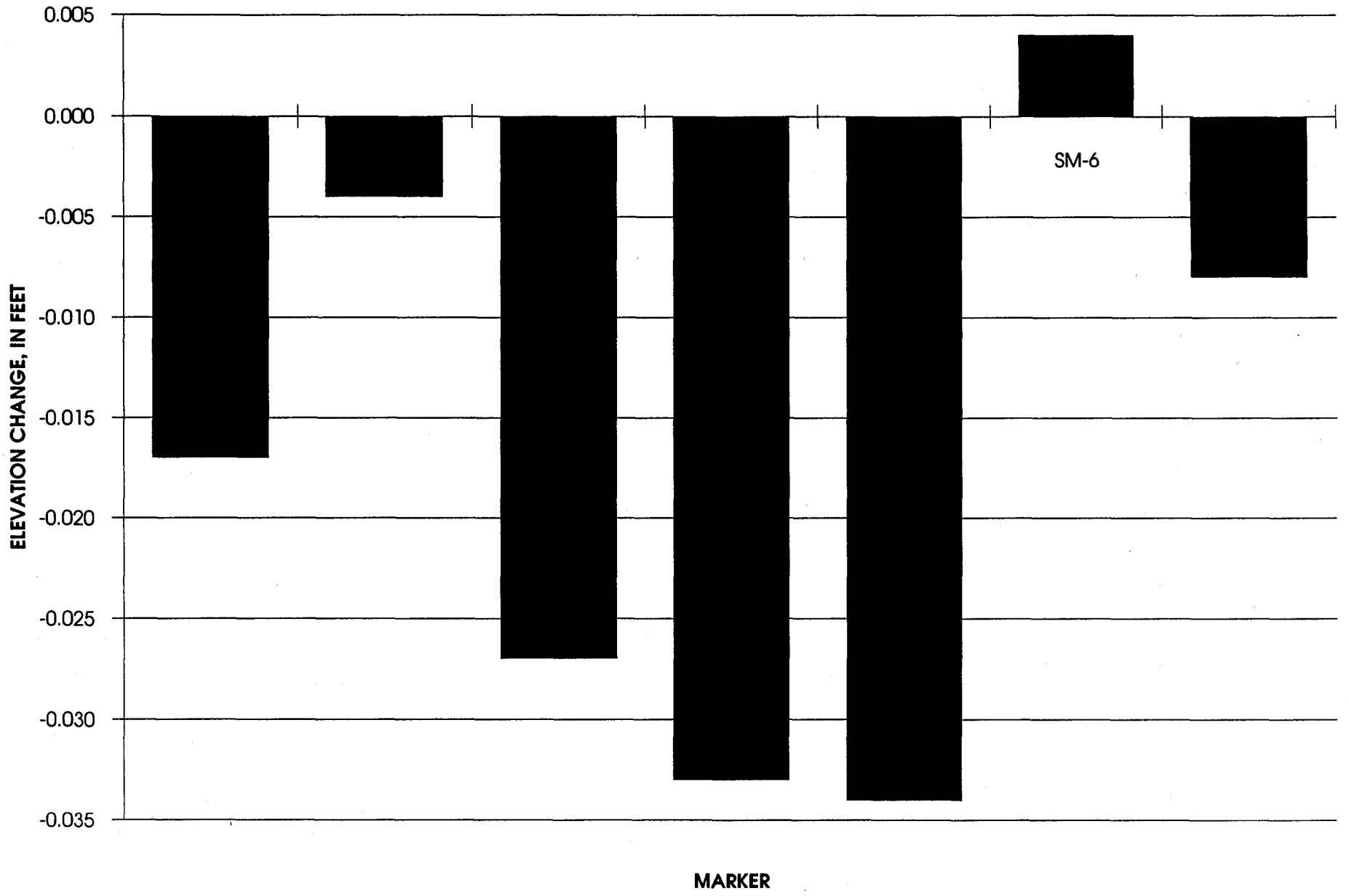


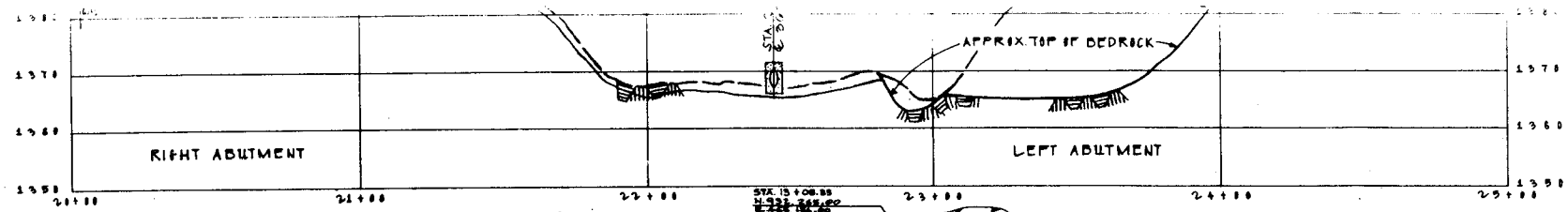
DREAMY DRAW DAM SUBSIDENCE MONITORING												
STATION	**MARKER**	**Jan-74**	**Apr-74**	**Nov-74**	**Nov-75**	**Sep-76**	**Oct-81**	**May-83**	**1/74-9/76**	**9/76-10/81**	**10/81-5/83**	**1/74-5/83**
17+25?	SM-1	1418.133	1418.133	1418.135	1418.123	1418.127	1418.119	1418.116	0.004	-0.008	-0.003	-0.017
19+60?	SM-2	1417.939	1417.938	1417.943	1417.942	1417.946	1417.937	1417.935	0.004	-0.009	-0.002	-0.004
21+50	SM-3	1416.661	1416.660	1416.663	1416.650	1416.655	1416.639	1416.634	0.005	-0.016	-0.005	-0.027
22+00	SM-4	1416.667	1416.664	1416.665	1416.654	1416.656	1416.639	1416.634	0.002	-0.017	-0.005	-0.033
22+50	SM-5	1416.703	1416.703	1416.702	1416.692	1416.690	1416.674	1416.669	-0.002	-0.016	-0.005	-0.034
23+50	SM-6	1416.761	1416.791	1416.795	1416.788	1416.783	1416.770	1416.765	-0.005	-0.013	-0.005	0.004
24+10	SM-7	1416.770	1416.772	1416.768	1416.769	1416.767	1416.764	1416.762	-0.002	-0.003	-0.002	-0.008
AVERAGE CHANGE									**0.001**	**-0.012**	**-0.004**	**-0.017**
MINIMUM		1416.661	1416.660	1416.663	1416.650	1416.655	1416.639	1416.634	-0.005	-0.017	-0.005	-0.034
MAXIMUM		1418.133	1418.133	1418.135	1418.123	1418.127	1418.119	1418.116	0.005	-0.003	-0.002	0.004
NOTES:												
1) CONSTRUCTION COMPLETED 1974												
2) DESIGN CREST = 1418.0												
3) DESIGN SPILLWAY CREST = 1405.0												
4) MAXIMUM HEIGHT = 56'												
5) FREEBOARD = 5'												
6) SM-1 AND SM-2 ARE NOT ON THE EMBANKMENT												

DREAMY DRAW DAM CREST SETTLEMENT MONUMENTS

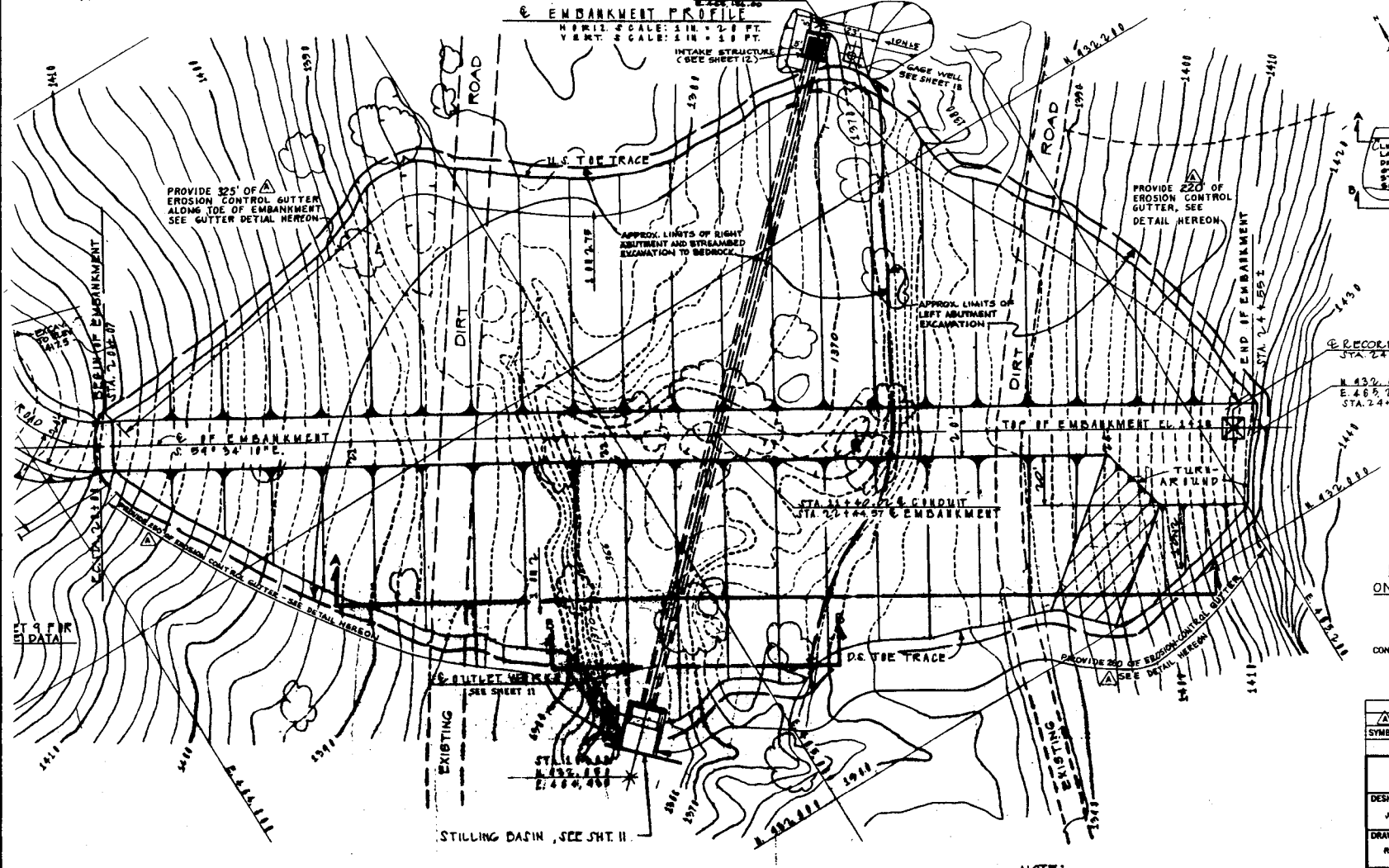


DREAMY DRAW DAM CHANGE IN CREST ELEVATION, 1974 TO 1983





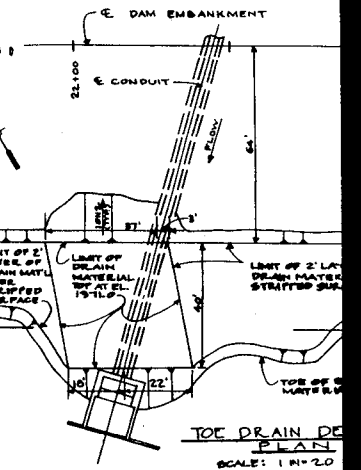
℄ EMBANKMENT PROFILE
HORIZ. SCALE: 1 IN. = 20 FT.
VERT. SCALE: 1 IN. = 10 FT.



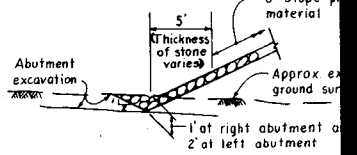
PLAN
SCALE: 1 IN. = 20 FT.

NOTE:
FOR SECTIONS A-A AND B-B SEE SHT. 8

DETAIL OF EROSION-CONTROL GUTTER ON UPSTREAM SLOPE OF EMBANKMENT
NOT TO SCALE



TOE DRAIN DETAIL PLAN
SCALE: 1 IN. = 20



DETAIL OF EROSION CONTROL GUTTER ON DOWNSTREAM SLOPE OF EMBANKMENT
NOT TO SCALE

RECORD DRAWING - AS CONSTRUCTED
CONT. NO. 73-C-0019 REV. "A" DATE 17 Jul 74 BY J. W.

DATUM IS MEAN SEA LEVEL

SYMBOL	DESCRIPTIONS
	deleted, 'DETAIL OF EROSION' "As Constructed"
A	Length of 'EROSION-CONTROL GUTTER' increased. Slope information

REVISIONS

U.S. ARMY ENGINEER
LOS ANGELES
CORPS OF ENGIN

DESIGNED BY: J.H.W.
DRAWN BY: R.L.A.
CHECKED BY: R.R.K. J.A.

GILA RIVER BASIN
NEW RIVER AND PHOENIX CITY STREAMS, A

DREAMY DRAW DAM

EMBANKMENT-PLAN AND PROF

SUBMITTED BY: P. L. Wiskirchen, CHIEF, DESIGN BRANCH
DATE: FEBRUARY 1972

SPEC. NO. DACW09-73-B-0
DRAWING NUMBER
DISTRICT FILE NO. 222/301

5/17/95

HARQUAHALA FRS SUBSIDENCE MONITORING									
MARKER	STATION	DESIGN	Feb-84	Jul-86	Jul-91	1984-1986	1986-1991	1984-1991	DESIGN-1991
SM-A1	439+78	1421.70	1421.645	1421.223	1421.373	-0.422	0.150	-0.272	-0.327
SM-A2	449+80	1422.18	1422.442	1421.983	1422.135	-0.459	0.152	-0.307	-0.045
SM-A3	460+00	1422.20	1423.005	1422.529	1422.704	-0.476	0.175	-0.301	0.504
SM-A4	471+23	1422.20	1422.915	1422.483	1422.624	-0.432	0.141	-0.291	0.424
SM-A5	480+20	1422.20	1422.791	1422.340	1422.476	-0.451	0.136	-0.315	0.276
SM-A6	490+20	1422.20	1423.331	1422.903	1423.038	-0.428	0.135	-0.293	0.838
SM-A7	500+20	1422.20	1422.600	1422.169	1422.317	-0.431	0.148	-0.283	0.117
SM-A8	510+00	1422.20	1422.643	1422.209	1422.329	-0.434	0.120	-0.314	0.129
SM-A9	517+42	1422.20	1422.969	1422.482	1422.584	-0.487	0.102	-0.385	0.384
SM-A10	527+58	1422.20	1422.662	1422.182	1422.290	-0.480	0.108	-0.372	0.090
SM-A11	538+27	1422.12	1422.479	1422.011	1422.170	-0.468	0.159	-0.309	0.050
SM-A12	547+93	1422.10	1422.776	1422.308	1422.467	-0.468	0.159	-0.309	0.367
SM-A13	558+13	1422.10	1422.949	1422.368	1422.493	-0.581	0.125	-0.456	0.393
SM-A14	567+97	1422.10	1422.625	1422.185	1422.338	-0.440	0.153	-0.287	0.238
SM-A15	578+65	1422.10	1422.905	1422.446	1422.621	-0.459	0.175	-0.284	0.521
SM-A16	589+28	1422.10	1422.786	1422.363	1422.518	-0.423	0.155	-0.268	0.418
SM-A17	597+16	1422.10	1422.655	1422.256	1422.388	-0.399	0.132	-0.267	0.288
SM-A18	607+37	1422.10	1422.815	1422.425	1422.566	-0.390	0.141	-0.249	0.466
SM-A19	617+67	1422.10	1422.899	1422.526	1422.664	-0.373	0.138	-0.235	0.564
SM-A20	627+50	1422.10	1423.059	1422.676	1422.804	-0.383	0.128	-0.255	0.704
SM-A21	637+77	1422.10	1422.566	1422.222	1422.331	-0.344	0.109	-0.235	0.231
SM-A22	647+92	1422.10	1422.574	1422.229	1422.361	-0.345	0.132	-0.213	0.261
SM-A23	657+97	1422.10	1422.603	1422.286	1422.386	-0.317	0.100	-0.217	0.286
SM-A24	668+08	1422.10	1422.776	1422.479	1422.548	-0.297	0.069	-0.228	0.448
SM-A25	678+32	1422.10	1422.619	1422.332	1422.422	-0.287	0.090	-0.197	0.322
SM-A26	688+40	1422.10	1422.529	1422.245	1422.341	-0.284	0.096	-0.188	0.241
SM-A27	698+42	1422.10	1422.646	1422.358	1422.484	-0.288	0.126	-0.162	0.384
SM-A28	708+44	1422.10	1422.837	1422.554	1422.689	-0.283	0.135	-0.148	0.589
SM-A29	718+47	1420.60	1421.573	1421.295	1421.434	-0.278	0.139	-0.139	0.834
SM-A30	729+58	1420.60	1420.336	1420.075	1420.197	-0.261	0.122	-0.139	-0.403
SM-A31	737+36	1420.60	1420.149	1419.875	1420.000	-0.274	0.125	-0.149	-0.600
SM-A32	749+52	1420.53	1421.035	1420.781	1420.892	-0.254	0.111	-0.143	0.362
SM-A33	758+41	1420.50	1420.887	1420.630	1420.732	-0.257	0.102	-0.155	0.232
SM-A34	766+14	1420.50	1420.503	1420.245	1420.353	-0.258	0.108	-0.150	-0.147
SM-A35	777+05	1420.50	1421.141	1420.872	1420.989	-0.269	0.117	-0.152	0.489
SM-A36	786+49	1420.50	1421.015	1420.759	1420.868	-0.256	0.109	-0.147	0.368
SM-A37	796+99	1420.50	1420.519	1420.259	1420.373	-0.260	0.114	-0.146	-0.127
SM-A38	808+46	1420.50	1421.179	1420.947	1421.029	-0.232	0.082	-0.150	0.529
SM-A39	818+25	1420.46	1420.828	1420.649	1420.714	-0.179	0.065	-0.114	0.254
SM-A40	827+22	1420.40	1421.264	1421.097	1421.162	-0.167	0.065	-0.102	0.762
SM-A41	837+91	1420.35	1420.266	1420.119	1420.164	-0.147	0.045	-0.102	-0.186

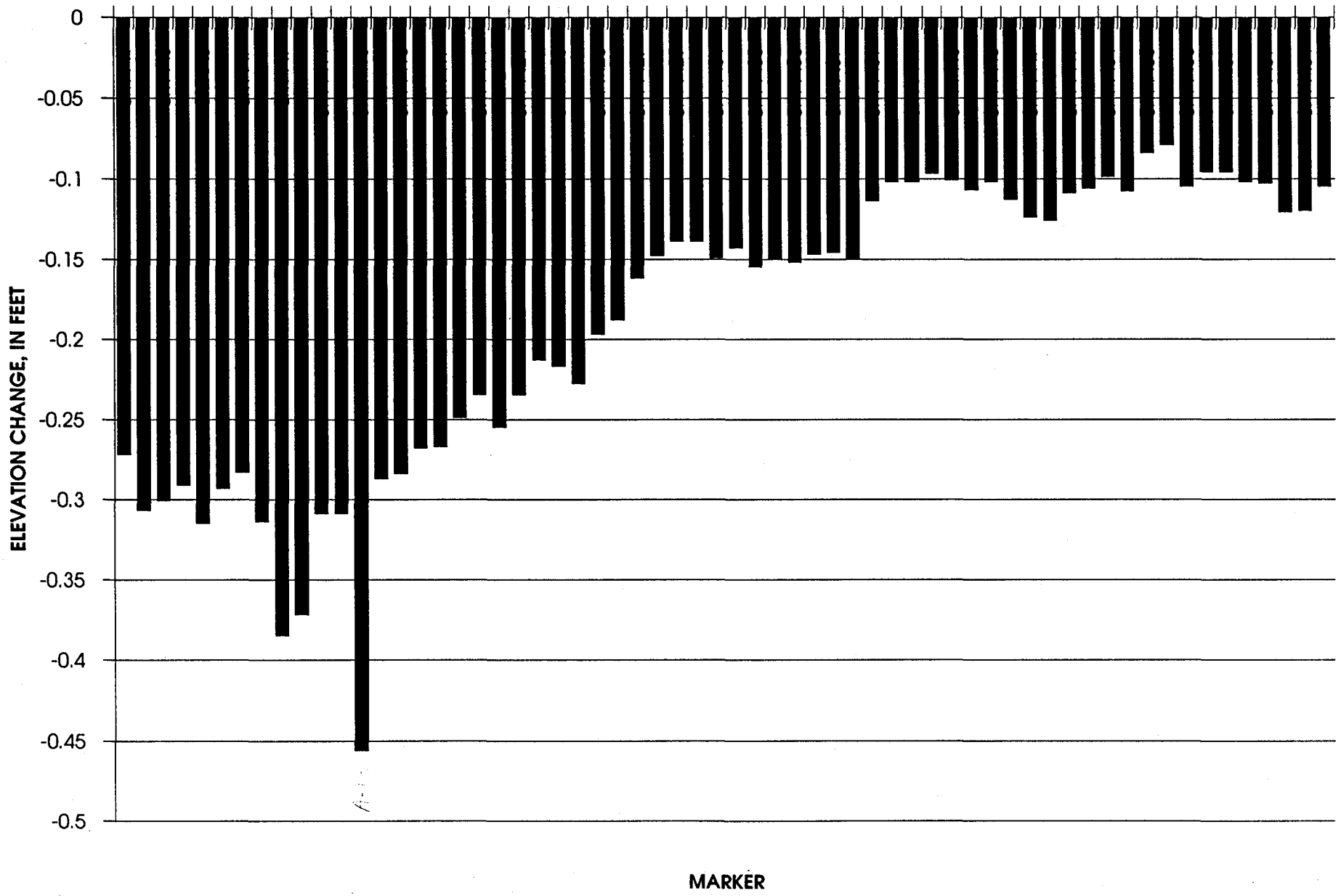
SM-A42	847+76	1420.30	1420.774	1420.612	1420.677	-0.162	0.065	-0.097	0.377
SM-A43	857+54	1420.25	1420.509	1420.348	1420.408	-0.161	0.060	-0.101	0.158
SM-A44	867+87	1420.20	1420.582	1420.417	1420.475	-0.165	0.058	-0.107	0.275
SM-A45	877+95	1420.15	1420.462	1420.318	1420.360	-0.144	0.042	-0.102	0.210
SM-A46	887+65	1420.10	1420.499	1420.356	1420.386	-0.143	0.030	-0.113	0.286
SM-A47	897+33	1420.05	1420.311	1420.163	1420.187	-0.148	0.024	-0.124	0.137
SM-A48	907+89	1420.00	1420.506	1420.348	1420.380	-0.158	0.032	-0.126	0.380
SM-A49	917+96	1419.85	1420.076	1419.950	1419.967	-0.126	0.017	-0.109	0.117
SM-A50	928+83	1419.70	1420.098	1419.987	1419.992	-0.111	0.005	-0.106	0.292
SM-A51	930+19	1419.70	1419.796	1419.680	1419.697	-0.116	0.017	-0.099	-0.003
SM-A52	948+66	1419.70	1419.502	1419.378	1419.394	-0.124	0.016	-0.108	-0.306
SM-A53	958+35	1419.70	1419.593	1419.483	1419.509	-0.110	0.026	-0.084	-0.191
SM-A54	970+87	1419.70	1419.943	1419.855	1419.864	-0.088	0.009	-0.079	0.164
SM-A55	979+47	1419.70	1419.549	1419.435	1419.444	-0.114	0.009	-0.105	-0.256
SM-A56	988+60	1419.70	1420.010	1419.897	1419.914	-0.113	0.017	-0.096	0.214
SM-A57	999+17	1419.70	1418.688	1418.577	1418.592	-0.111	0.015	-0.096	-1.108
SM-A58	1010+09	1419.70	1419.880	1419.759	1419.778	-0.121	0.019	-0.102	0.078
SM-A59	1020+11	1419.70	1419.971	1419.839	1419.868	-0.132	0.029	-0.103	0.168
SM-A60	1030+98	1419.70	1420.029	1419.907	1419.908	-0.122	0.001	-0.121	0.208
SM-A61	1040+19	1419.70	1419.401	1419.295	1419.281	-0.106	-0.014	-0.120	-0.419
SM-A62	1049+91	1419.70	1419.669	1419.560	1419.564	-0.109	0.004	-0.105	-0.136
AVERAGE CHANGE						**-0.276**	**0.088**	**-0.188**	**0.196**
MINIMUM			**1418.688**	**1418.577**	**1418.592**	**-0.581**	**-0.014**	**-0.456**	**-1.108**
MAXIMUM			**1423.331**	**1422.903**	**1423.038**	**-0.088**	**0.175**	**-0.079**	**0.838**
SM-B1	439+78		1417.738	1417.329		-0.409			
SM-B2	449+80		1413.495	1413.096		-0.399			
SM-B3	460+00		1404.015	1403.569		-0.446			
SM-B4	471+23		1398.822	1398.436		-0.386			
SM-B5	480+20		1396.678	1396.326		-0.352			
SM-B6	490+20		1395.051	1394.686		-0.365			
SM-B7	500+20		1395.921	1395.569		-0.352			
SM-B8	510+00		1395.834	1395.452		-0.382			
SM-B9	517+42		1395.724	1395.343		-0.381			
SM-B10	527+58		1395.714	1395.293		-0.421			
SM-B11	538+27		1396.631	1396.216		-0.415			
SM-B12	547+93		1396.281	1395.879		-0.402			
SM-B13	558+13		1396.104	1395.729		-0.375			
SM-B14	567+97		1395.704	1395.315		-0.389			
SM-B15	578+65		1395.114	1395.735		0.621			
SM-B16	589+28		1395.697	1395.321		-0.376			
SM-B17	597+16		1394.670	1394.398		-0.272			
SM-B18	607+37		1395.060	1394.781		-0.279			

SM-B19	617+67		1397.234	1396.951		-0.283			
SM-B20	627+50		1395.110	1394.808		-0.302			
SM-B21	637+77		1395.030	1394.741		-0.289			
SM-B22	647+92		1394.694	1394.335		-0.359			
SM-B23	657+97		1394.187	1393.835		-0.352			
SM-B24	668+08		1391.014	1390.645		-0.369			
SM-B25	678+32		1394.490	1394.178		-0.312			
SM-B26	688+40		1396.670	1396.372		-0.298			
SM-B27	698+42		1396.771	1396.465		-0.306			
SM-B28	708+44		1396.281	1395.958		-0.323			
SM-B29	718+47		1397.162	1396.848		-0.314			
SM-B30	729+58		1391.828	1391.542		-0.286			
SM-B31	737+36		1389.333	1389.049		-0.284			
SM-B32	749+52		1386.358	1386.114		-0.244			
SM-B33	758+41		1388.571	1388.334		-0.237			
SM-B34	766+14		1392.114	1391.874		-0.240			
SM-B35	777+05		1397.228	1396.987		-0.241			
SM-B36	786+49		1393.940	1393.692		-0.248			
SM-B37	796+99		1395.121	1394.870		-0.251			
SM-B38	808+46		1396.150	1395.912		-0.238			
SM-B39	818+25		1400.893	1400.641		-0.252			
SM-B40	827+22		1400.014	1399.751		-0.263			
SM-B41	837+91		1397.068	1396.816		-0.252			
SM-B42	847+76		1397.678	1397.414		-0.264			
SM-B43	857+54		1397.261	1396.994		-0.267			
SM-B44	867+87		1399.023	1398.753		-0.270			
SM-B45	877+95		1395.735	1395.446		-0.289			
SM-B46	887+65		1396.688	1396.391		-0.297			
SM-B47	897+33		1394.666	1394.383		-0.283			
SM-B48	907+89		1394.838	1394.550		-0.288			
SM-B49	917+96		1397.314	1397.025		-0.289			
SM-B50	928+83		1397.737	1397.428		-0.309			
SM-B51	930+19		1396.522	1396.216		-0.306			
SM-B52	948+66		1394.400	1394.106		-0.294			
SM-B53	958+35		1395.842	1395.561		-0.281			
SM-B54	970+87			1395.267		XXXX			
SM-B55	979+47			1393.278		XXXX			
SM-B56	988+60		1395.240	1394.955		-0.285			
SM-B57	999+17		1394.178	1393.874		-0.304			
SM-B58	1010+09		1394.801	1394.485		-0.316			
SM-B59	1020+11		1394.666	1394.323		-0.343			
SM-B60	1030+98		1392.225	1391.863		-0.362			
SM-B61	1040+19		1386.155	1385.793		-0.362			

SM-B62	1049+91		1388.535	1388.289		-0.246			
AVERAGE CHANGE						**-0.300**			
MINIMUM						**-0.446**			
MAXIMUM						**0.621**			
SM-C1			1353.197	1353.170	1353.132	-0.027	-0.038	-0.065	
SM-C2			1339.552	1339.453	1339.494	-0.099	0.041	-0.058	
SM-C3			1329.733	1329.607	1329.696	-0.126	0.089	-0.037	
SM-C4			1320.464	1320.340	1320.437	-0.124	0.097	-0.027	
SM-C5			1311.072	1310.973	1311.065	-0.099	0.092	-0.007	
SM-C6			1301.790	1301.703	1301.794	-0.087	0.091	0.004	
SM-C7			1292.468	1292.387	1292.483	-0.081	0.096	0.015	
SM-C8			1282.499	1282.434	1282.516	-0.065	0.082	0.017	
SM-C9			1272.477	1272.414	1272.512	-0.063	0.098	0.035	
SM-C10			1262.348	1262.301	1262.404	-0.047	0.103	0.056	
SM-C11			1245.588	1245.523	1245.594	-0.065	0.071	0.006	
SM-C12			1236.354	1236.280	1236.351	-0.074	0.071	-0.003	
SM-C13			1227.007	1226.947	1227.070	-0.060	0.123	0.063	
SM-C14			1217.768	1217.710	1217.835	-0.058	0.125	0.067	
SM-C15			1208.567	1208.546	1208.651	-0.021	0.105	0.084	
SM-C16			1199.415	1199.406	1199.513	-0.009	0.107	0.098	
AVERAGE CHANGE						**-0.069**	**0.085**	**0.016**	
MINIMUM						**-0.126**	**-0.038**	**-0.065**	
MAXIMUM						**-0.009**	**0.125**	**0.098**	
GREGG			1433.652	1433.362	1433.515	-0.290	0.153	-0.137	
NOTES:									
1) "A" MONUMENTS ARE ON THE DAM CREST									
2) "B" MONUMENTS ARE AT THE DOWNSTREAM TOE									
3) "C" MONUMENTS ARE ALONG THE OUTLET FLOODWAY									
4) CONSTRUCTION COMPLETED 1982									
5) DESIGN CREST ELEVATION = 1419.70									
6) DESIGN SPILLWAY CREST = 1408.40									
7) MAXIMUM HEIGHT = 55'									

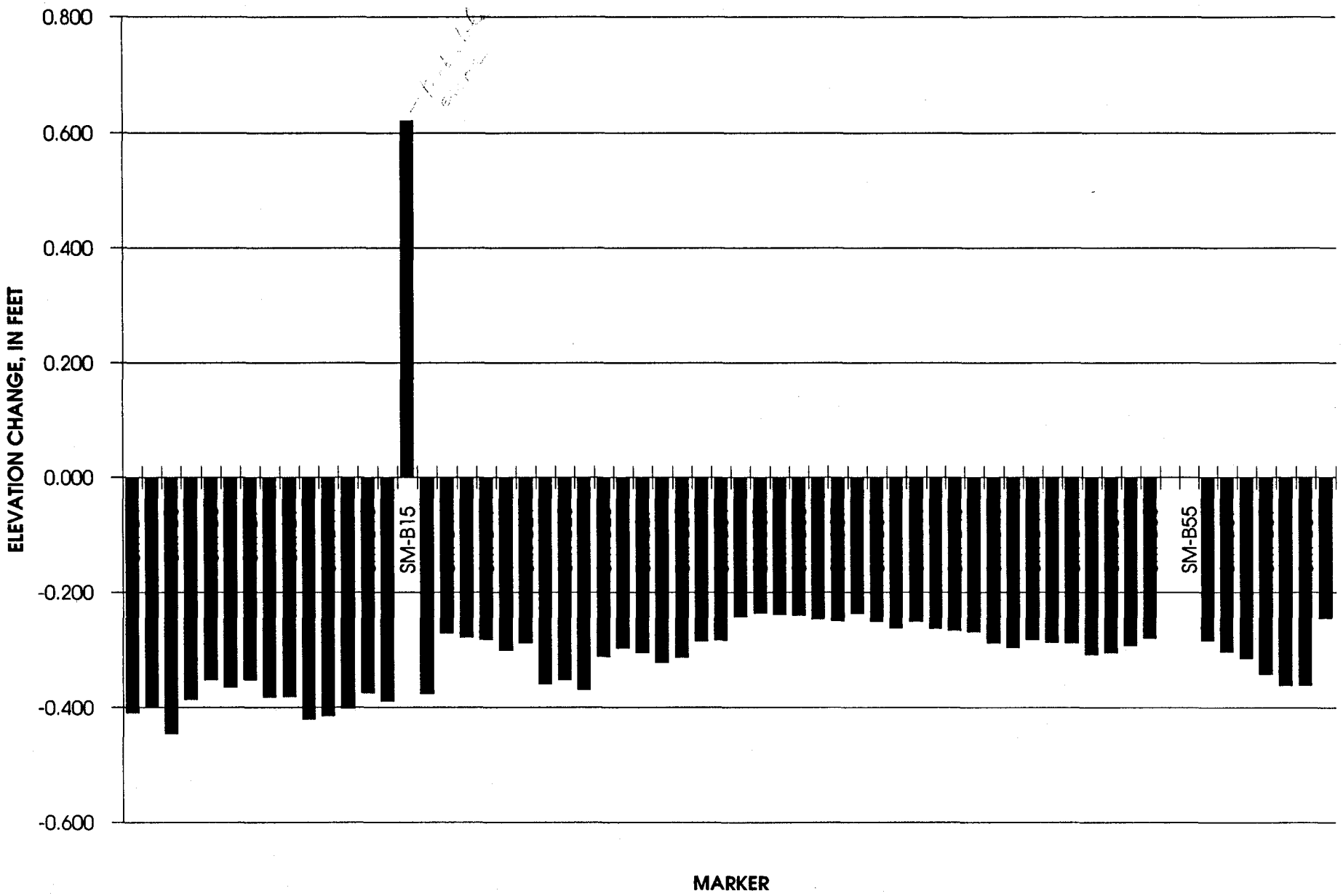
5/2/95

HARQUAHALA FRS CHANGE IN CREST ELEVATION 1984 TO 1991

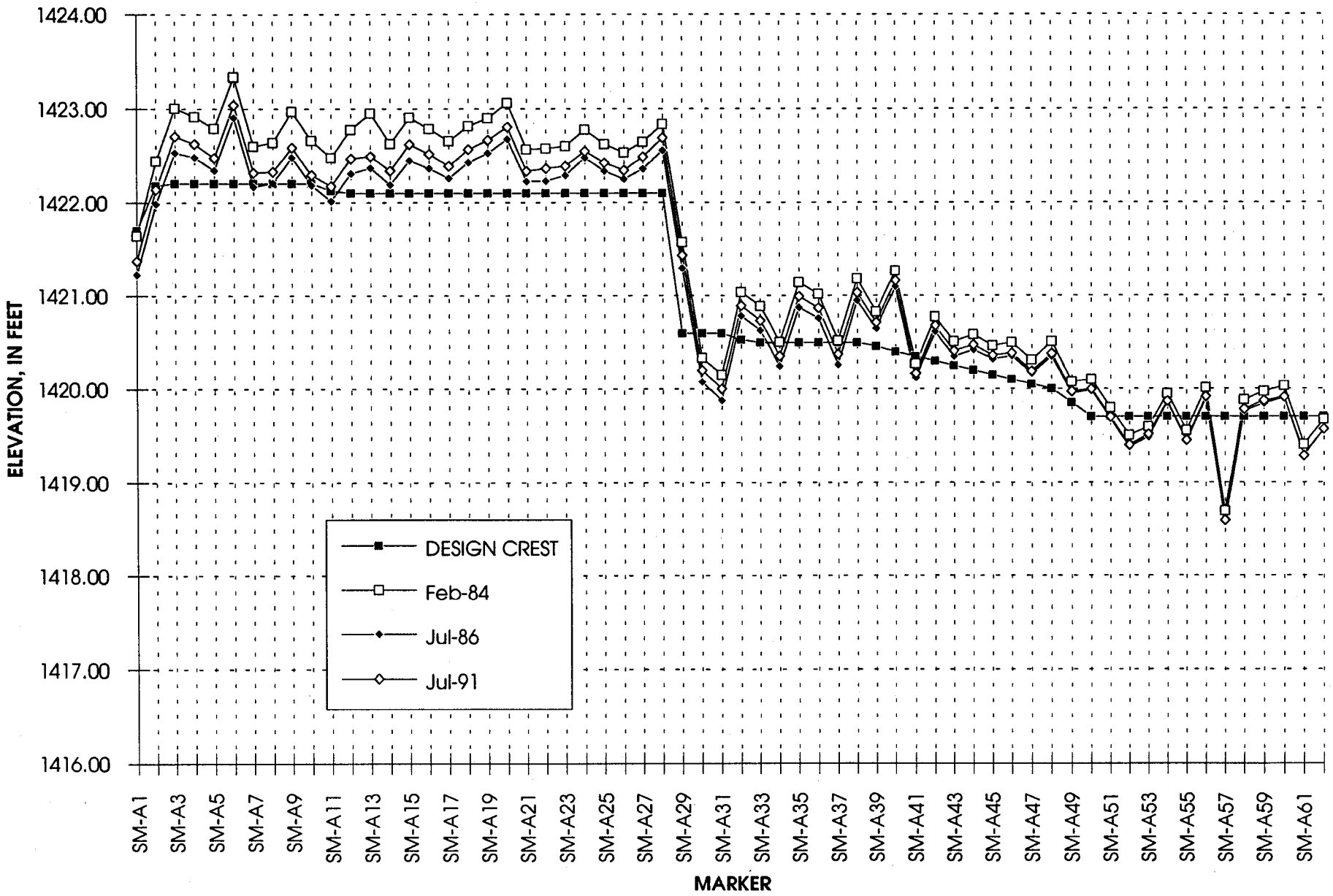


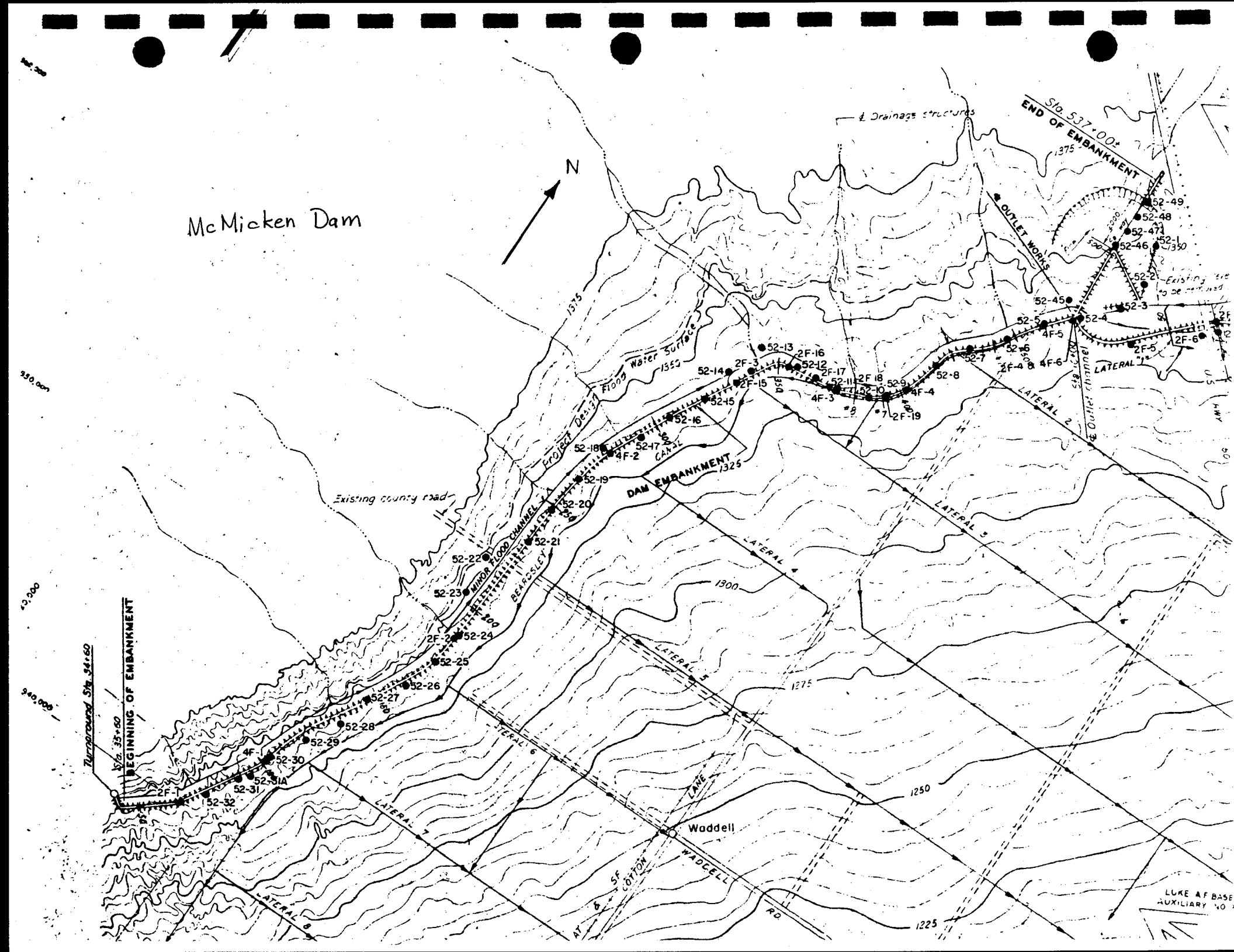
4/27/95

HARQUAHALA FRS CHANGE IN DOWNSTREAM TOE MONUMENTS 1984 TO 1986



HARQUAHALA FRS CREST SETTLEMENT MONUMENTS




McMicken Dam
N
Sta. 537+00±
END OF EMBANKMENT
℄ Drainage structures
OUTLET WORKS
Existing structures to be removed
LATERAL 1
LATERAL 2
LATERAL 3
LATERAL 4
LATERAL 5
LATERAL 6
LATERAL 7
LATERAL 8
℄ Outlet channel
Flood Water Surface
Project Design
MINOR FLOOD CHANNEL
BEARDSLEY
CANAL
DAM EMBANKMENT
Existing county road
Turnaround Sta. 34+60
Sta. 35+60
BEGINNING OF EMBANKMENT
Waddell
WADDELL RD
SF COTTON LANE
AT & SF
LUKE AF BASE AUXILIARY NO 1
1375
1355
1325
1300
1275
1250
1225
950,000
940,000
52-1
52-2
52-3
52-4
52-5
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52-31
52-31A
52-32
52-45
52-46
52-47
52-48
52-49
2F-1
2F-2
2F-3
2F-4
2F-5
2F-6
2F-15
2F-16
2F-17
2F-18
2F-19
4F-2
4F-3
4F-4
4F-5
4F-6
#7
#8

McMICKEN DAM CREST SETTLEMENT PROFILE
1955 - 1982

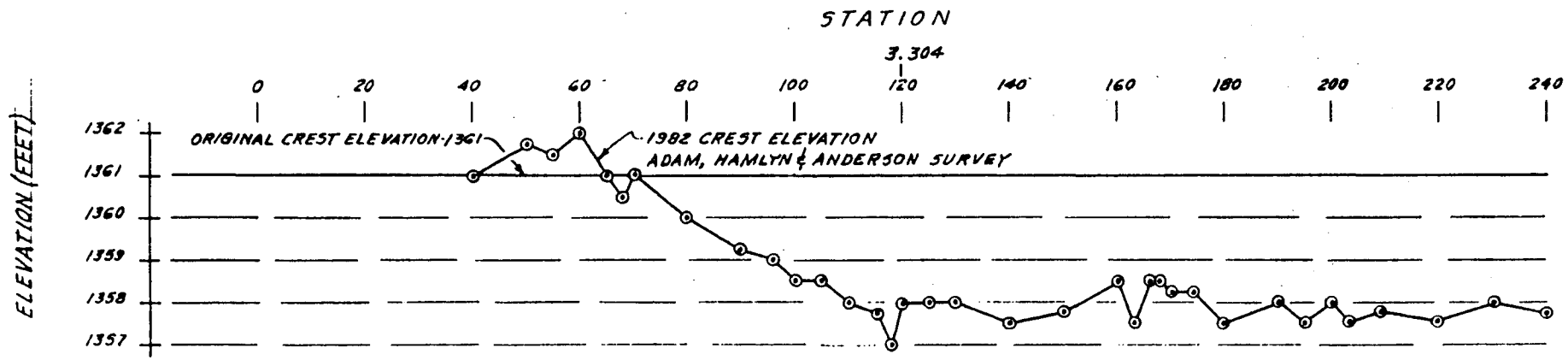


FIGURE 17

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS
PHOENIX • ALBUQUERQUE • SANTA FE

Project: McMICKEN DAM
Job No.: E 81-138
Computed by: J.D.O. Ckd. by:
Date: 2-22-82 Page 1 of 2

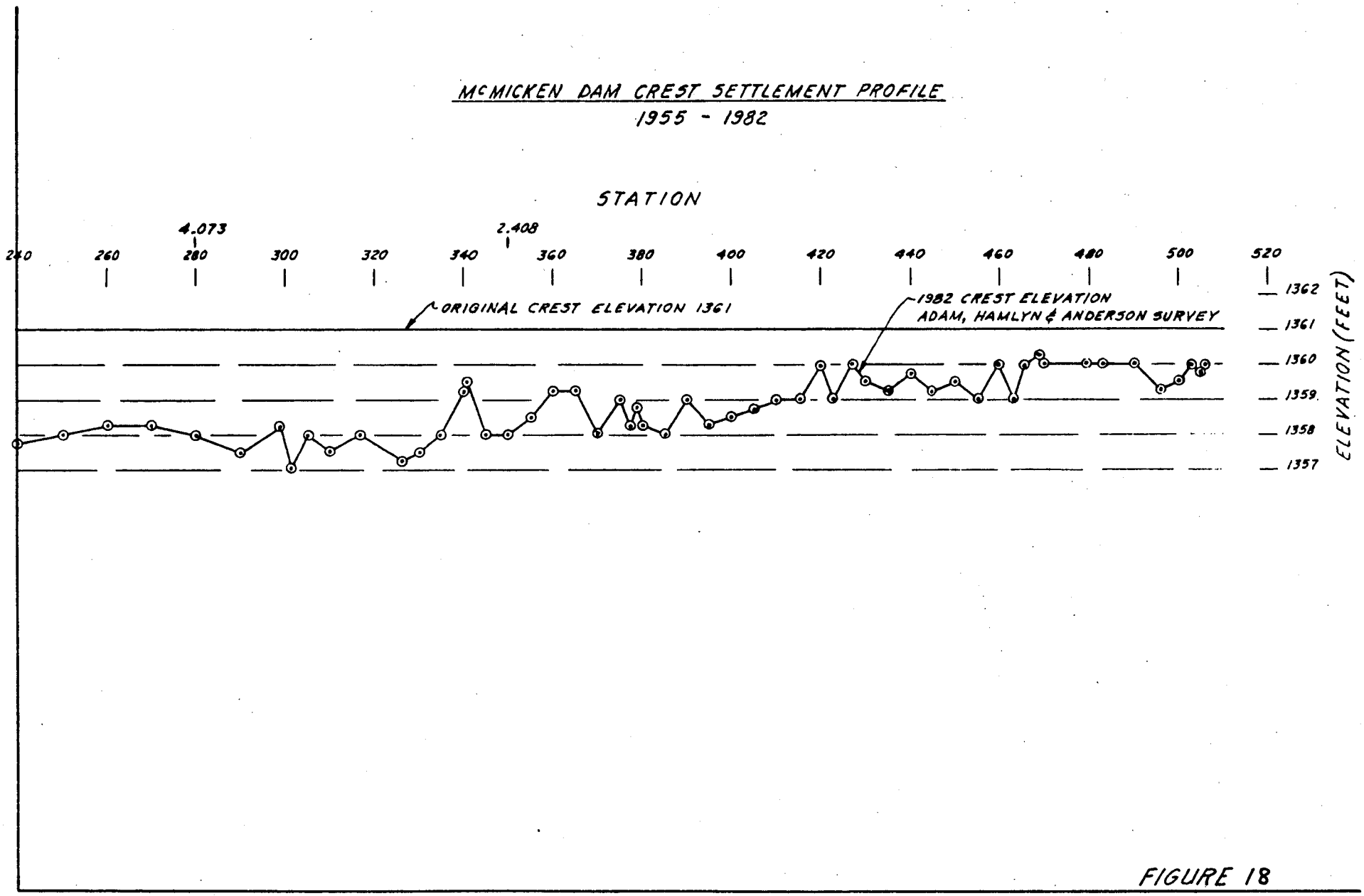


FIGURE 18

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS
PHOENIX • ALBUQUERQUE • SANTA FE

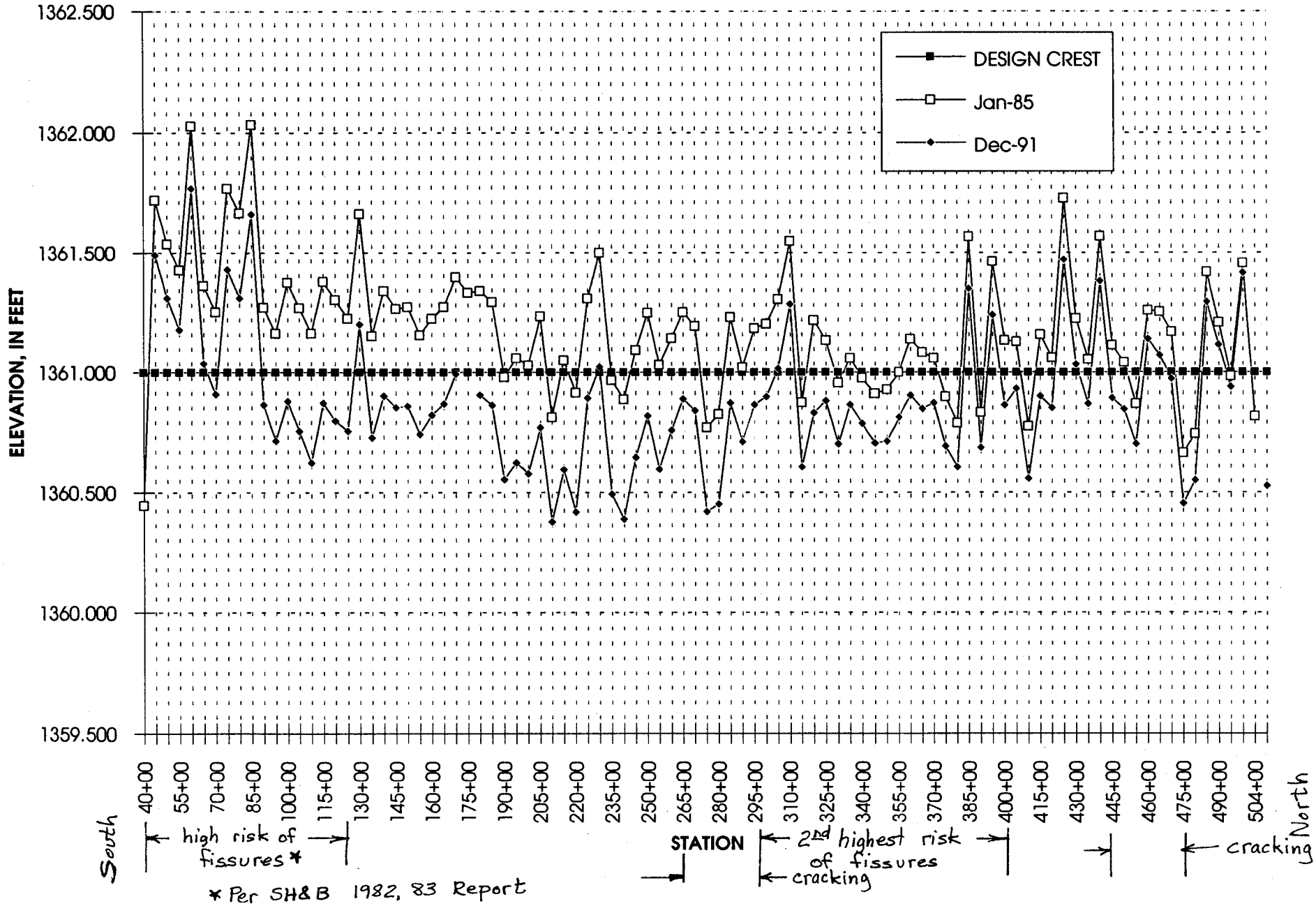
Project: MCMICKEN DAM
Job No.: E 81-138
Computed by: J.D.D. Ckd. by:
Date: 2-22-82 Page 2 of 2

MICKMICKEN DAM SUBSIDENCE MONITORING					
MARKER	STATION	DESIGN	Jan-85	Dec-91	1985-1991
SM-1	40+00	1361.000	1360.445		XXXX
SM-2	45+00	1361.000	1361.719	1361.490	-0.229
SM-3	50+00	1361.000	1361.537	1361.311	-0.226
SM-4	55+00	1361.000	1361.428	1361.179	-0.249
SM-5	60+00	1361.000	1362.027	1361.768	-0.259
SM-6	65+00	1361.000	1361.362	1361.038	-0.324
SM-7	70+00	1361.000	1361.253	1360.910	-0.343
SM-8	75+00	1361.000	1361.767	1361.430	-0.337
SM-9	80+00	1361.000	1361.665	1361.310	-0.355
SM-10	85+00	1361.000	1362.033	1361.660	-0.373
SM-11	90+00	1361.000	1361.271	1360.865	-0.406
SM-12	95+00	1361.000	1361.164	1360.716	-0.448
SM-13	100+00	1361.000	1361.375	1360.880	-0.495
SM-14	105+00	1361.000	1361.269	1360.756	-0.513
SM-15	110+00	1361.000	1361.164	1360.624	-0.540
SM-16	115+00	1361.000	1361.380	1360.872	-0.508
SM-17	120+00	1361.000	1361.303	1360.798	-0.505
SM-18	125+00	1361.000	1361.225	1360.756	-0.469
SM-19	130+00	1361.000	1361.662	1361.201	-0.461
SM-20	135+00	1361.000	1361.153	1360.728	-0.425
SM-21	140+00	1361.000	1361.341	1360.902	-0.439
SM-22	145+00	1361.000	1361.266	1360.854	-0.412
SM-23	150+00	1361.000	1361.273	1360.859	-0.414
SM-24	155+00	1361.000	1361.156	1360.742	-0.414
SM-25	160+00	1361.000	1361.226	1360.823	-0.403
SM-26	165+00	1361.000	1361.273	1360.868	-0.405
SM-27	170+00	1361.000	1361.397	1360.994	-0.403
SM-28	175+00	1361.000	1361.333		XXXX
SM-29	180+00	1361.000	1361.340	1360.907	-0.433
SM-30	185+00	1361.000	1361.294	1360.864	-0.430
SM-31	190+00	1361.000	1360.980	1360.553	-0.427
SM-32	195+00	1361.000	1361.061	1360.624	-0.437
SM-33	200+00	1361.000	1361.031	1360.577	-0.454
SM-34	205+00	1361.000	1361.234	1360.770	-0.464
SM-35	210+00	1361.000	1360.814	1360.378	-0.436
SM-36	215+00	1361.000	1361.051	1360.595	-0.456

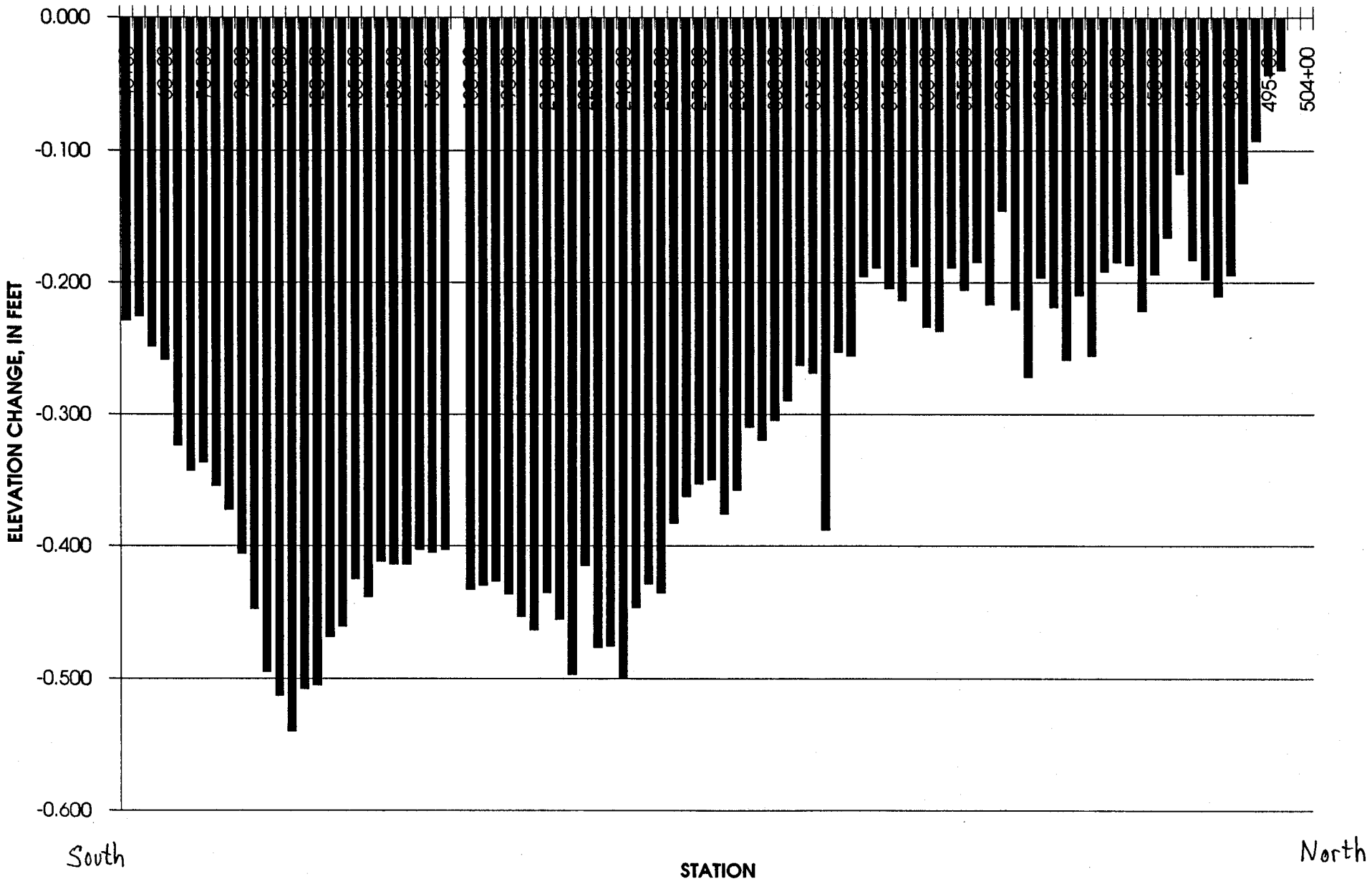
SM-37	220+00	1361.000	1360.915	1360.418	-0.497
SM-38	225+00	1361.000	1361.309	1360.894	-0.415
SM-39	230+00	1361.000	1361.500	1361.023	-0.477
SM-40	235+00	1361.000	1360.968	1360.492	-0.476
SM-41	240+00	1361.000	1360.888	1360.388	-0.500
SM-42	245+00	1361.000	1361.094	1360.647	-0.447
SM-43	250+00	1361.000	1361.249	1360.820	-0.429
SM-44	255+00	1361.000	1361.033	1360.597	-0.436
SM-45	260+00	1361.000	1361.143	1360.760	-0.383
SM-46	265+00	1361.000	1361.252	1360.889	-0.363
SM-47	270+00	1361.000	1361.194	1360.841	-0.353
SM-48	275+00	1361.000	1360.770	1360.420	-0.350
SM-49	280+00	1361.000	1360.827	1360.451	-0.376
SM-50	285+00	1361.000	1361.230	1360.872	-0.358
SM-51	290+00	1361.000	1361.022	1360.712	-0.310
SM-52	295+00	1361.000	1361.185	1360.865	-0.320
SM-53	300+00	1361.000	1361.203	1360.898	-0.305
SM-54	305+00	1361.000	1361.305	1361.015	-0.290
SM-55	310+00	1361.000	1361.548	1361.285	-0.263
SM-56	315+00	1361.000	1360.875	1360.606	-0.269
SM-57	320+00	1361.000	1361.219	1360.831	-0.388
SM-58	325+00	1361.000	1361.135	1360.882	-0.253
SM-59	330+00	1361.000	1360.957	1360.701	-0.256
SM-60	335+00	1361.000	1361.061	1360.865	-0.196
SM-61	340+00	1361.000	1360.976	1360.787	-0.189
SM-62	345+00	1361.000	1360.911	1360.706	-0.205
SM-63	350+00	1361.000	1360.928	1360.714	-0.214
SM-64	355+00	1361.000	1361.001	1360.813	-0.188
SM-65	360+00	1361.000	1361.139	1360.905	-0.234
SM-66	365+00	1361.000	1361.085	1360.848	-0.237
SM-67	370+00	1361.000	1361.061	1360.872	-0.189
SM-68	375+00	1361.000	1360.899	1360.693	-0.206
SM-69	380+00	1361.000	1360.790	1360.605	-0.185
SM-70	385+00	1361.000	1361.567	1361.350	-0.217
SM-71	390+00	1361.000	1360.833	1360.687	-0.146
SM-72	395+00	1361.000	1361.462	1361.241	-0.221
SM-73	400+00	1361.000	1361.135	1360.863	-0.272
SM-74	405+00	1361.000	1361.129	1360.932	-0.197

SM-75	410+00	1361.000	1360.777	1360.558	-0.219
SM-76	415+00	1361.000	1361.159	1360.900	-0.259
SM-77	420+00	1361.000	1361.062	1360.852	-0.210
SM-78	425+00	1361.000	1361.727	1361.471	-0.256
SM-79	430+00	1361.000	1361.226	1361.034	-0.192
SM-80	435+00	1361.000	1361.054	1360.869	-0.185
SM-81	440+00	1361.000	1361.569	1361.382	-0.187
SM-82	445+00	1361.000	1361.115	1360.893	-0.222
SM-83	450+00	1361.000	1361.041	1360.847	-0.194
SM-84	455+00	1361.000	1360.868	1360.702	-0.166
SM-85	460+00	1361.000	1361.258	1361.140	-0.118
SM-86	465+00	1361.000	1361.254	1361.071	-0.183
SM-87	470+00	1361.000	1361.170	1360.972	-0.198
SM-88	475+00	1361.000	1360.664	1360.453	-0.211
SM-89	480+00	1361.000	1360.745	1360.550	-0.195
SM-90	485+00	1361.000	1361.419	1361.294	-0.125
SM-91	490+00	1361.000	1361.209	1361.116	-0.093
SM-92	495+00	1361.000	1360.984	1360.940	-0.044
SM-93	500+00	1361.000	1361.455	1361.415	-0.040
SM-94	504+00	1361.000	1360.817		XXXX
SM-94(REPL)	504+00	1361.000		1360.525	XXXXX
AVERAGE CHANGE					**-0.316**
MINIMUM			**1360.445**	**1360.378**	**-0.540**
MAXIMUM			**1362.033**	**1361.768**	**-0.040**

MCMICKEN DAM CREST SETTLEMENT MONUMENTS



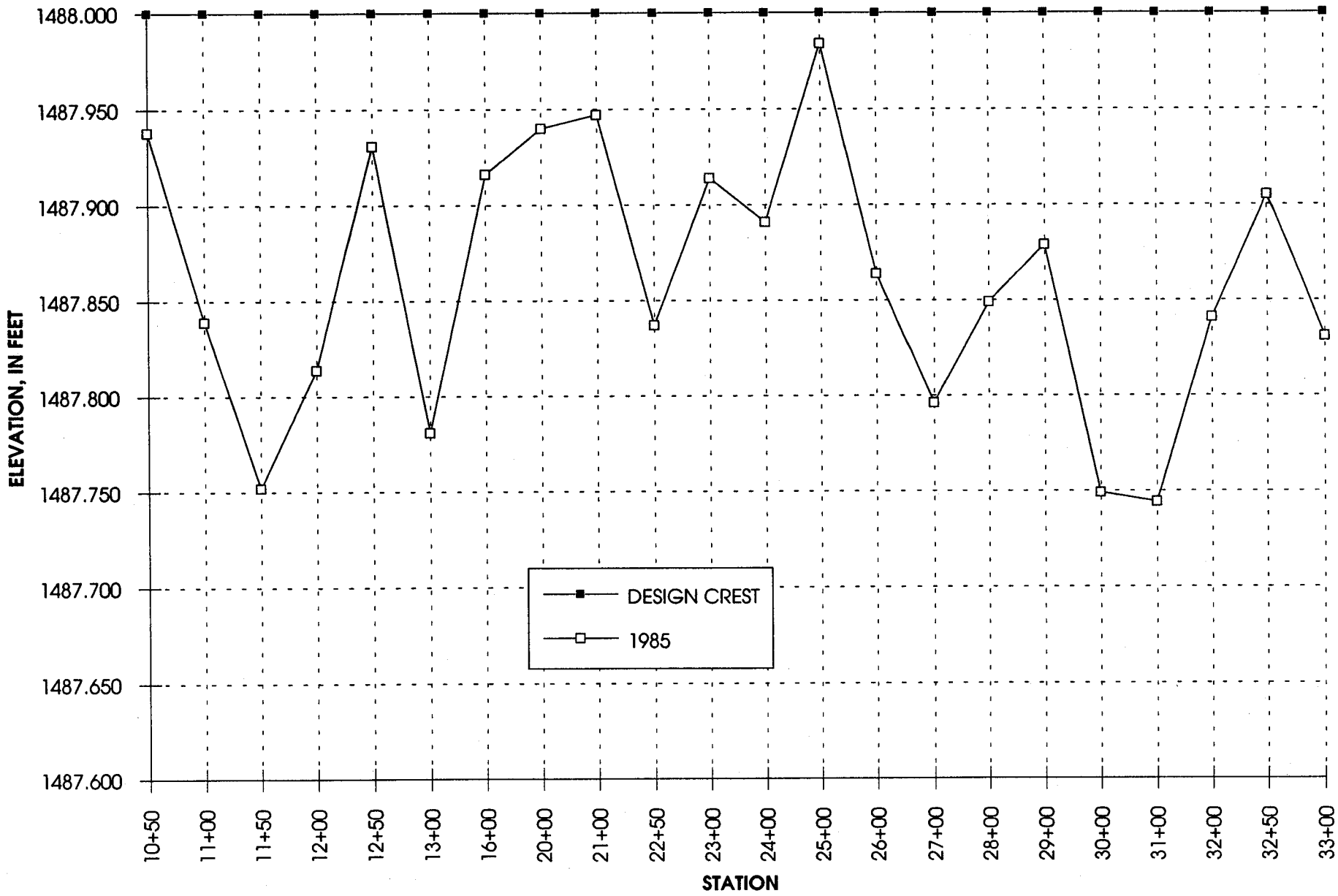
MCMICKEN DAM CHANGE IN CREST 1985 TO 1991



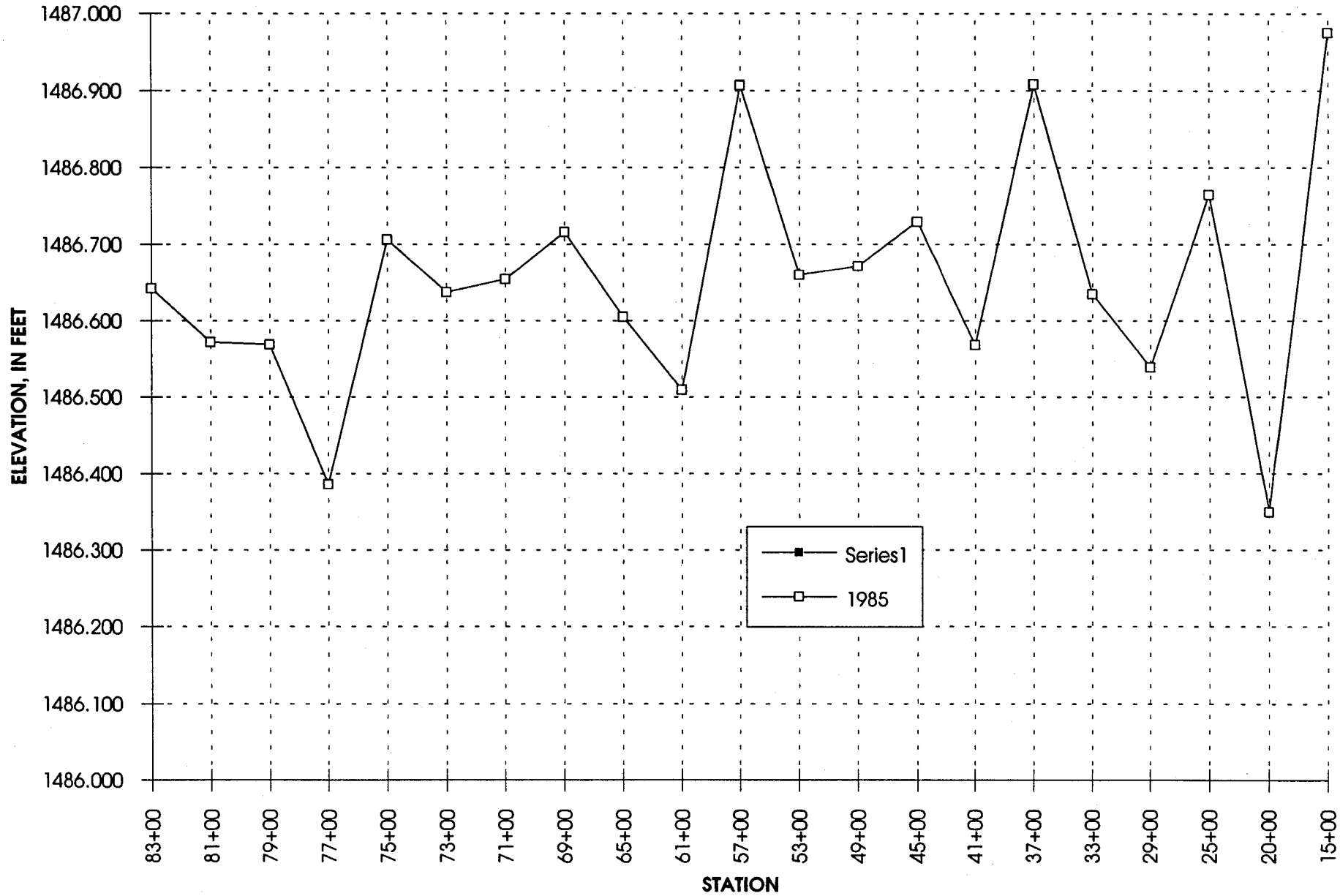
NEW RIVER DAM SUBSIDENCE MONITORING									
MARKER	**STATION**	**O CENTERLINE**	**DESIGN**	**Jan-85**					
SM-1	10+50	8' U/S	1488.000	1487.938					
SM-2	11+00	8' U/S	1488.000	1487.839					
SM-3	11+50	8' U/S	1488.000	1487.752					
SM-4	12+00	8' U/S	1488.000	1487.814					
SM-5	12+50	8' U/S	1488.000	1487.931					
SM-6	13+00	8' U/S	1488.000	1487.781					
SM-7	16+00	8' U/S	1488.000	1487.916					
SM-9	20+00	8' U/S	1488.000	1487.940					
SM-10	21+00	8' U/S	1488.000	1487.947					
SM-12	22+50	8' U/S	1488.000	1487.837					
SM-13	23+00	8' U/S	1488.000	1487.914					
SM-15	24+00	8' U/S	1488.000	1487.891					
SM-16	25+00	8' U/S	1488.000	1487.984					
SM-18	26+00	8' U/S	1488.000	1487.864					
SM-19	27+00	8' U/S	1488.000	1487.796					
SM-21	28+00	8' U/S	1488.000	1487.849					
SM-22	29+00	8' U/S	1488.000	1487.879					
SM-24	30+00	8' U/S	1488.000	1487.749					
SM-26	31+00	8' U/S	1488.000	1487.744					
SM-27	32+00	8' U/S	1488.000	1487.841					
SM-28	32+50	8' U/S	1488.000	1487.905					
SM-29	33+00	8' U/S	1488.000	1487.831					
MINIMUM				**1487.744**					
MAXIMUM				**1487.984**					
SM-8	19+50	150' U/S		1436.754					
SM-11	21+50	150' U/S		1437.106					
SM-14	23+50	150' U/S		1430.764					
SM-17	25+50	150' U/S		1430.752					
SM-20	27+50	150' U/S		1430.473					
SM-23	29+50	150' U/S		1430.952					
SM-25	30+50	150' U/S		1430.652					
DIKE #1									
SM-30	83+00			1486.642					
SM-31	81+00			1486.572					
SM-32	79+00			1486.569					
SM-33	77+00			1486.386					
SM-34	75+00			1486.706					
SM-35	73+00			1486.637					
SM-36	71+00			1486.654					

SM-37	69+00			1486.716					
SM-38	65+00			1486.605					
SM-39	61+00			1486.509					
SM-40	57+00			1486.907					
SM-41	53+00			1486.660					
SM-42	49+00			1486.671					
SM-43	45+00			1486.729					
SM-44	41+00			1486.568					
SM-45	37+00			1486.908					
SM-46	33+00			1486.635					
SM-47	29+00			1486.539					
SM-48	25+00			1486.765					
SM-49	20+00			1486.349					
SM-50	15+00			1486.975					
NOTES:									
1) CONSTRUCTION COMPLETED 1985									
2) DESIGN CREST ELEVATION = 1488.0									
3) DESIGN SPILLWAY ELEVATION = 1488.00									
4) MAXIMUM HEIGHT = 104'									
5) FREEBOARD = 5.5'									
6) BETWEEN STATION 20+00 AND 30+00 DAM IS CONSTRUCTED ON ALLUVIAL MATERIALS. GREATEST SETTLEMENT EXPECTED IN THIS ARE									

NEW RIVER DAM CREST SETTLEMENT MONUMENTS

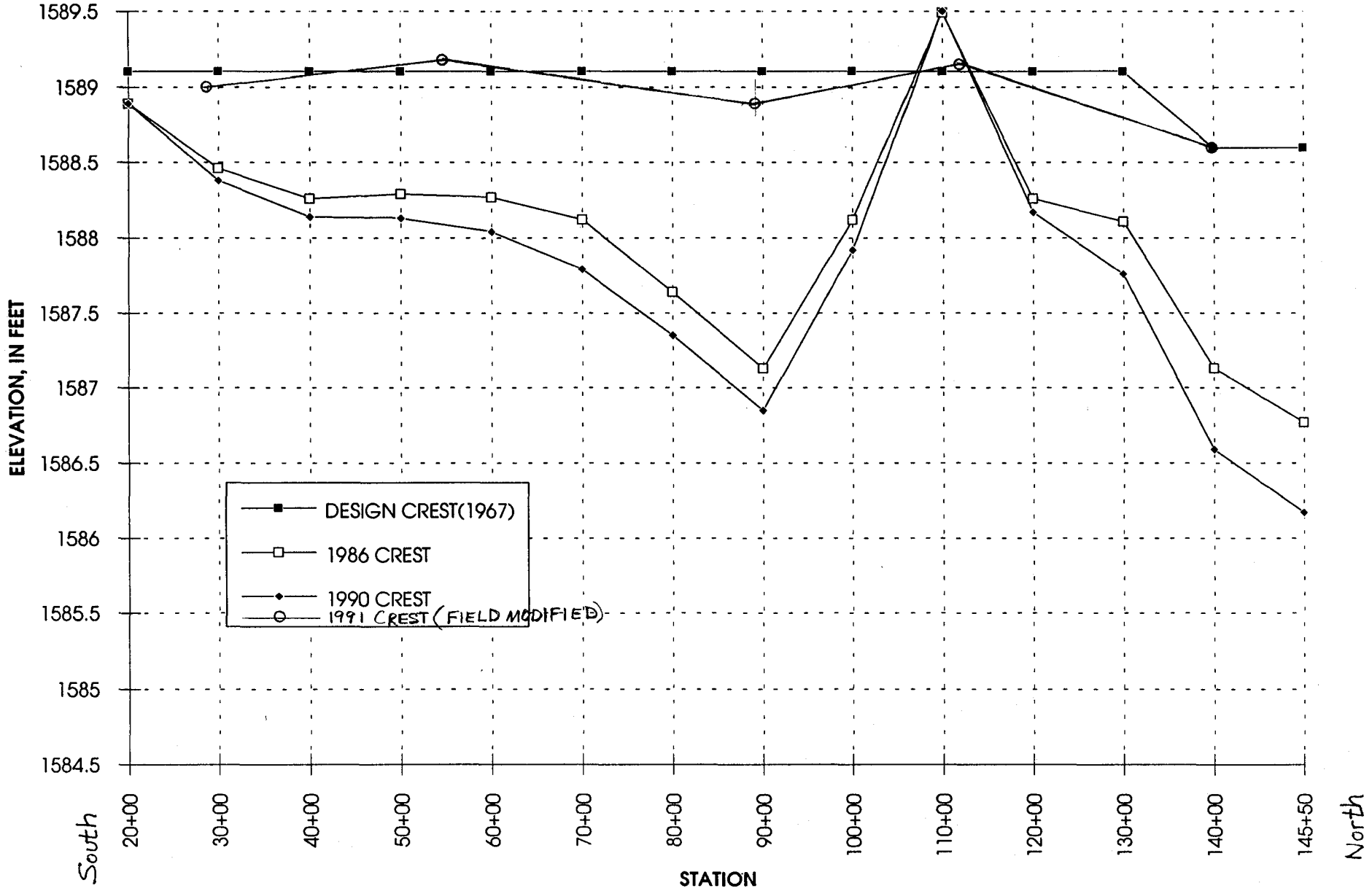


NEW RIVER DAM DIKE #1 SETTLEMENT MONITORING



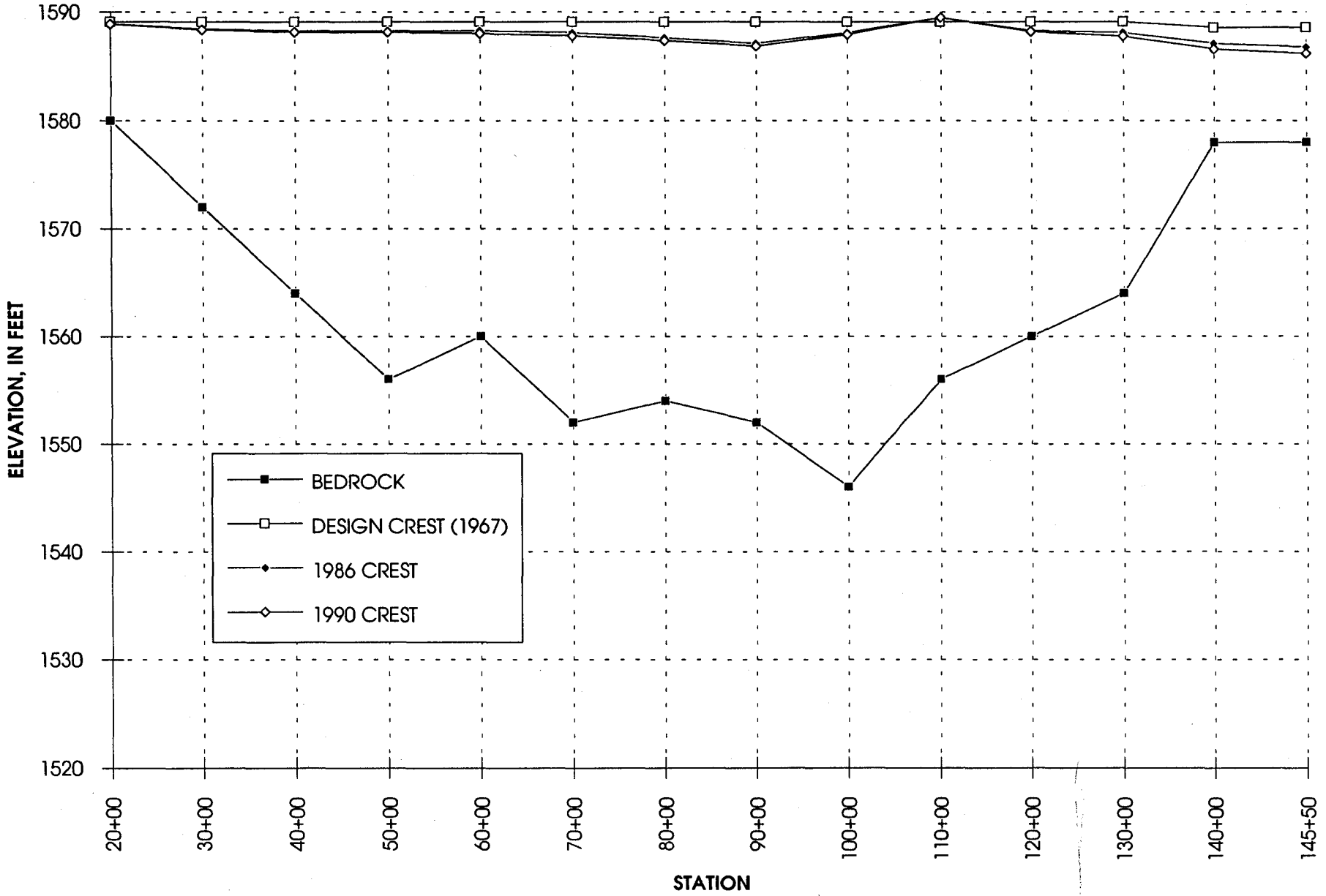
5/15/95

POWERLINE FRS CREST SETTLEMENT MONUMENTS



5/23/95

POWERLINE FRS CREST SETTLEMENT MONUMENTS



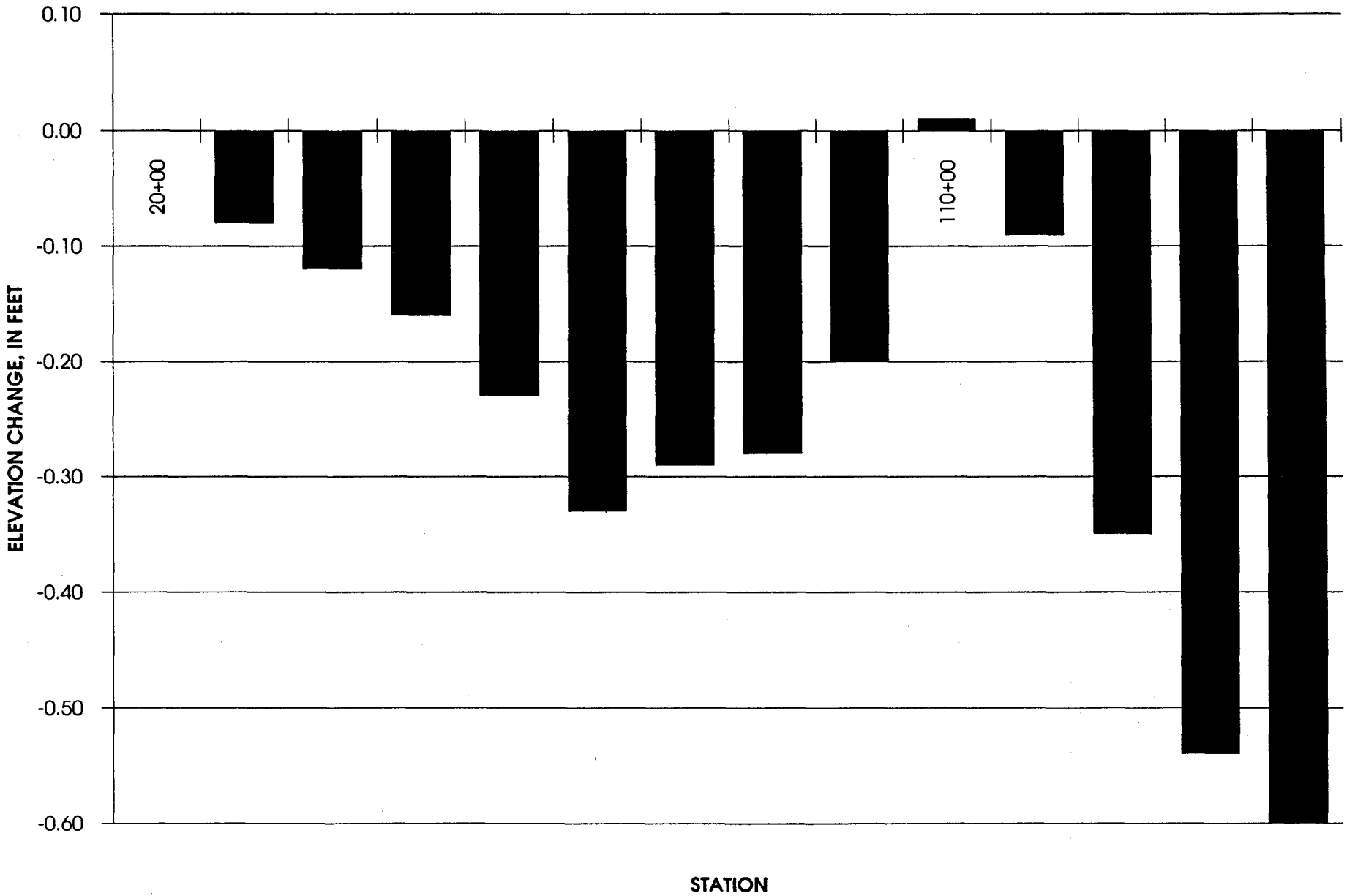
5/17/95

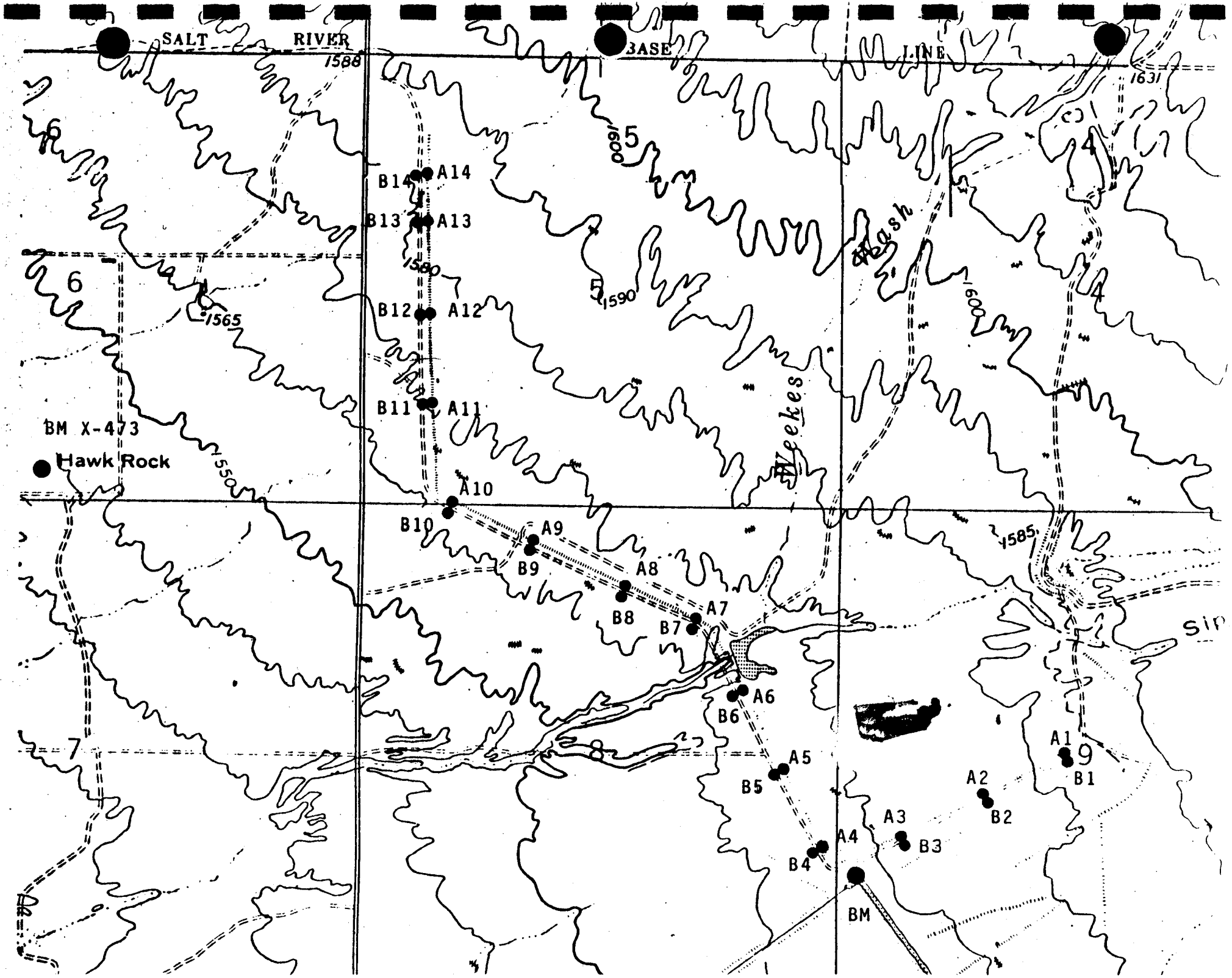
POWERLINE FRS SUBSIDENCE MONITORING									
MARKER	**STATION**	**DESIGN**	**1986**	**1990**	**1986-1990**				
SM-A1	20+00	1589.10	1588.89	1588.89	0.00				
SM-A2	30+00	1589.10	1588.46	1588.38	-0.08				
SM-A3	40+00	1589.10	1588.26	1588.14	-0.12				
SM-A4	50+00	1589.10	1588.29	1588.13	-0.16				
SM-A5	60+00	1589.10	1588.27	1588.04	-0.23				
SM-A6	70+00	1589.10	1588.12	1587.79	-0.33				
SM-A7	80+00	1589.10	1587.64	1587.35	-0.29				
SM-A8	90+00	1589.10	1587.13	1586.85	-0.28				
SM-A9	100+00	1589.10	1588.12	1587.92	-0.20				
SM-A10	110+00	1589.10	1589.49	1589.50	0.01				
SM-A11	120+00	1589.10	1588.26	1588.17	-0.09				
SM-A12	130+00	1589.10	1588.11	1587.76	-0.35				
SM-A13	140+00	1588.60	1587.13	1586.59	-0.54				
SM-A14	145+50	1588.60	1586.77	1586.17	-0.60				
AVERAGE CHANGE			**1588.07**	**1587.83**	**-0.23**				
MINIMUM			**1586.77**	**1586.17**	**-0.60**				
MAXIMUM			**1589.49**	**1589.50**	**0.01**				
SM-B1	20+00		1584.15						
SM-B2	30+00		1578.20						
SM-B3	40+00		1572.00						
SM-B4	50+00		1565.98						
SM-B5	60+00		1564.46						
SM-B6	70+00		1562.13						
SM-B7	80+00		1563.44						
SM-B8	90+00		1564.30						
SM-B9	100+00		1564.12						
SM-B10	110+00		1564.00						
SM-B11	120+00		1569.50						
SM-B12	130+00		1574.69						
SM-B13	140+00		1581.39						
SM-B14	145+00		1582.51						
NOTES:									
1) CONSTRUCTION COMPLETED 1967									
2) DESIGN CREST ELEVATION = 1589.10									
3) DESIGN SPILLWAY CREST = 1583.30									
4) MAXIMUM HEIGHT = 24'									
5) FREEBOARD = 4.8'.									
6) POWERLINE FRS REPAIR COMPLETED IN 1991. ADDED CENTER DRAIN. CREST FIELD MODIFIED AS FOLLOWS.									

7) 1990 CREST ELEVATIONS ARE FROM THE 1991 REPAIR PLANS. THIS INFO HAS NOT BEEN FORMALLY SUBMITTED TO FCD.									
STATION	DOWNSTREAM	UPSTREAM							
29+00	89.00	88.70							
55+00	89.30	88.80							
89+00	88.80	88.70							
112+00	89.30	88.90							
140+00	88.70	88.20							

5/16/95

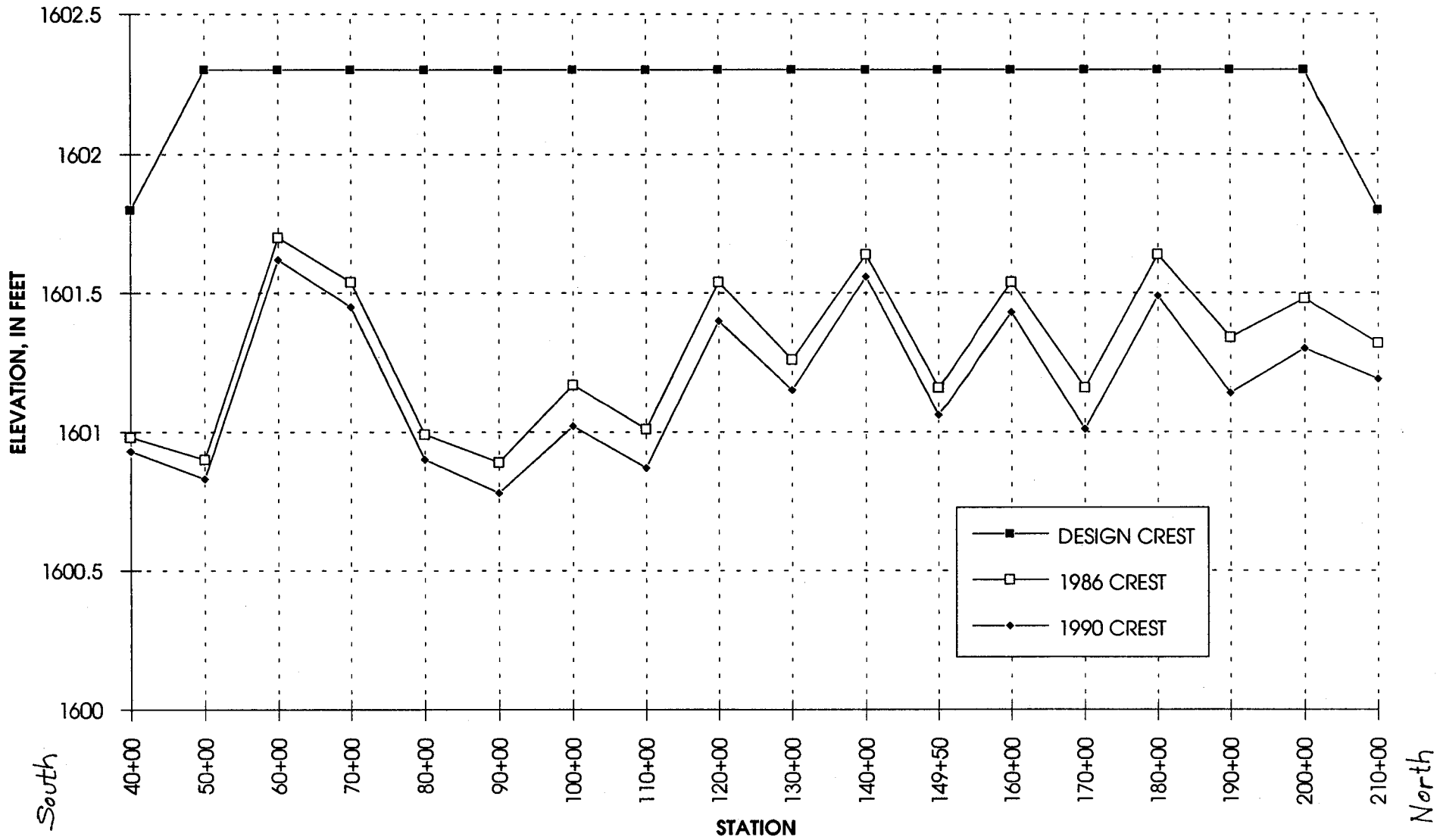
POWERLINE FRS CHANGE IN CREST 1986 TO 1990




SALT RIVER BASE LINE
1588
1631
6
5
4
B14
A14
B13
A13
1580
1590
1600
B12
A12
1565
B11
A11
BM X-473
Hawk Rock
550
A10
B10
A9
B9
A8
B8
A7
B7
A6
B6
A5
B5
A4
B4
BM
A3
B3
A2
B2
A1
B1
1585
7
8
9
Weekes
Wash

5/4/95

RITTENHOUSE FRS CREST SETTLEMENT MONUMENTS

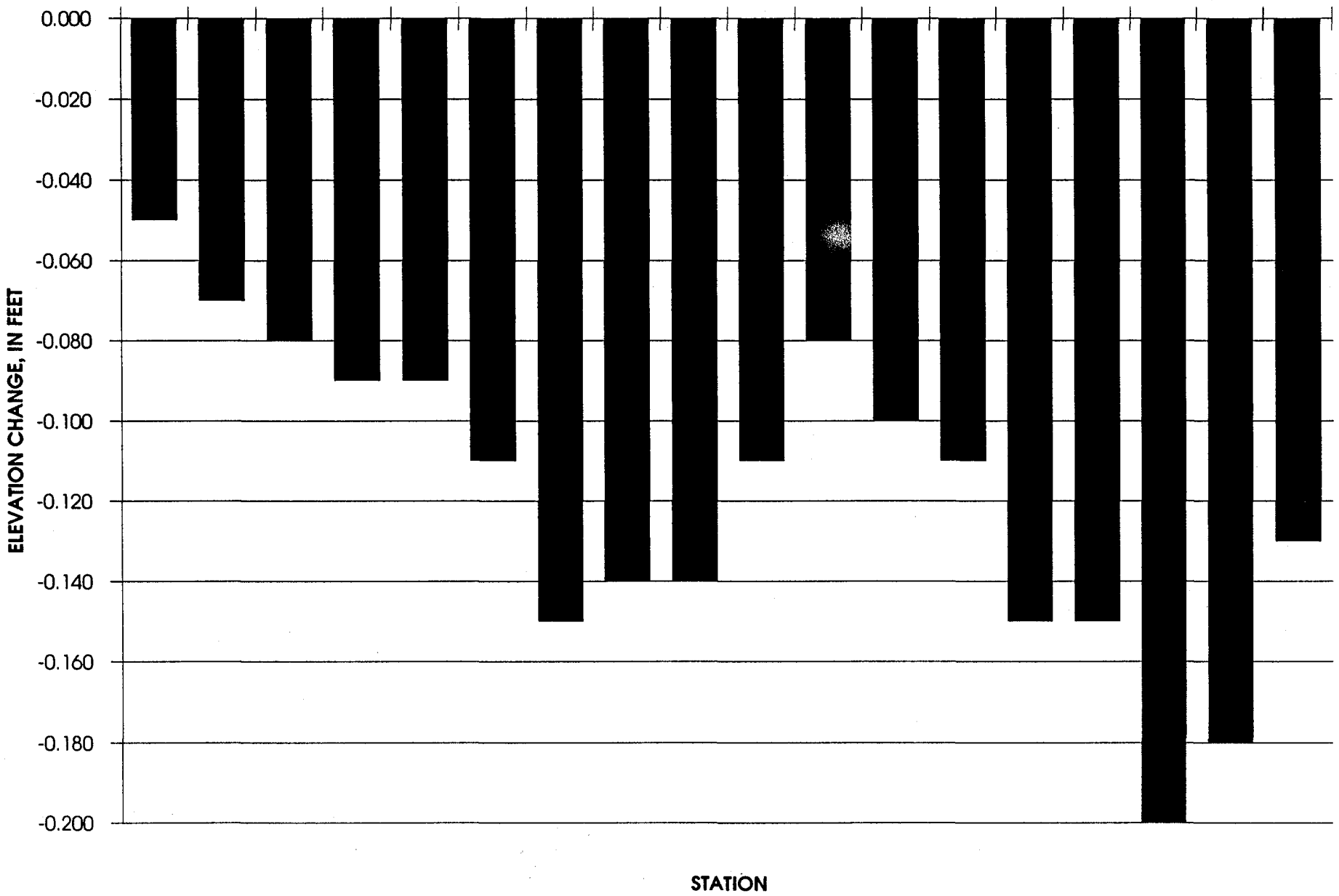


RITTENHOUSE FRS SUBSIDENCE MONITORING					
MARKER	**DESIGN**	**1986**	**1990**	**STATION**	**1986-1990**
SM-A1	1601.800	1600.98	1600.93	40+00	-0.050
SM-A2	1602.300	1600.90	1600.83	50+00	-0.070
SM-A3	1602.300	1601.70	1601.62	60+00	-0.080
SM-A4	1602.300	1601.54	1601.45	70+00	-0.090
SM-A5	1602.300	1600.99	1600.90	80+00	-0.090
SM-A6	1602.300	1600.89	1600.78	90+00	-0.110
SM-A7	1602.300	1601.17	1601.02	100+00	-0.150
SM-A8	1602.300	1601.01	1600.87	110+00	-0.140
SM-A9	1602.300	1601.54	1601.40	120+00	-0.140
SM-A10	1602.300	1601.26	1601.15	130+00	-0.110
SM-A11	1602.300	1601.64	1601.56	140+00	-0.080
SM-A12	1602.300	1601.16	1601.06	149+50	-0.100
SM-A13	1602.300	1601.54	1601.43	160+00	-0.110
SM-A14	1602.300	1601.16	1601.01	170+00	-0.150
SM-A15	1602.300	1601.64	1601.49	180+00	-0.150
SM-A16	1602.300	1601.34	1601.14	190+00	-0.200
SM-A17	1602.300	1601.48	1601.30	200+00	-0.180
SM-A18	1601.800	1601.32	1601.19	210+00	-0.130
AVERAGE CHANGE					**-0.118**
MINIMUM		**1600.89**	**1600.78**		**-0.20**
MAXIMUM		**1601.70**	**1601.62**		**-0.05**
SM-B1		1593.36	1593.30	40+00	-0.060
SM-B2		1585.40	1585.33	50+00	-0.070
SM-B3		1583.96	1583.88	60+00	-0.080
SM-B4		1583.76	1583.68	70+00	-0.080
SM-B5		1585.35	1585.25	80+00	-0.100
SM-B6		1586.25	1586.13	90+00	-0.120
SM-B7		1585.04	1584.92	100+00	-0.120
SM-B8		1585.03	1584.91	110+00	-0.120
SM-B9		1585.90	1585.79	120+00	-0.110
SM-B10		1583.90	1583.82	130+00	-0.080
SM-B11		1587.51	1587.43	140+00	-0.080
SM-B12		1585.54	1585.46	149+50	-0.080
SM-B13		1584.39	1584.30	160+00	-0.090
SM-B14		1585.06	1584.96	170+00	-0.100
SM-B15		1584.50	1584.38	180+00	-0.120
SM-B16		1582.82	1582.69	190+00	-0.130
SM-B17		1588.83	1588.71	200+00	-0.120
SM-B18		1595.89	1595.78	210+00	-0.110
AVERAGE CHANGE					**-0.098**

MINIMUM					**-0.130**
MAXIMUM					**-0.070**
CHANGE 1				40+00	0.010
CHANGE 2				50+00	0.000
CHANGE 3				60+00	0.000
CHANGE 4				70+00	-0.010
CHANGE 5				80+00	0.010
CHANGE 6				90+00	0.010
CHANGE 7				100+00	-0.030
CHANGE 8				110+00	-0.020
CHANGE 9				120+00	-0.030
CHANGE 10				130+00	-0.030
CHANGE 11				140+00	0.000
CHANGE 12				149+50	-0.020
CHANGE 13				160+00	-0.020
CHANGE 14				170+00	-0.050
CHANGE 15				180+00	-0.030
CHANGE 16				190+00	-0.070
CHANGE 17				200+00	-0.060
CHANGE 18				210+00	-0.020
AVERAGE CHANGE					**-0.020**
MINIMUM					**-0.070**
MAXIMUM					**0.010**
NOTES:					
1) CONSTRUCTION COMPLETED 1969					
2) DESIGN CREST ELEVATION = 1602.3					
3) DESIGN SPILLWAY CREST = 1597.60					
4) SPILLWAY AT STATION 27+00 CONSTRUCTED OF COMPACTED EARTHFILL.					
5) MAXIMUM HEIGHT = 20'					
6) FREEBOARD = 4.7'					

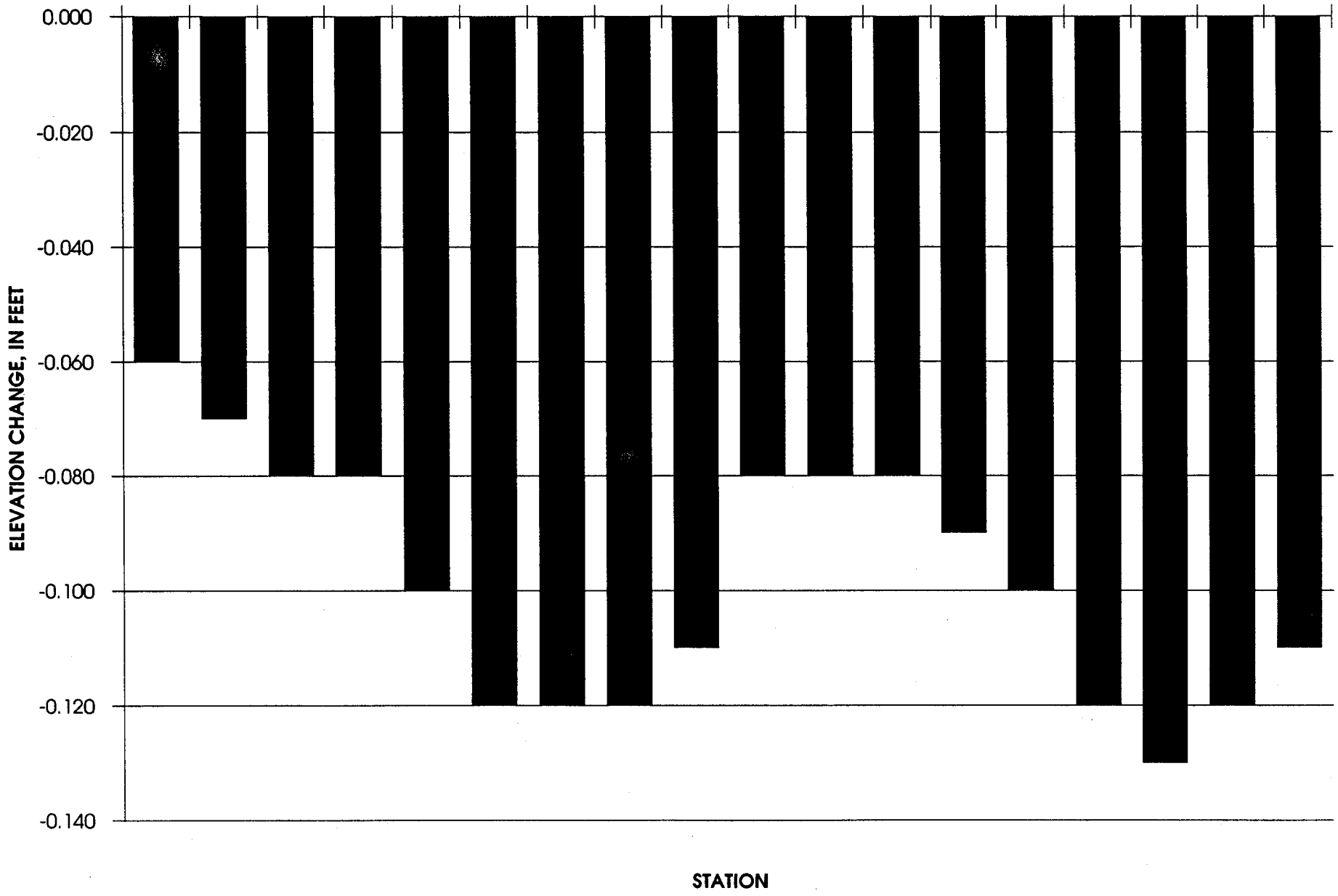
4/27/95

RITTENHOUSE FRS, CHANGE IN CREST 1986 TO 1990



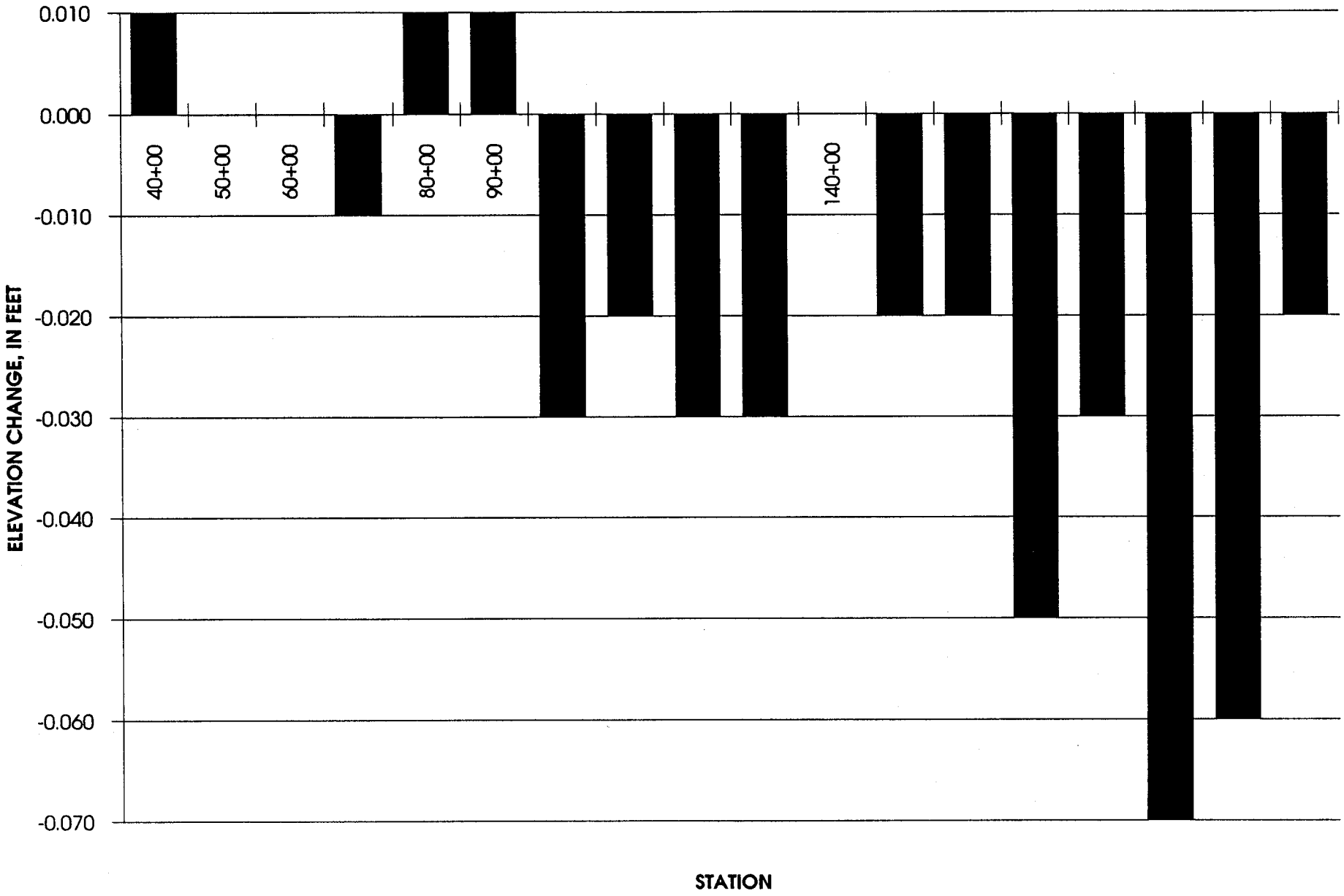
4/27/95

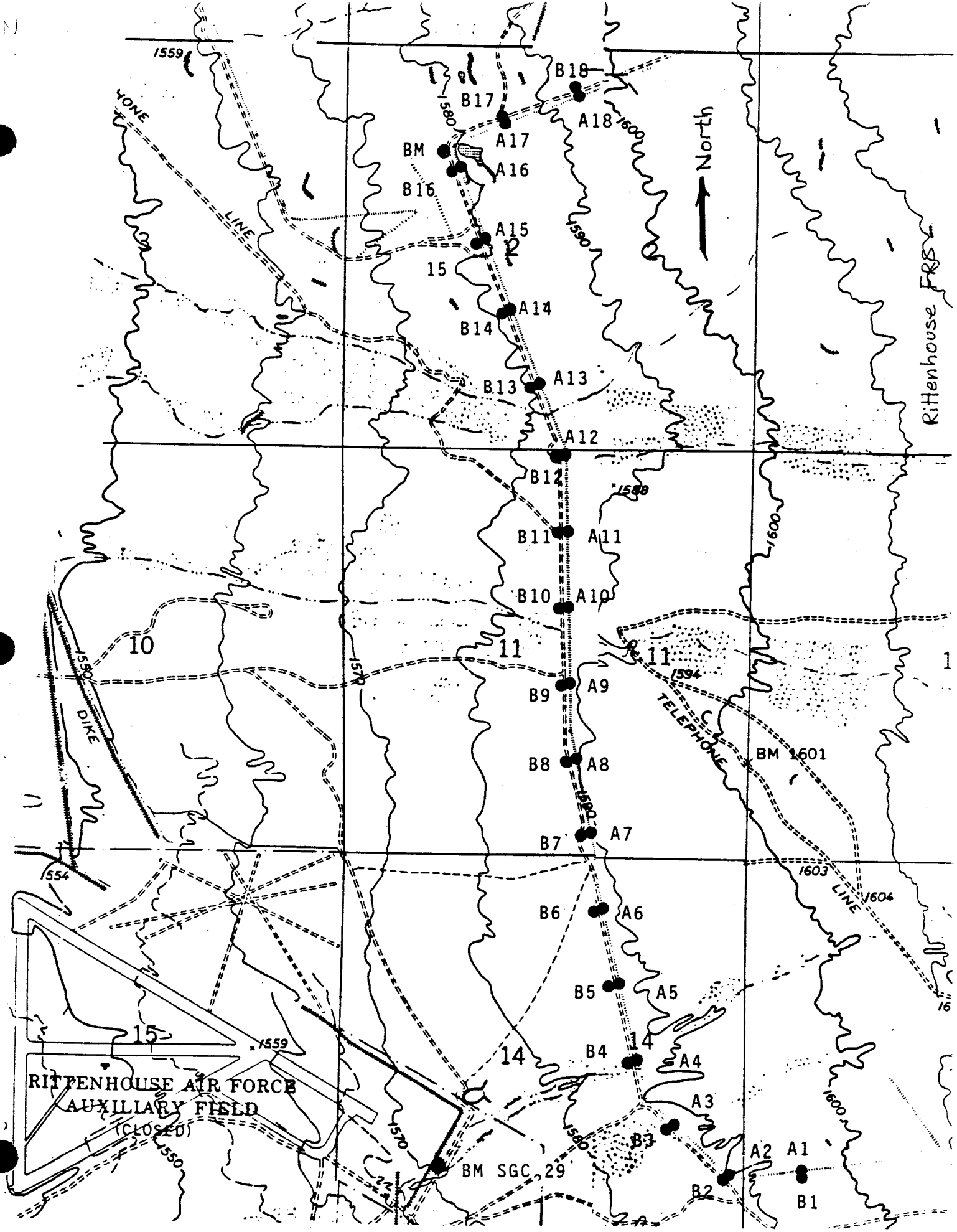
RITTENHOUSE FRS CHANGE IN DOWNSTREAM TOE 1986 TO 1990



4/27/95

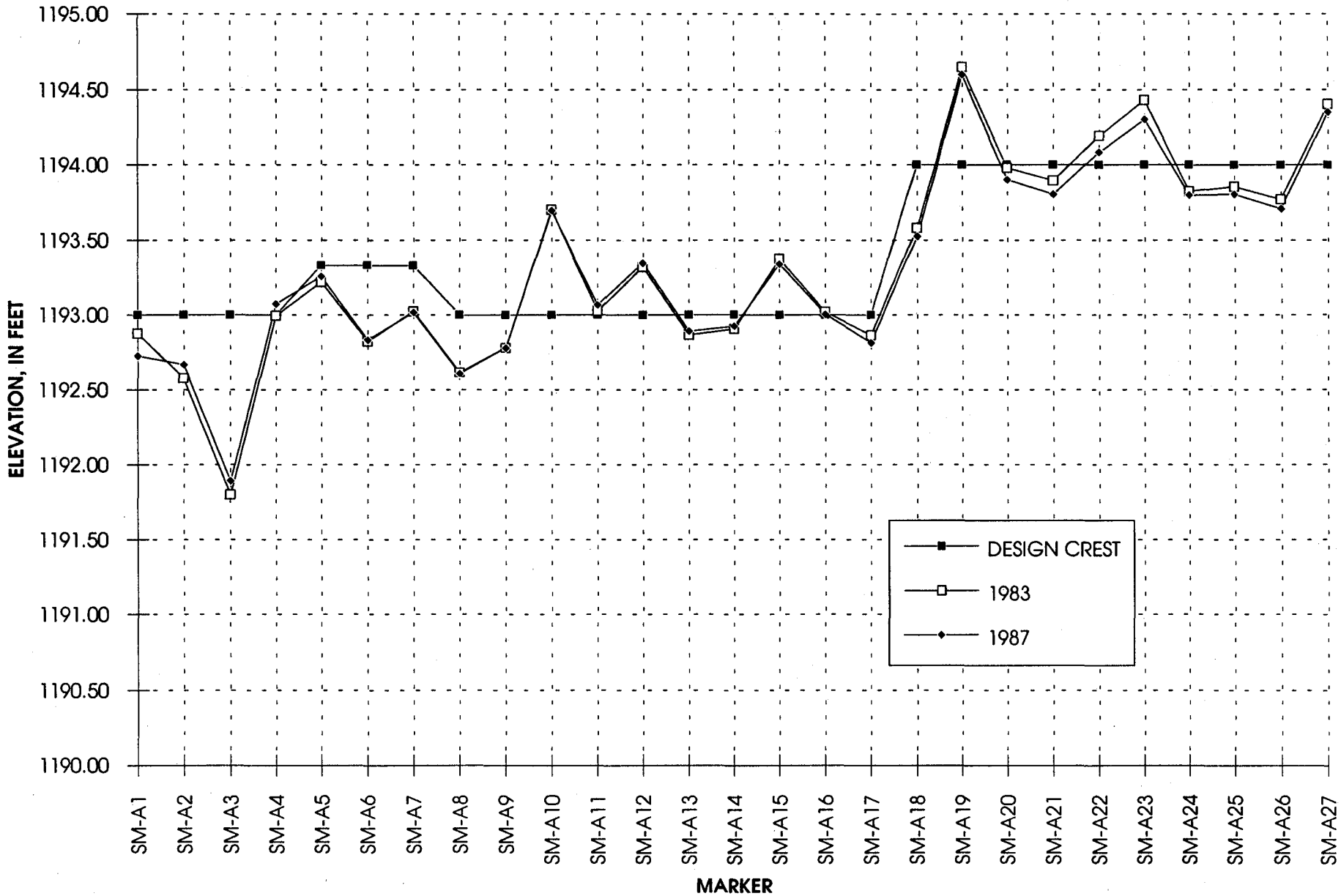
RITTENHOUSE FRS CONSOLIDATION/EXPANSION OF FILL, 1986 TO 1990




North
Rittenhouse FRS
B18
A18
B17
A17
BM
A16
B16
A15
15
A14
B14
B13
A13
A12
B12
B11
A11
B10
A10
10
11
11
B9
A9
B8
A8
B7
A7
B6
A6
B5
A5
15
14
14
B4
A4
A3
B3
A2
A1
B1
B2
BM SGC 29
BM 1601
TELEPHONE
LINE
DIKE
RITTENHOUSE AIR FORCE
AUXILIARY FIELD
(CLOSED)
1559
1580
1600
1590
1588
1594
1603
1604
1554
1570
1550

5/4/95

SADDLEBACK FRS CREST SETTLEMENT MONUMENTS



5/15/95

SADDLEBACK FRS SUBSIDENCE MONITORING						
MARKER	**STATION**	**DESIGN**	**1983**	**1986**	**1983-1986**	**DESIGN-1986**
R-1			1251.881	1251.881	0.000	
R-2			1199.987	1200.060	0.073	
SM-A1	10	1193.00	1192.876	1192.727	-0.149	-0.273
SM-A2	20	1193.00	1192.578	1192.669	0.091	-0.331
SM-A3	30	1193.00	1191.798	1191.893	0.095	-1.107
SM-A4	40	1193.00	1192.994	1193.073	0.079	0.073
SM-A5	50	1193.33	1193.219	1193.257	0.038	-0.073
SM-A6	60	1193.33	1192.824	1192.832	0.008	-0.498
SM-A7	70	1193.33	1193.022	1193.016	-0.006	-0.314
SM-A8	80	1193.00	1192.614	1192.609	-0.005	-0.391
SM-A9	90	1193.00	1192.780	1192.780	0.000	-0.220
SM-A10	100	1193.00	1193.703	1193.697	-0.006	0.697
SM-A11	110	1193.00	1193.026	1193.067	0.041	0.067
SM-A12	120	1193.00	1193.320	1193.347	0.027	0.347
SM-A13	130	1193.00	1192.866	1192.892	0.026	-0.108
SM-A14	140	1193.00	1192.903	1192.923	0.020	-0.077
SM-A15	150	1193.00	1193.375	1193.341	-0.034	0.341
SM-A16	160	1193.00	1193.020	1193.003	-0.017	0.003
SM-A17	170	1193.00	1192.865	1192.815	-0.050	-0.185
SM-A18	180	1194.00	1193.582	1193.523	-0.059	-0.477
SM-A19	190	1194.00	1194.647	1194.596	-0.051	0.596
SM-A20	200	1194.00	1193.979	1193.902	-0.077	-0.098
SM-A21	210	1194.00	1193.895	1193.805	-0.090	-0.195
SM-A22	220	1194.00	1194.193	1194.085	-0.108	0.085
SM-A23	230	1194.00	1194.431	1194.303	-0.128	0.303
SM-A24	240	1194.00	1193.823	1193.798	-0.025	-0.202
SM-A25	250	1194.00	1193.853	1193.806	-0.047	-0.194
SM-A26	260	1194.00	1193.771	1193.709	-0.062	-0.291
SM-A27	270	1194.00	1194.406	1194.354	-0.052	0.354
AVERAGE CHANGE					**-0.020**	**-0.080**
MINIMUM			**1191.798**	**1191.893**	**-0.149**	**-1.107**
MAXIMUM			**1194.647**	**1194.596**	**0.095**	**0.697**
SM-B1			1185.953	1186.044	0.091	
SM-B2			1179.673	1179.781	0.108	
SM-B3			1181.133	1181.252	0.119	
SM-B4			1181.365	1181.482	0.117	
SM-B5			1177.253	1177.379	0.126	
SM-B6			1173.820	1173.907	0.087	
SM-B7			1175.994	1176.044	0.050	

3

6

32

6-32
3-32
6-32

Averaging

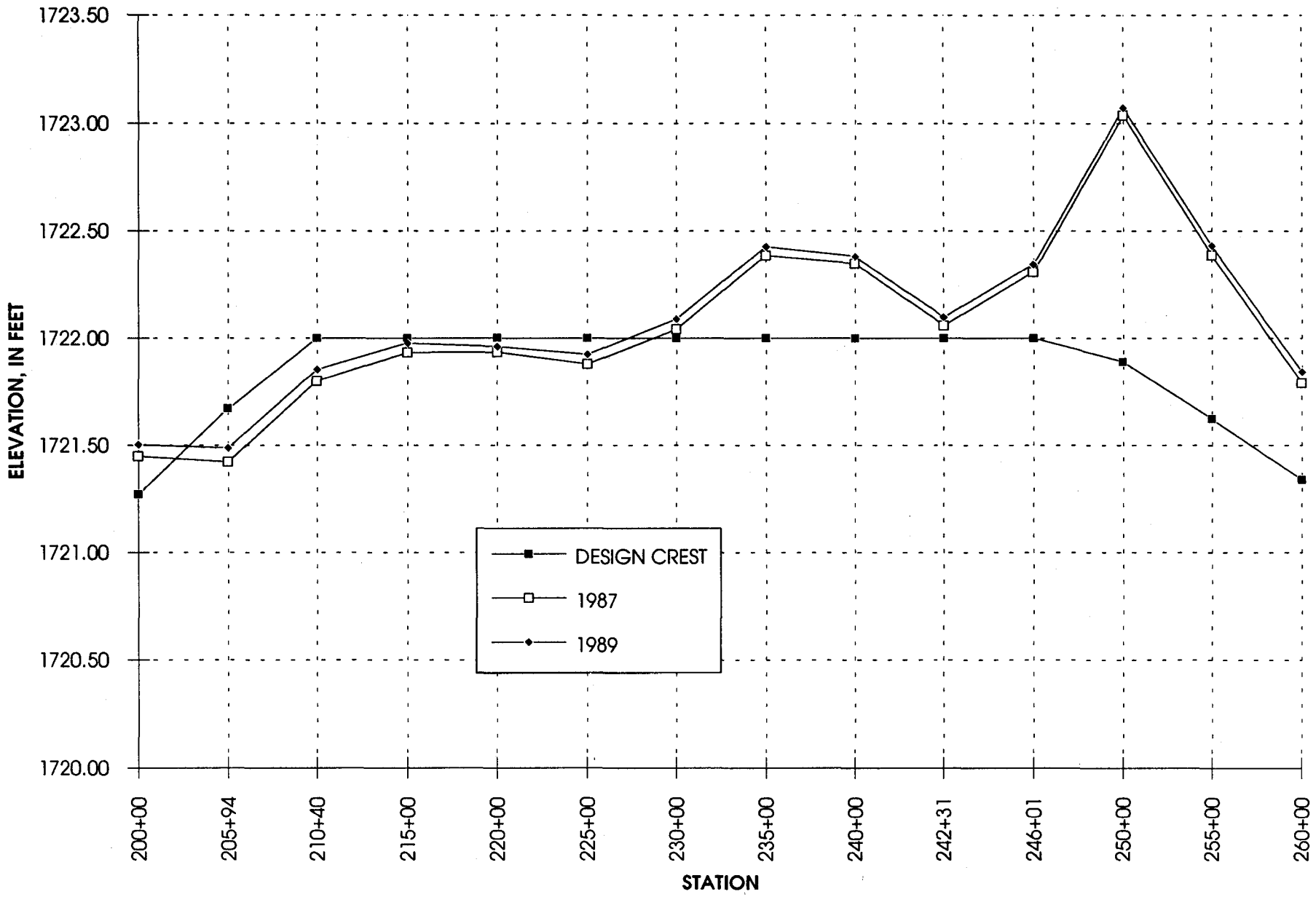
#'s are not consistant

SM-B8			1179.008	1179.086	0.078	
SM-B9			1180.747	1180.826	0.079	
SM-B10			1184.245	1184.271	0.026	
SM-B11			1185.782	1185.839	0.057	
SM-B12			1186.592	1186.622	0.030	
SM-B13			1185.577	1185.590	0.013	
SM-B14			1185.120	1185.118	-0.002	
SM-B15			1185.474	1185.443	-0.031	
SM-B16			1185.552	1185.526	-0.026	
SM-B17			1186.243	1186.146	-0.097	
SM-B18			1186.849	1186.787	-0.062	
SM-B19			1190.891	1190.514	-0.377	
SM-B20			1187.657	1187.647	-0.010	
SM-B21			1190.592	1190.514	-0.078	
SM-B22			1189.433	1189.359	-0.074	
SM-B23			1186.800	1186.732	-0.068	
SM-B24			1185.880	1185.847	-0.033	
SM-B25			1185.337	1185.287	-0.050	
SM-B26			1183.295	1183.239	-0.056	
SM-B27			1189.645	1189.605	-0.040	
AVERAGE CHANGE					**-0.001**	
MINIMUM					**-0.377**	
MAXIMUM					**0.126**	
CHANGE 1					-0.058	
CHANGE 2					0.199	
CHANGE 3					0.214	
CHANGE 4					0.196	
CHANGE 5					0.164	
CHANGE 6					0.095	
CHANGE 7					0.044	
CHANGE 8					0.073	
CHANGE 9					0.079	
CHANGE 10					0.020	
CHANGE 11					0.098	
CHANGE 12					0.057	
CHANGE 13					0.039	
CHANGE 14					0.018	
CHANGE 15					-0.065	
CHANGE 16					-0.043	
CHANGE 17					-0.147	
CHANGE 18					-0.121	
CHANGE 19					-0.428	

CHANGE 20					-0.087	
CHANGE 21					-0.168	
CHANGE 22					-0.182	
CHANGE 23					-0.196	
CHANGE 24					-0.058	
CHANGE 25					-0.097	
CHANGE 26					-0.118	
CHANGE 27					-0.092	
AVERAGE CHANGE					**-0.021**	
MINIMUM					**-0.428**	
MAXIMUM					**0.214**	
NOTES:						
1) CONSTRUCTION COMPLETED 1982						
2) DESIGN CREST ELEVATION = 1193.00						
3) THERE IS NO EMERGENCY SPILLWAY FOR THIS STRUCTURE						
4) MAXIMUM HEIGHT = 22'						
5) STATIONS ARE ONLY APPROXIMATE FOR THIS STRUCTURE						

5/4/95

SIGNAL BUTTE FRS CREST SETTLEMENT MONUMENTS

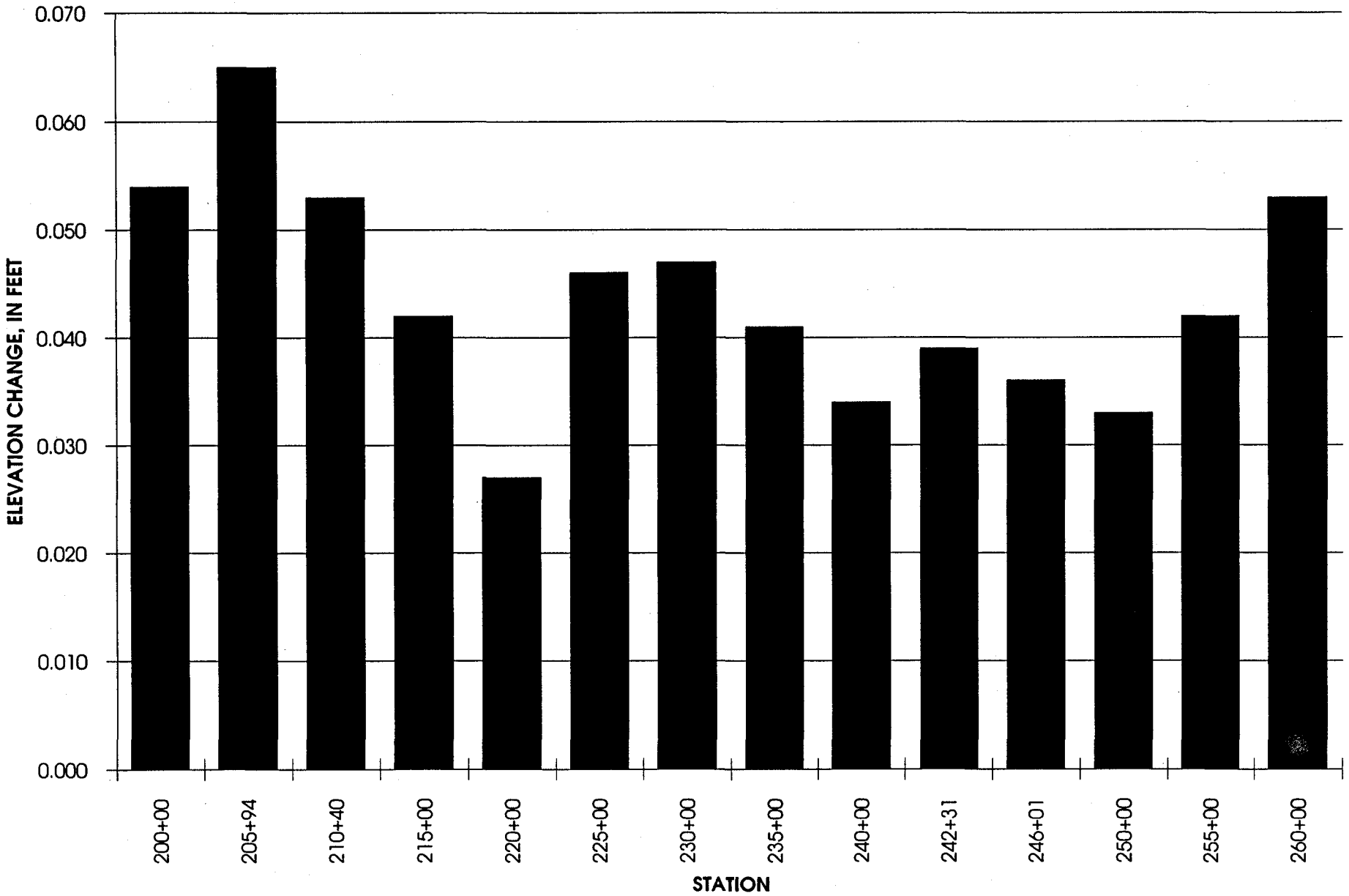


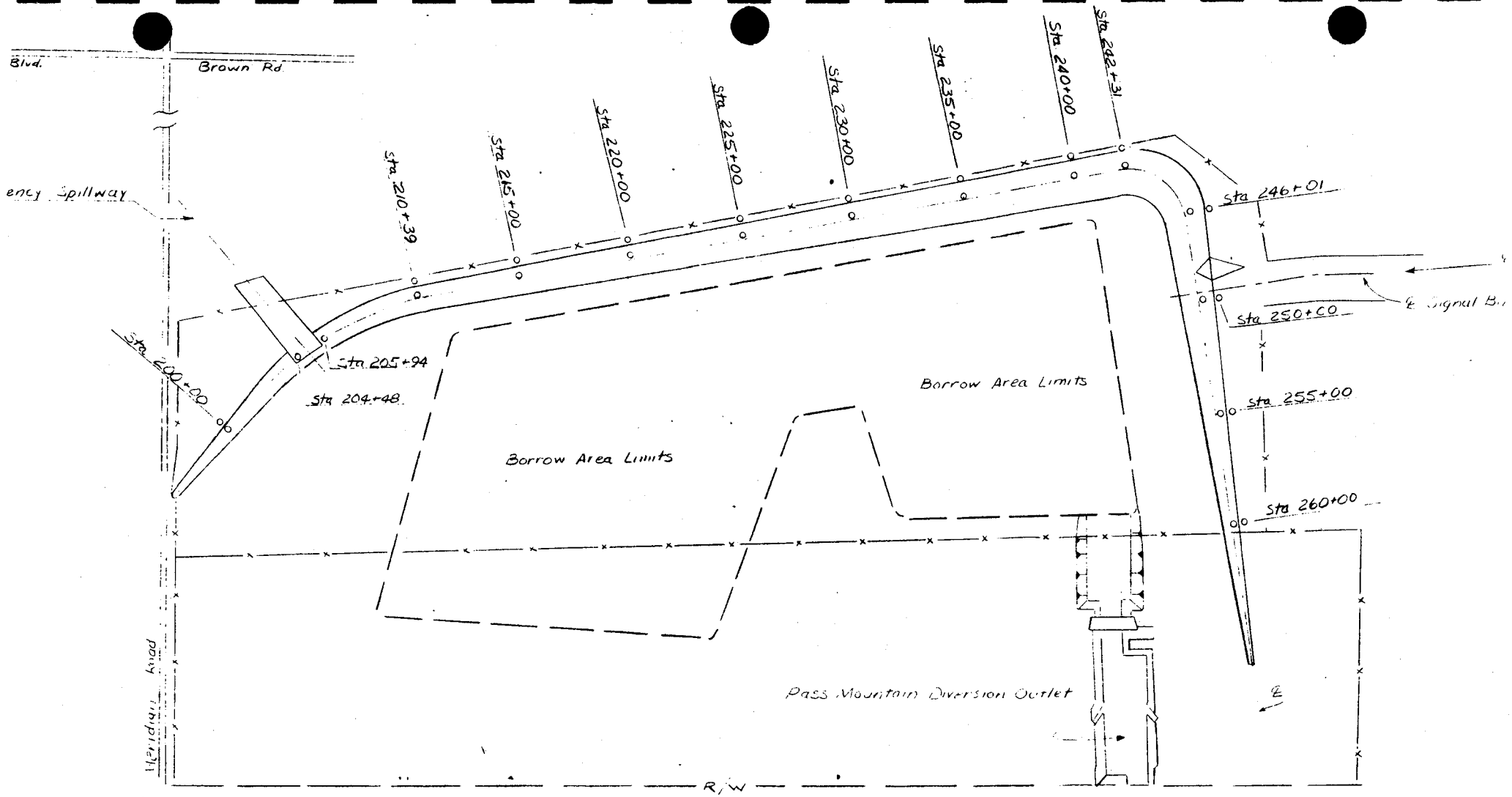
SIGNAL BUTTE FRS SUBSIDENCE MONITORING					
MARKER	**STATION**	**DESIGN**	**1987**	**1989**	**1987-1989**
SM-A1	200+00	1721.27	1721.448	1721.502	0.054
SM-A2	205+94	1721.67	1721.421	1721.486	0.065
SM-A3	210+40	1722.00	1721.799	1721.852	0.053
SM-A4	215+00	1722.00	1721.933	1721.975	0.042
SM-A5	220+00	1722.00	1721.935	1721.962	0.027
SM-A6	225+00	1722.00	1721.878	1721.924	0.046
SM-A7	230+00	1722.00	1722.041	1722.088	0.047
SM-A8	235+00	1722.00	1722.385	1722.426	0.041
SM-A9	240+00	1722.00	1722.348	1722.382	0.034
SM-A10	242+31	1722.00	1722.059	1722.098	0.039
SM-A11	246+01	1722.00	1722.308	1722.344	0.036
SM-A12	250+00	1721.89	1723.038	1723.071	0.033
SM-A13	255+00	1721.62	1722.388	1722.430	0.042
SM-A14	260+00	1721.34	1721.790	1721.843	0.053
AVERAGE CHANGE					**0.044**
MINIMUM			**1721.421**	**1721.486**	**0.027**
MAXIMUM			**1723.038**	**1723.071**	**0.065**
SM-B1	200+00		1712.521	1712.581	0.060
SM-B2	204+48		1712.435	1712.501	0.066
SM-B3	210+40		1699.839	1699.902	0.063
SM-B4	215+00		1698.076	1698.137	0.061
SM-B5	220+00		1692.797	1692.854	0.057
SM-B6	225+00		1693.107	1693.164	0.057
SM-B7	230+00		1691.986	1692.044	0.058
SM-B8	235+00		1692.091	1692.142	0.051
SM-B9	240+00		1686.281	1686.327	0.046
SM-B10	242+31		1687.144	1687.188	0.044
SM-B11	246+01		1693.304	1693.346	0.042
SM-B12	250+00		1699.200	1699.244	0.044
SM-B13	255+00		1705.116	1705.160	0.044
SM-B14	260+00		1710.680	1710.723	0.043
AVERAGE CHANGE					**0.053**
MINIMUM					**0.042**
MAXIMUM					**0.066**
CHANGE 1					-0.006
CHANGE 2					-0.001
CHANGE 3					-0.010
CHANGE 4					-0.019
CHANGE 5					-0.030

CHANGE 6					-0.011
CHANGE 7					-0.011
CHANGE 8					-0.010
CHANGE 9					-0.012
CHANGE 10					-0.005
CHANGE 11					-0.006
CHANGE 12					-0.011
CHANGE 13					-0.002
CHANGE 14					0.010
AVERAGE CHANGE					**-0.009**
MINIMUM					**-0.030**
MAXIMUM					**0.010**
NOTES:					
1) CONSTRUCTION COMPLETED 1987					
2) DESIGN CREST ELEVATION =					
3) DESIGN SPILLWAY CREST =					
4) MAXIMUM HEIGHT = 39'					

5/1/95

SIGNAL BUTTE FRS CHANGE IN CREST, 1987 TO 1989

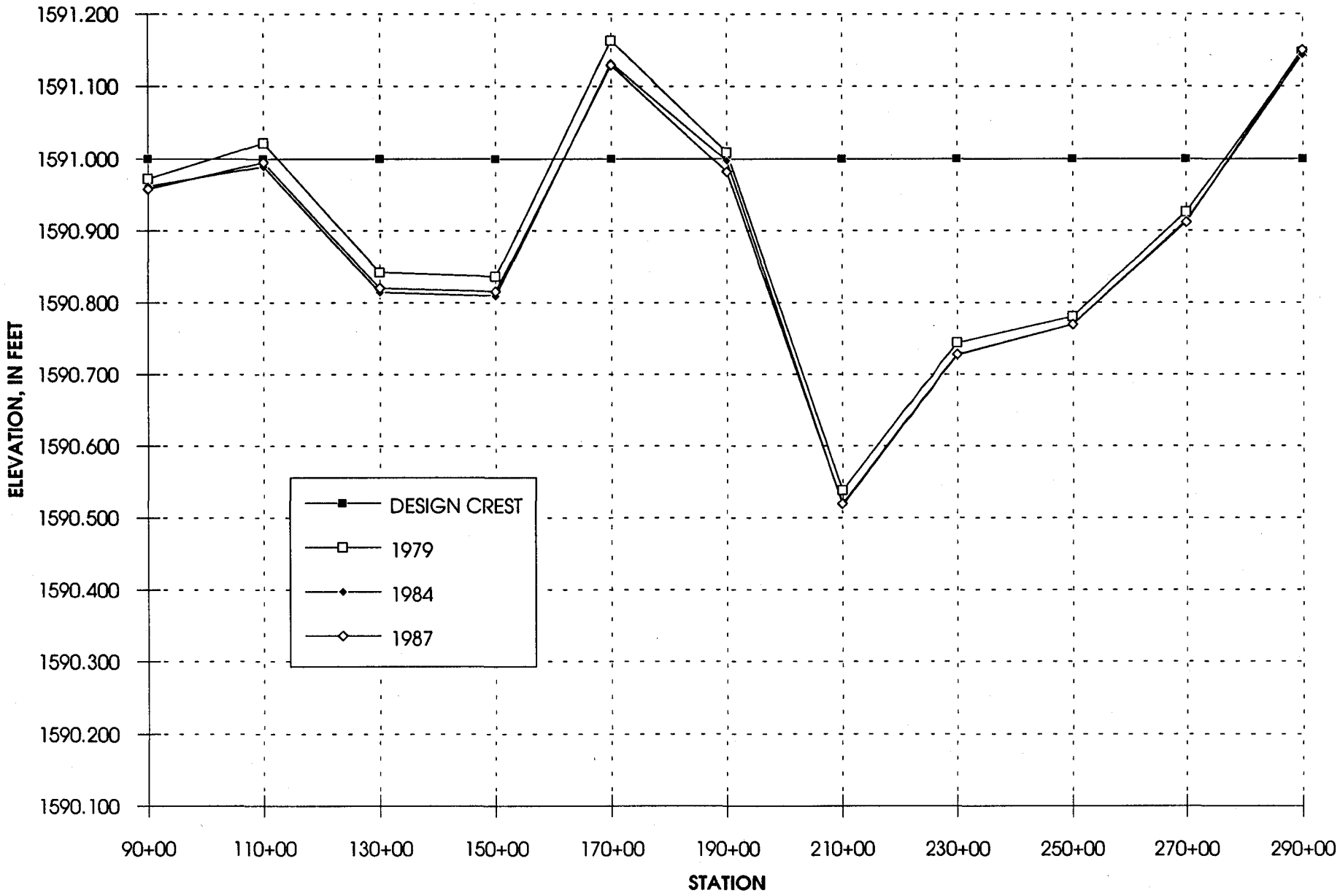




Signal Butte FRS

5/4/95

SPOOKHILL FRS CREST SETTLEMENT MONUMENTS

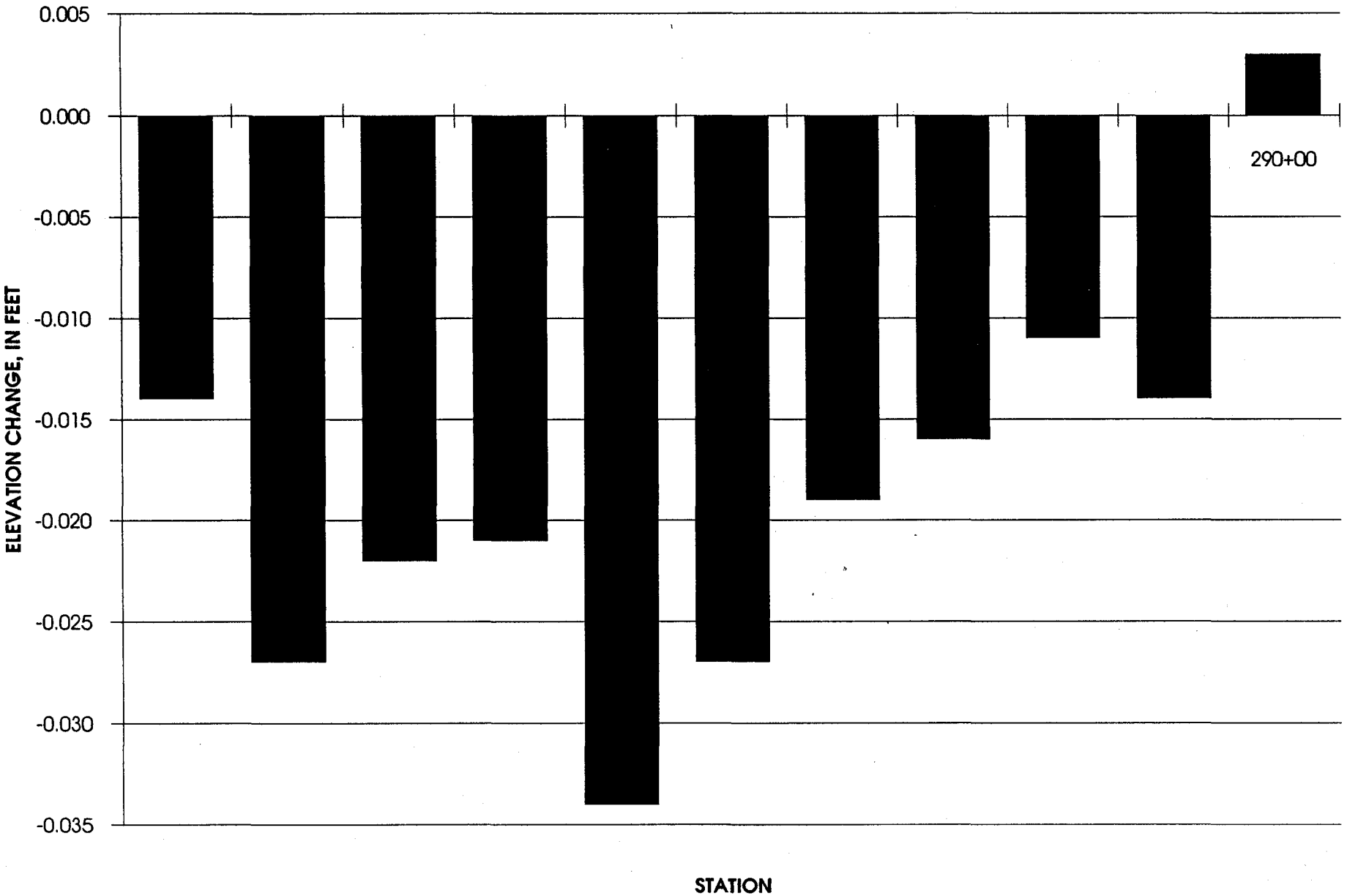


5/30/95

SPOOKHILL FRS SUBSIDENCE MONITORING								
MARKER	**STATION**	**DESIGN**	**Nov-79**	**1984**	**1987**	**1979-1984**	**1984-1987**	**1979-1987**
CREST								
SM-1	90+00	1591.000	1590.972	1590.962	1590.958	-0.010	-0.004	-0.014
SM-2	110+00	1591.000	1591.022	1590.989	1590.995	-0.033	0.006	-0.027
SM-3	130+00	1591.000	1590.842	1590.814	1590.820	-0.028	0.006	-0.022
SM-4	150+00	1591.000	1590.836	1590.809	1590.815	-0.027	0.006	-0.021
SM-5	170+00	1591.000	1591.163	1591.132	1591.129	-0.031	-0.003	-0.034
SM-6	190+00	1591.000	1591.009	1590.997	1590.982	-0.012	-0.015	-0.027
SM-7	210+00	1591.000	1590.538	1590.517	1590.519	-0.021	0.002	-0.019
SM-8	230+00	1591.000	1590.744	1590.727	1590.728	-0.017	0.001	-0.016
SM-9	250+00	1591.000	1590.780	1590.769	1590.769	-0.011	0.000	-0.011
SM-10	270+00	1591.000	1590.926	1590.914	1590.912	-0.012	-0.002	-0.014
SM-11	290+00	1591.000	1591.147	1591.143	1591.150	-0.004	0.007	0.003
EMERGENCY SPILLWAY		1582.000	1589.953	1589.953	1589.965	0.000	0.012	0.012
PRINCIPAL SPILLWAY				1577.497	1577.485	XXXX	-0.012	XXXX
AVERAGE CHANGE						**-0.017**	**0.000**	**-0.016**
MINIMUM			**1590.538**	**1590.517**	**1590.519**	**-0.033**	**-0.015**	**-0.034**
MAXIMUM			**1591.163**	**1591.143**	**1591.150**	**-0.004**	**0.007**	**0.003**
DOWNSTREAM TOE								
SM-1	90+00		1584.540	1584.539	1584.566	-0.001	0.027	0.026
SM-2	110+00		1573.712	1573.710	1573.750	-0.002	0.040	0.038
SM-3	130+00		1573.402	1573.398	1573.422	-0.004	0.024	0.020
SM-4	150+00		1570.567	1570.556	1570.587	-0.011	0.031	0.020
SM-5	170+00		1569.694	1569.695	1569.722	0.001	0.027	0.028
SM-6	190+00		1572.255	1572.243	1572.263	-0.012	0.020	0.008
SM-7	210+00		1568.932	1580.709	NOT FOUND	XXXX	XXXX	XXXX
SM-8	230+00		1569.379	1569.378	1569.387	-0.001	0.009	0.008
SM-9	250+00		1572.684	1572.690	1572.675	0.006	-0.015	-0.009
SM-10	270+00		1574.418	1574.413	1574.400	-0.005	-0.013	-0.018
SM-11	290+00		1571.356	1571.353	1571.353	-0.003	0.000	-0.003
AVERAGE CHANGE						**-0.003**	**0.015**	**0.012**
MINIMUM						**-0.012**	**-0.015**	**-0.018**
MAXIMUM						**0.006**	**0.040**	**0.038**
NOTES:								
1) CONSTRUCTION COMPLETED 1979								
2) DESIGN CREST ELEVATION = 1593.3								
3) DESIGN SPILLWAY CREST = 1582.2								
4) MAXIMUM HEIGHT = 25'								
5) SM-7 AT DOWNSTREAM TOE WAS RESET IN JUNE 1984								

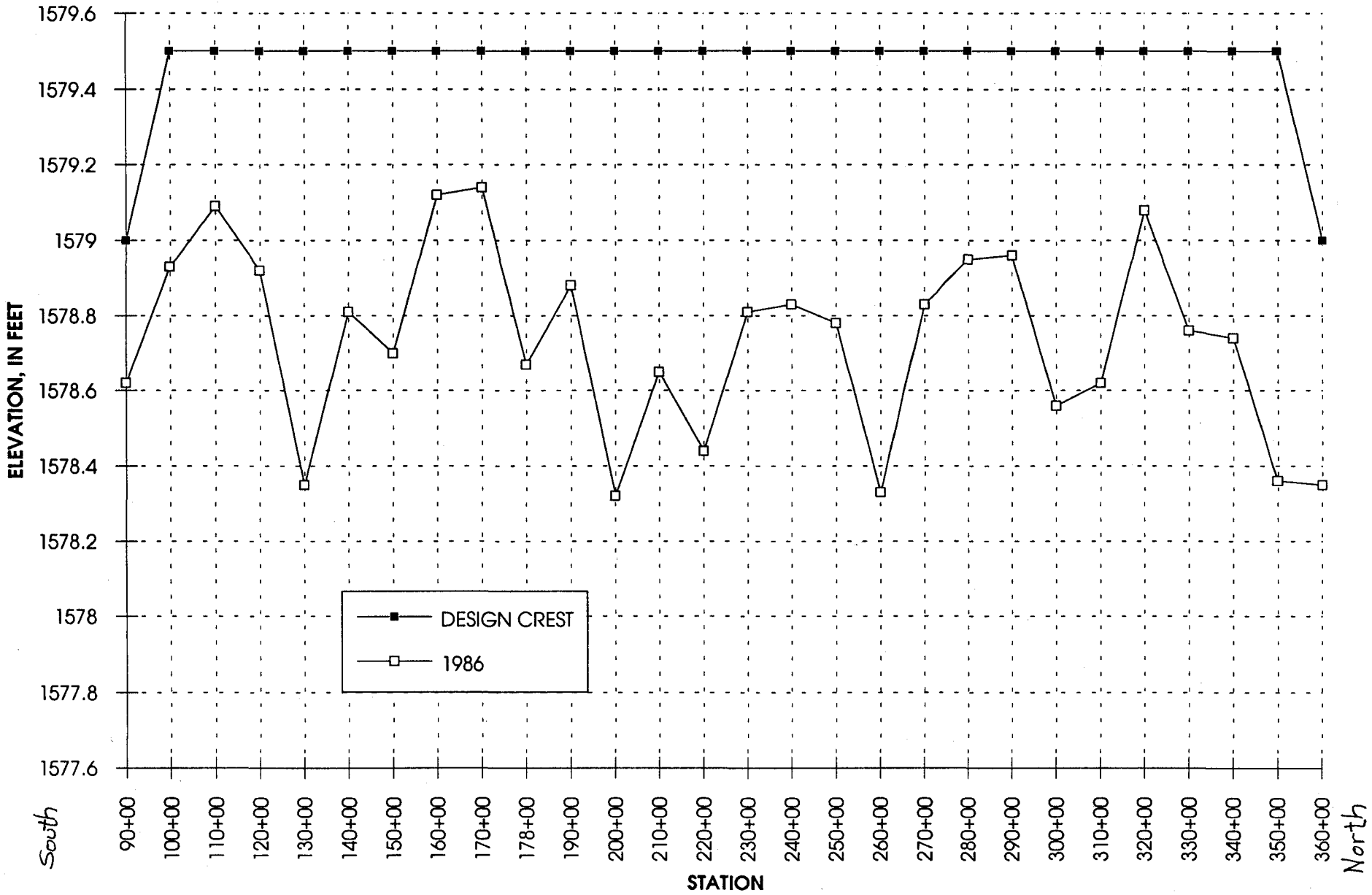
4/25/95

SPOOKHILL FRS CHANGE IN CREST ELEVATION, 1979 TO 1987



5/4/95

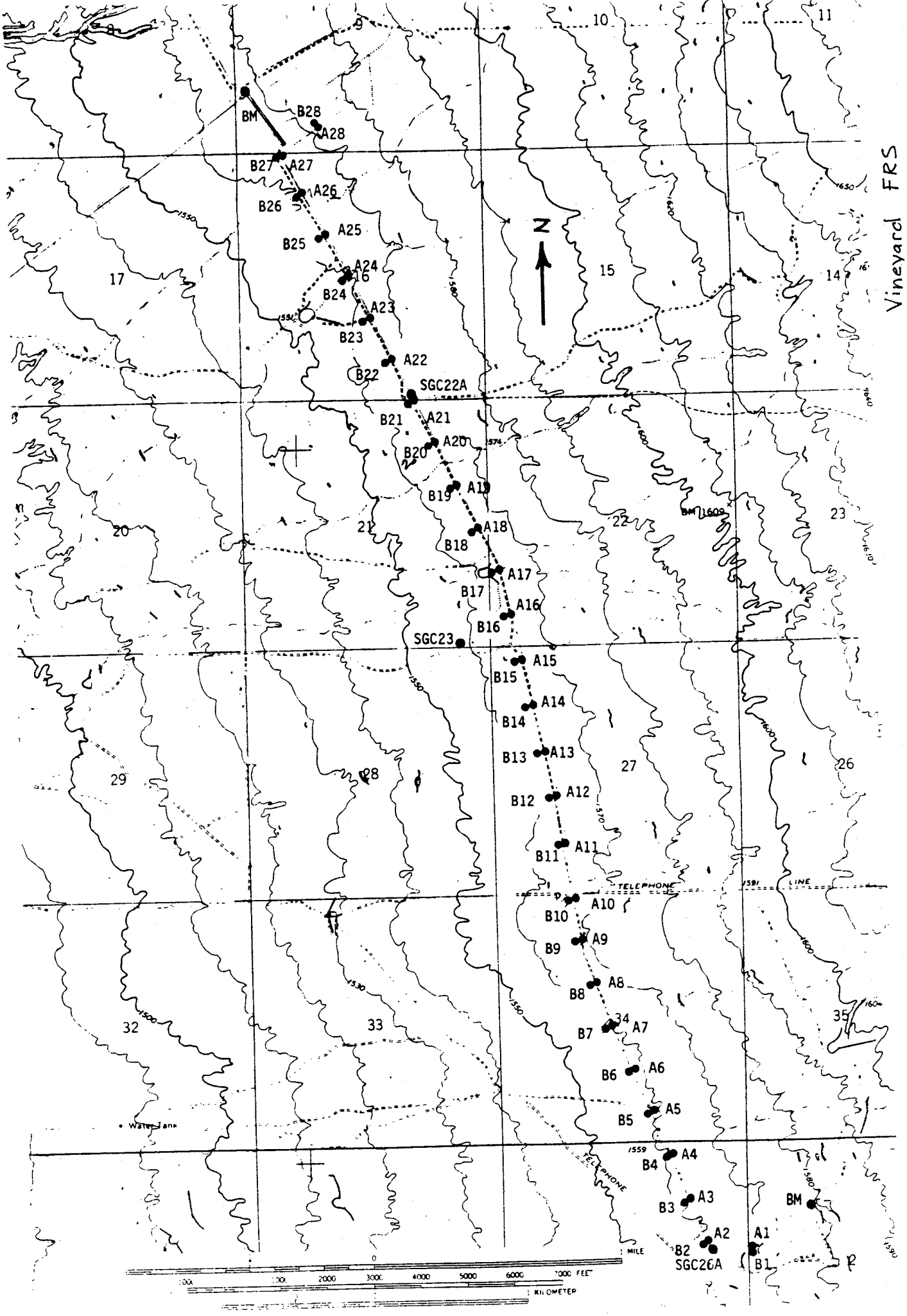
VINEYARD FRS CREST SETTLEMENT MONITORING



VINEYARD FRS SUBSIDENCE MONITORING							
MARKER	**STATION**	**DESIGN**	**1986**	**DESIGN-1986**			
SM-A1	90+00	1579.00	1578.62	-0.380			
SM-A2	100+00	1579.50	1578.93	-0.570			
SM-A3	110+00	1579.50	1579.09	-0.410			
SM-A4	120+00	1579.50	1578.92	-0.580			
SM-A5	130+00	1579.50	1578.35	-1.150			
SM-A6	140+00	1579.50	1578.81	-0.690			
SM-A7	150+00	1579.50	1578.70	-0.800			
SM-A8	160+00	1579.50	1579.12	-0.380			
SM-A9	170+00	1579.50	1579.14	-0.360			
SM-A10	178+00	1579.50	1578.67	-0.830			
SM-A11	190+00	1579.50	1578.88	-0.620			
SM-A12	200+00	1579.50	1578.32	-1.180			
SM-A13	210+00	1579.50	1578.65	-0.850			
SM-A14	220+00	1579.50	1578.44	-1.060			
SM-A15	230+00	1579.50	1578.81	-0.690			
SM-A16	240+00	1579.50	1578.83	-0.670			
SM-A17	250+00	1579.50	1578.78	-0.720			
SM-A18	260+00	1579.50	1578.33	-1.170			
SM-A19	270+00	1579.50	1578.83	-0.670			
SM-A20	280+00	1579.50	1578.95	-0.550			
SM-A21	290+00	1579.50	1578.96	-0.540			
SM-A22	300+00	1579.50	1578.56	-0.940			
SM-A23	310+00	1579.50	1578.62	-0.880			
SM-A24	320+00	1579.50	1579.08	-0.420			
SM-A25	330+00	1579.50	1578.76	-0.740			
SM-A26	340+00	1579.50	1578.74	-0.760			
SM-A27	350+00	1579.50	1578.36	-1.140			
SM-A28	360+00	1579.00	1578.35	-0.650			
MINIMUM			**1578.32**	**-1.18**			
MAXIMUM			**1579.14**	**-0.36**			
SM-B1	90+00		1571.52				
SM-B2	100+00		1565.42				
SM-B3	110+00		1564.13				
SM-B4	120+00		1565.19				
SM-B5	130+00		1563.87				

SM-B6	140+00		1563.42				
SM-B7	150+00		1563.12				
SM-B8	160+00		1564.91				
SM-B9	170+00		1567.94				
SM-B10	178+00		1564.82				
SM-B11	190+00		1562.01				
SM-B12	200+00		1563.53				
SM-B13	210+00		1564.05				
SM-B14	220+00		1563.57				
SM-B15	230+00		1564.85				
SM-B16	240+00		1565.12				
SM-B17	250+00		1564.60				
SM-B18	260+00		1566.00				
SM-B19	270+00		1564.47				
SM-B20	280+00		1565.65				
SM-B21	290+00		1565.39				
SM-B22	300+00		1564.27				
SM-B23	310+00		1563.17				
SM-B24	320+00		1561.50				
SM-B25	330+00		1564.16				
SM-B26	340+00		1563.02				
SM-B27	350+00		1562.80				
SM-B28	360+00		1569.06				
BM STAMPED 1570.36 (1968?)			1570.03	-0.330			
BM STAMPED 1583.20 (1968?)			1582.42	-0.780			
BM SGC-22A	291+63		1579.48				
BM SGC-23	234+50		1558.74				
BM SGC-26A	99+60		1578.93				
NOTES:							
1) CONSTRUCTION COMPLETED 1968							
2) DESIGN CREST ELEVATION = 1579.5							
3) DESIGN SPILLWAY CREST (2) = 1574.8							
4) MAXIMUM HEIGHT = 16.5'							
5) FREEBOARD = 4.7'							
6) STRUCTURE EMBANKMENT AND DRAIN FILL REPAIR STARTED 10/13/89 AND COMPLETED 1/25/90							
7) REPAIR CONSISTED OF:							

	FROM	TO					
CELL #1	120+00	124+00					
CELL #2	102+00	106+05					
CELL #3	251+90	256+25					
CELL #4	NONE						
CELL #5	108+07	111+53					


Vineyard FRS
N
BM
B28
A28
B27
A27
B26
A26
B25
A25
B24
A24
B23
A23
B22
A22
SGC22A
B21
A21
B20
A20
B19
A19
B18
A18
B17
A17
B16
A16
SGC23
B15
A15
B14
A14
B13
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B11
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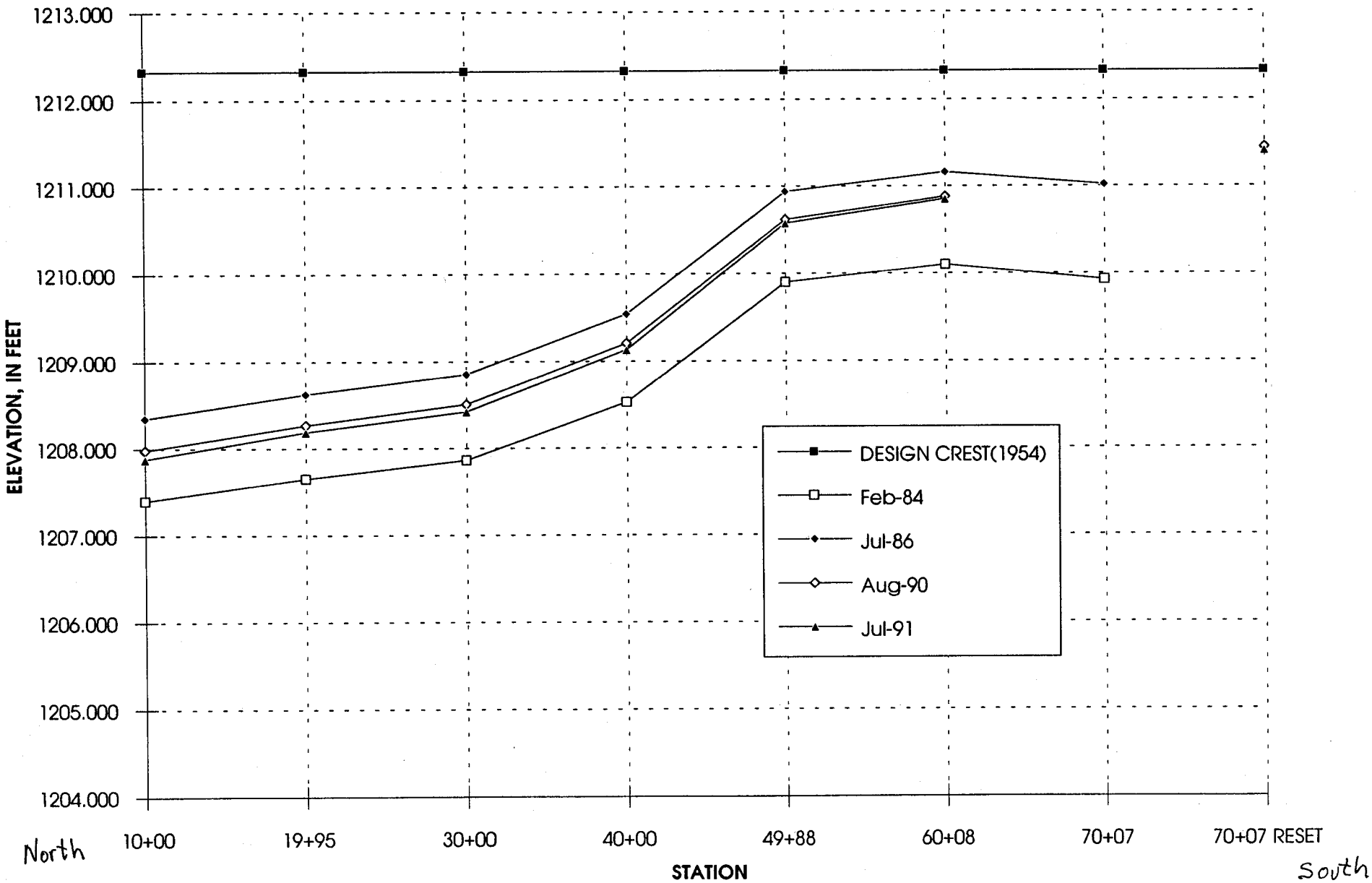
A9
B8
A8
B7
A7
B6
A6
B5
A5
B4
A4
B3
A3
B2
A2
SGC26A
B1
A1
BM
TELEPHONE LINE
Water Tank
MILE
KILOMETER
FEET

5/16/95

WHITE TANKS #3 FRS CREST SETTLEMENT MONUMENTS



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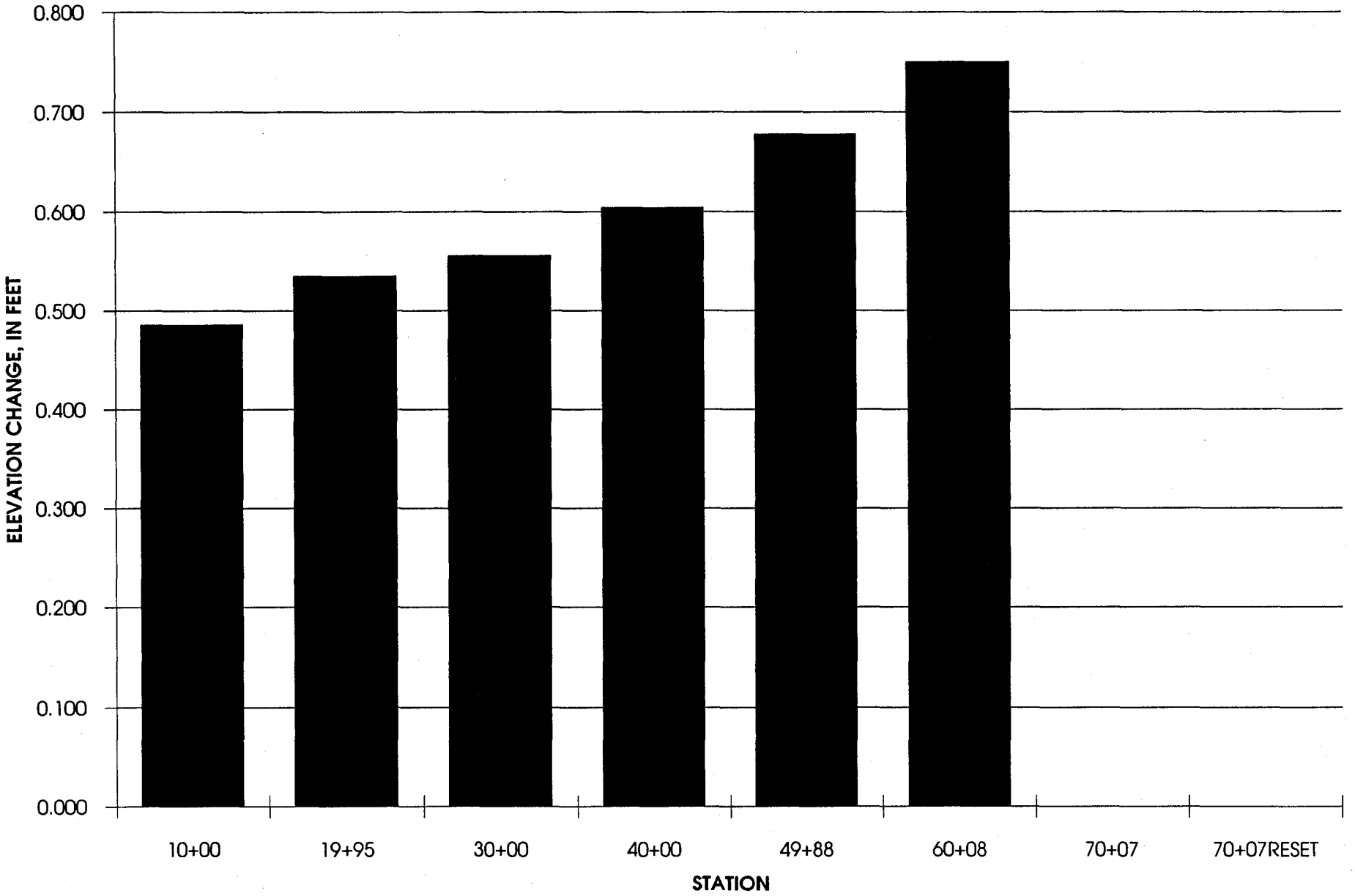
WHITE TANKS FRS #3 SUBSIDENCE MONITORING													
MARKER	**STATION**	**Feb-84**	**Jul-86**	**Aug-90**	**ADJ 90**	**ADJUST**	**Jul-91**	**ADJ 91**	**ADJUST**	**84-86**	**86-90**	**90-91**	**84-91**
SM-A1	10+00	1207.397	1208.348	1207.979	1211.650	3.671	1207.883	1211.561	3.678	0.951	-0.369	-0.096	0.486
SM-A2	19+95	1207.652	1208.622	1208.267	1211.946	3.679	1208.187	1211.866	3.679	0.970	-0.355	-0.080	0.535
SM-A3	30+00	1207.864	1208.849	1208.504	1212.183	3.679	1208.420	1212.099	3.679	0.985	-0.345	-0.084	0.556
SM-A4	40+00	1208.529	1209.542	1209.204	1212.883	3.679	1209.133	1212.812	3.679	1.013	-0.338	-0.071	0.604
SM-A5	49+88	1209.898	1210.939	1210.618	1214.297	3.679	1210.576	1214.255	3.679	1.041	-0.321	-0.042	0.678
SM-A6	60+08	1210.102	1211.163	1210.880	1214.559	3.679	1210.852	1214.531	3.679	1.061	-0.283	-0.028	0.750
SM-A7	70+07	1209.927	1211.017							1.090	XXXX	XXXX	XXXX
SM-A7 RESET				1211.445	1215.124	3.679	1211.412	1215.091	3.679	XXXX	XXXX	-0.033	XXXX
AVERAGE CHANGE										**1.016**	**-0.335**	**-0.062**	**0.602**
MINIMUM		**1207.397**	**1208.348**	**1207.979**			**1207.883**			**0.951**	**-0.369**	**-0.096**	**0.486**
MAXIMUM		**1210.102**	**1211.163**	**1211.445**			**1211.412**			**1.090**	**-0.283**	**-0.028**	**0.750**
SM-B1	10+00	1197.300	1198.268	1197.907	1201.586	3.679	1197.812	1201.491	3.679	0.968	-0.361	-0.095	0.512
SM-B2	19+95	1188.732	1189.701	1189.392	1193.071	3.679	1189.300	1192.979	3.679	0.969	-0.309	-0.092	0.568
SM-B3	30+00	1186.280	1187.264	1186.971	1190.650	3.679	1186.883	1190.562	3.679	0.984	-0.293	-0.088	0.603
SM-B4	40+00	1188.348	1189.354	1189.049	1192.728	3.679	1188.985	1192.664	3.679	1.006	-0.305	-0.064	0.637
SM-B5	49+88	1186.818	1187.837	1187.563	1191.242	3.679	1187.511	1191.190	3.679	1.019	-0.274	-0.052	0.693
SM-B6	60+08	1185.668	1186.724	1186.496	1190.175	3.679	1186.450	1190.129	3.679	1.056	-0.228	-0.046	0.782
SM-B7	70+07	1191.429	1192.518	1192.294	1195.973	3.679	1192.252	1195.931	3.679	1.089	-0.224	-0.042	0.823
AVERAGE CHANGE										**1.013**	**-0.285**	**-0.068**	**0.660**
MINIMUM										**0.968**	**-0.361**	**-0.095**	**0.512**
MAXIMUM										**1.089**	**-0.224**	**-0.042**	**0.823**
A1-B1	10+00									-0.017	-0.008	-0.001	-0.026
A2-B2	19+95									0.001	-0.046	0.012	-0.033
A3-B3	30+00									0.001	-0.052	0.004	-0.047
A4-B4	40+00									0.007	-0.033	-0.007	-0.033
A5-B5	49+88									0.022	-0.047	0.010	-0.015
A6-B6	60+08									0.005	-0.055	0.018	-0.032
A7-B7	70+07									XXXX	XXXX	0.009	XXXX
AVERAGE CHANGE										**0.003**	**-0.040**	**0.006**	**-0.031**
MINIMUM										**-0.017**	**-0.055**	**-0.007**	**-0.047**
MAXIMUM										**0.022**	**-0.008**	**0.018**	**-0.015**

NOTES:

1) CONSTRUCTION COMPLETED 1954
2) DESIGN CREST ELEVATION = 1216.00
3) DESIGN SPILLLWAY CREST = 1210.00
4) MAXIMUM HEIGHT = 30'
5) ELEVATIONS FOR 1990 & 1991 ADJUSTED BASED ON USGS DATUM, BM Q-475 ELEVATION 1434.646
6) DATA ANOMOLIES ARE SHADED. THESE HAVE BEEN CHECKED FROM SCS PLAN SHEETS, BUT ERROR IS SUSPECTED.
7) DATA ANOMOLY AT B4 FOR JULY 91 HAS BEEN CORRECTED, BUT IS STILL SHOWN AS SHADED.

5/16/95

WHITE TANKS #3 CHANGE IN CREST ELEVATION, 1984 TO 1991



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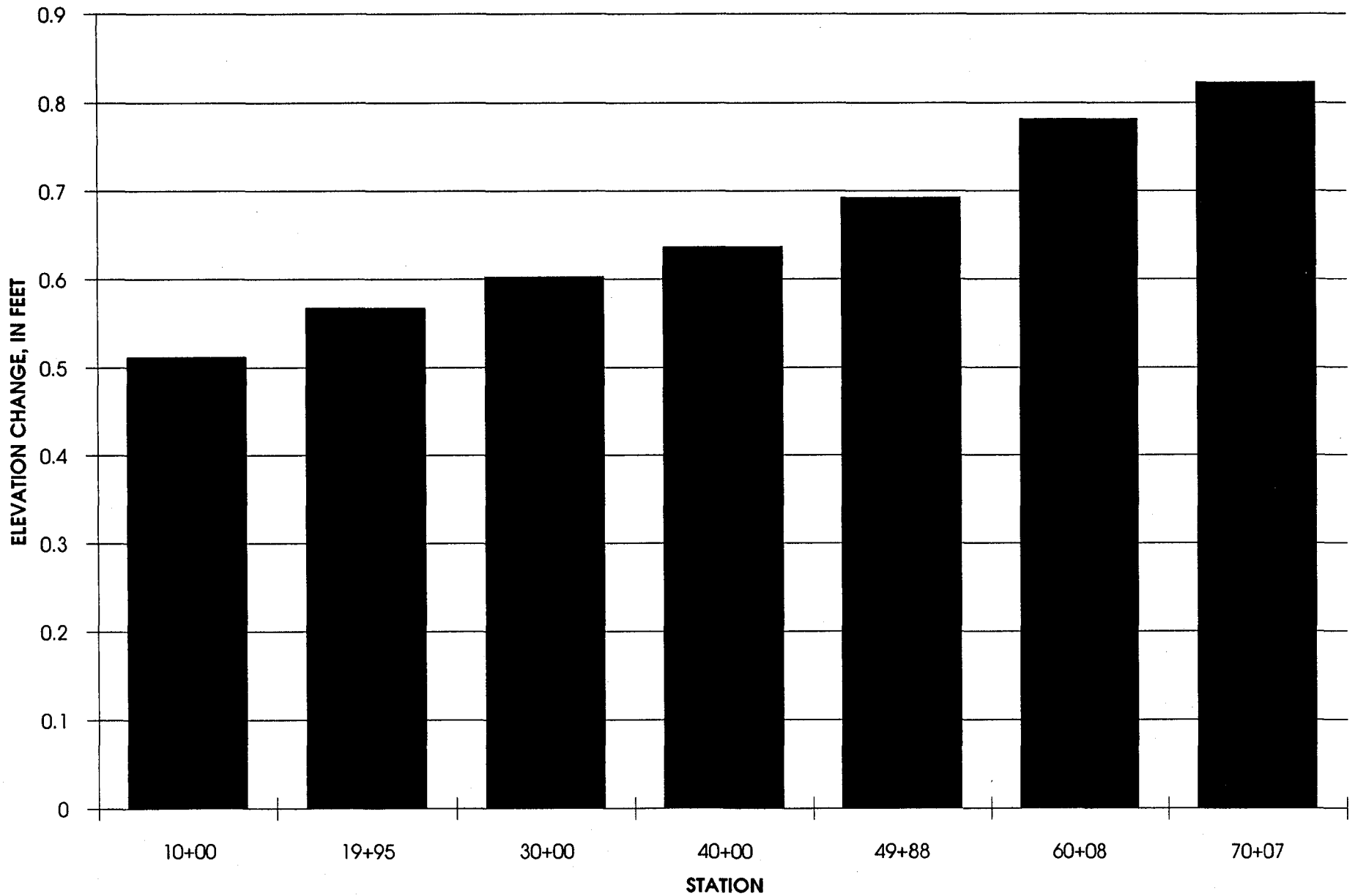
WHITE TANKS #3 FRS CHANGE IN DOWNSTREAM TOE 1984 TO 1991



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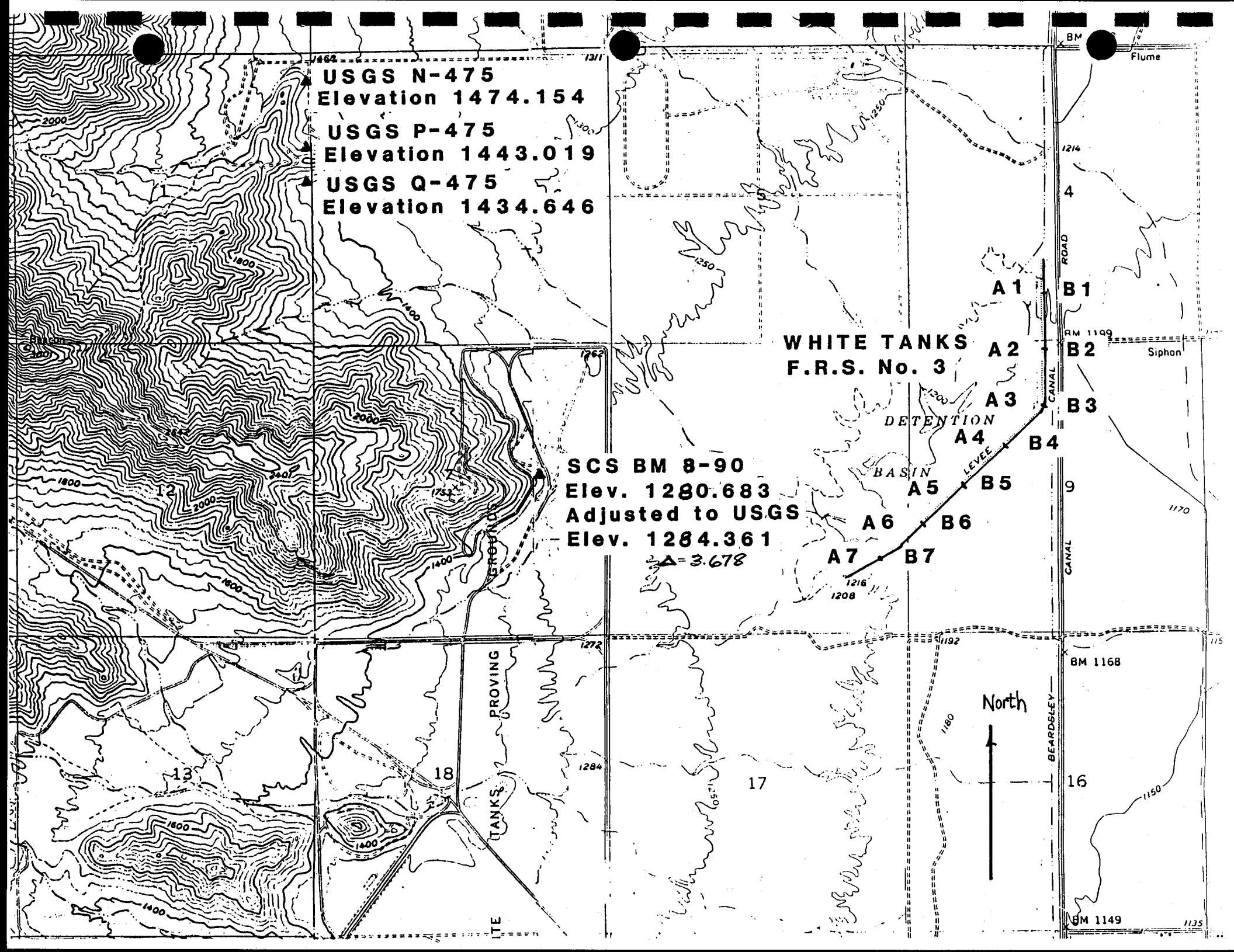
WHITE TANKS #3 FRS CONSOLIDATION OF FILL


USGS N-475
Elevation 1474.154
USGS P-475
Elevation 1443.019
USGS Q-475
Elevation 1434.646
WHITE TANKS
F.R.S. No. 3
DETENTION
BASIN
LEVEE
SCS BM 8-90
Elev. 1280.683
Adjusted to USGS
Elev. 1284.361
Δ=3.678
A1
A2
A3
A4
A5
A6
A7
B1
B2
B3
B4
B5
B6
B7
North
PROVING GROUND
WHITE TANKS
BEARDSLEY CANAL
ROAD
Flume
Siphon
BM 1199
BM 1168
BM 1149
Beacon
12
13
18
17
16
4
9

WHITE TANKS FRS #4 SUBSIDENCE/SETTLEMENT MONITORING							
MARKER	**STATION**	**DESIGN(1954)**	**Feb-84**	**Jul-86**	**1986-1984**		
SM-C1	00+47	1056.00	1050.766	1051.059	0.293		
SM-C2	10+00	1056.00	1051.395	1051.666	0.271		
SM-C3	19+62	1056.00	1051.300	1051.596	0.296		
SM-C4	29+59	1056.00	1051.359	1051.642	0.283		
SM-C5	39+64	1056.00	1051.909	1052.182	0.273		
SM-C6	49+68	1056.00	1051.773	1052.045	0.272		
SM-C7	59+87	1056.00	1051.248	1051.498	0.250		
AVERAGE CHANGE					**0.277**		
SM-D1	00+47		XXXX	1046.492	XXXX		
SM-D2	10+00		1037.665	1037.935	0.270		
SM-D3	19+62		1032.758	1033.022	0.264		
SM-D4	29+59		1032.361	1032.609	0.248		
SM-D5	39+64		1034.868	1035.132	0.264		
SM-D6	49+68		1035.910	1036.165	0.255		
SM-D7	59+87		1039.496	1039.749	0.253		
AVERAGE CHANGE					**0.259**		
C1-D1	00+47				XXXX		
C2-D2	10+00				0.001		
C3-D3	19+62				0.032		
C4-D4	29+59				0.035		
C5-D5	39+64				0.009		
C6-D6	49+68				0.017		
C7-D7	59+87				-0.003		
AVERAGE CHANGE					**0.015**		
NOTES:							
1) CONSTRUCTION COMPLETED 1954							
2) DESIGN CREST ELEVATION = 1056.0							
3) DESIGN SPILLWAY CREST = 1050.0							
4) MAXIMUM HEIGHT = 20'							
5) SURVEYS BASED ON BENCHMARK "DEAD" WHICH VARIES FROM OTHER USGS MONUMENTS BY APPROX 3.7'.							

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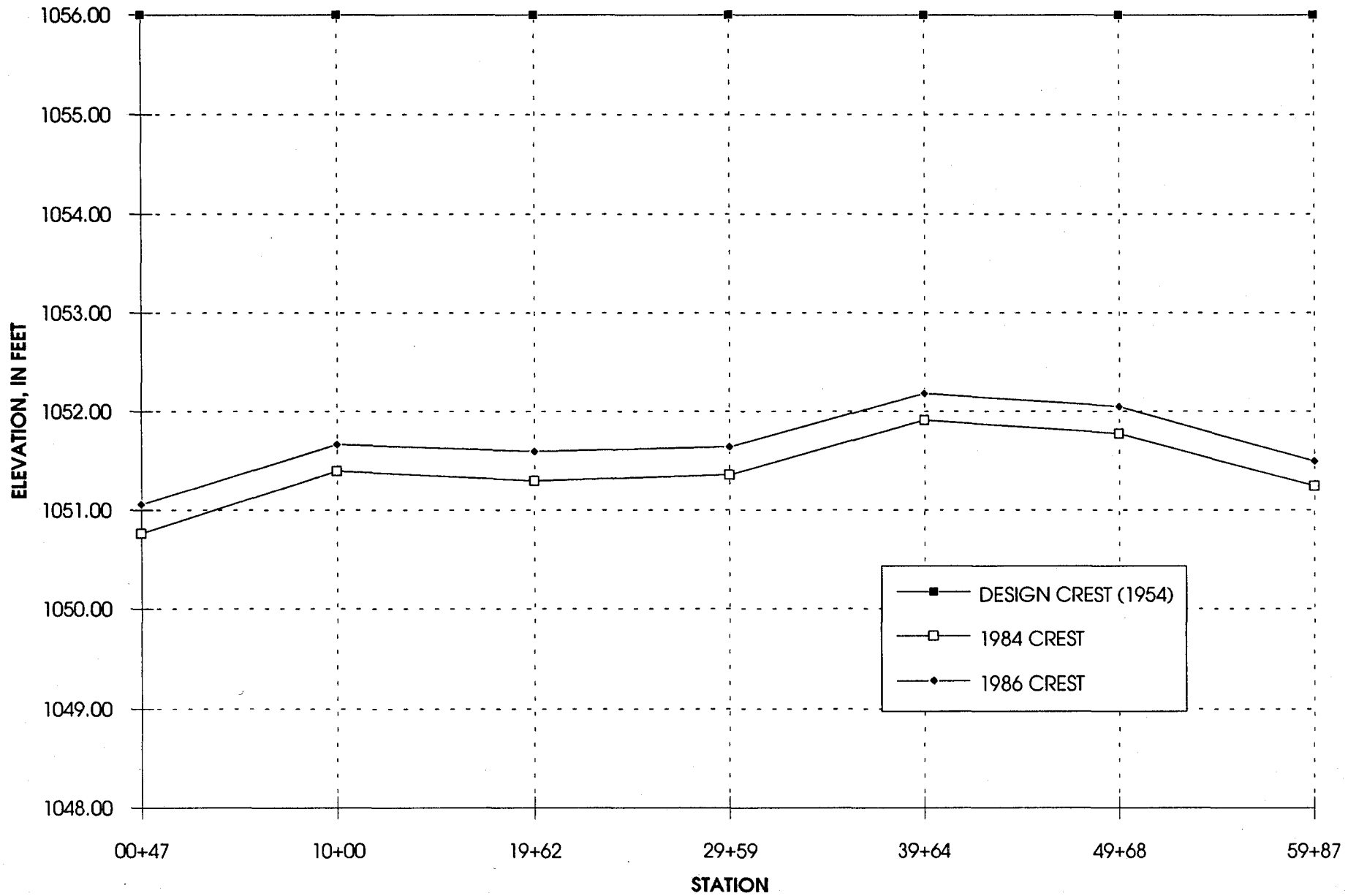
WHITE TANKS #4 FRS SETTLEMENT MONUMENTS



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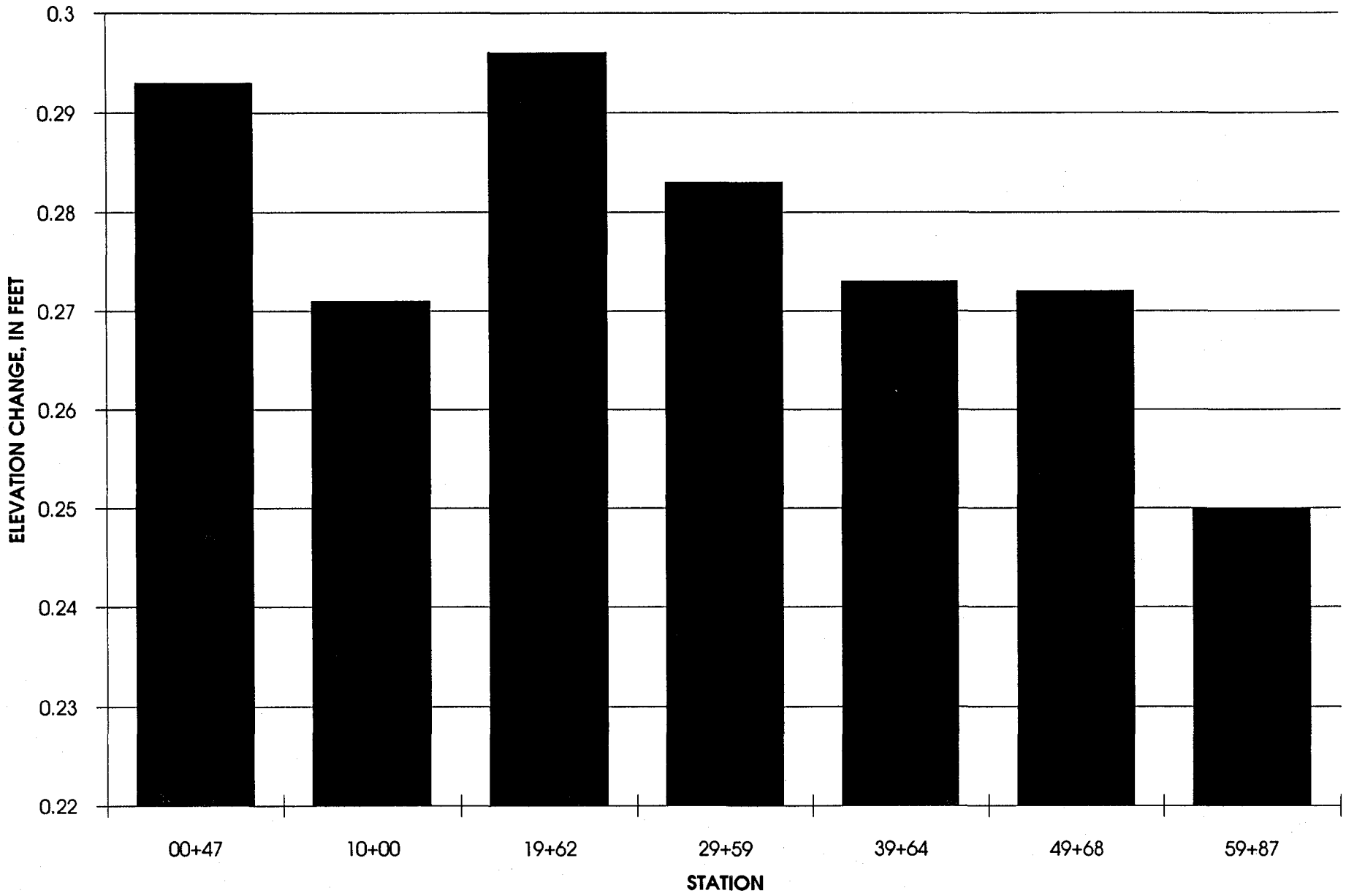
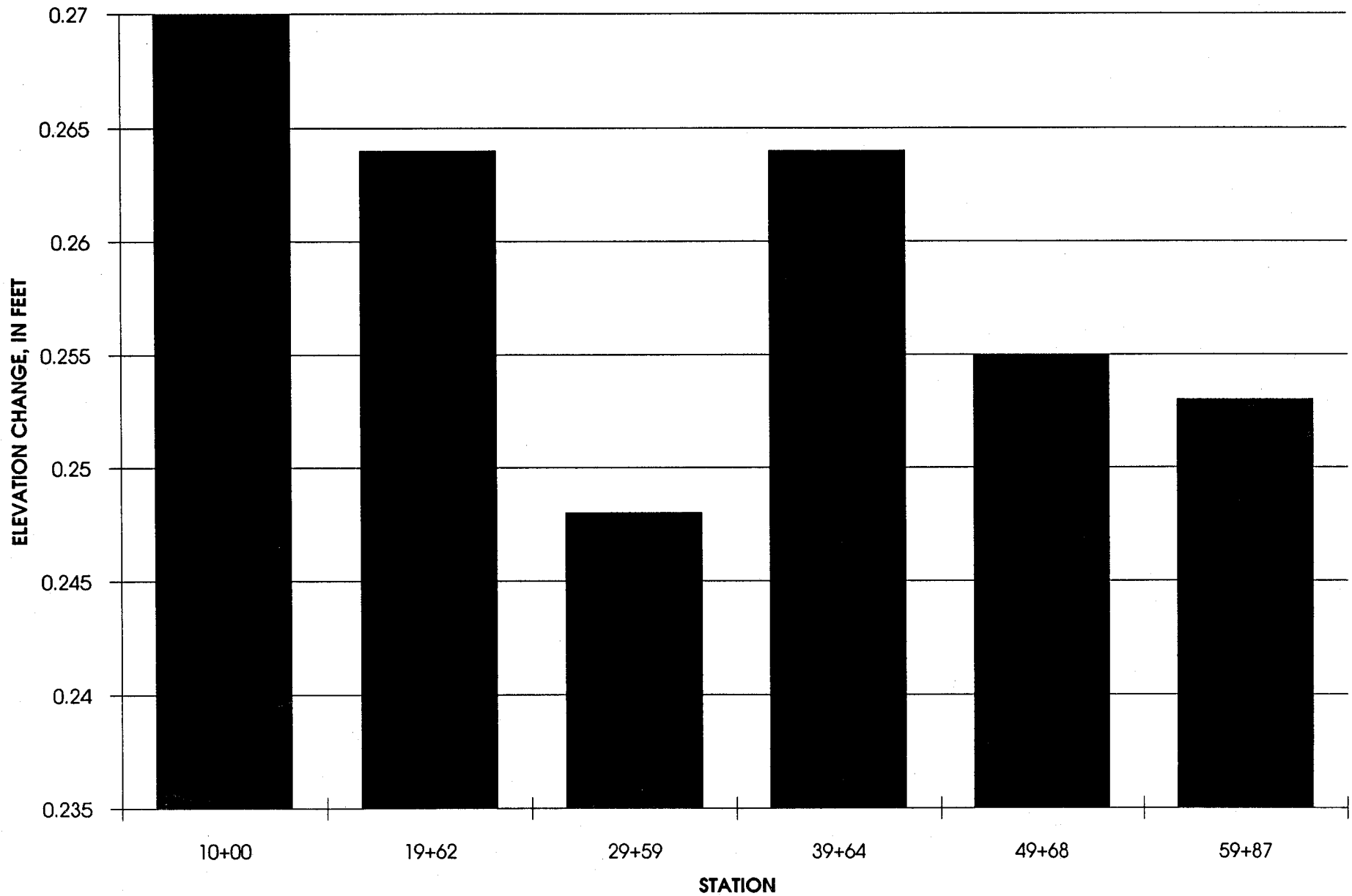
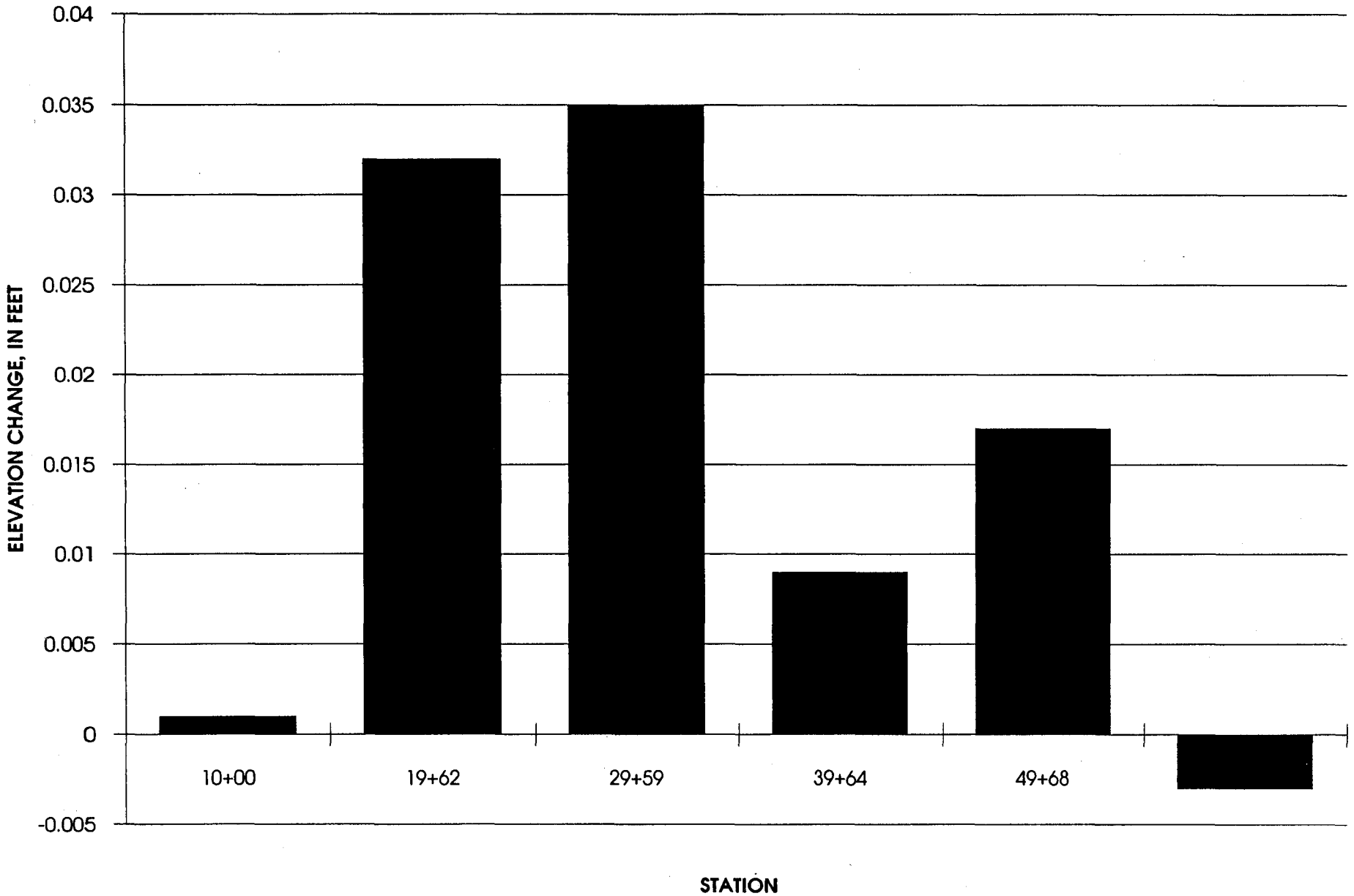
WT4 CHANGE IN CREST ELEVATION 1984 TO 1986



5/30/95

WHITE TANKS #4 CHANGE IN DOWNSTREAM TOE ELEVATION 1984 TO 1986



5/30/95

WHITE TANKS #4 CHANGE IN CREST MINUS TOE ELEVATION 1984 TO 1986