INTERIM BANK PROTECTION MEASURES SALT RIVER NEAR TRI-CITY LANDFILL

INVESTIGATION OF STABILITY OF INTERIM BANK PROTECTION MEASURES SALT RIVER NEAR THE TRI-CITY LANDFILL

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INVESTIGATION OF STABILITY OF INTERIM BANK PROTECTION MEASURES SALT RIVER NEAR THE TRI-CITY LANDFILL

Submitted to:

Salt River Pima-Maricopa Indian Community
Route 1, P.O. Box 216
Scottsdale, Arizona 85256

Submitted by:

Simons, Li & Associates, Inc.
4600 South Mill Avenue - Suite 200
Tempe, Arizona 85282

April, 1993

DRAFT

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Summary Report

Investigation of Stability of Interim Bank Protection Measures Salt River near the Tri-City Landfill

April 12, 1993

The Tri-City landfill is located just downstream of a major bend in the Salt River (**Figure 1**). A 1953 aerial photograph (**Figure 2**) and COE illustrations of the 1980 and 1966 flood events (**Figures 3 and 4**) indicate that portions of the landfill site are located within the limits of previous flood events. The 1966 flood event had a peak discharge of 67,000 cfs, and the 1980 peak was 170,000 cfs (both measured at Granite Reef Dam).

The peak-frequency relationship for the Salt River in the vicinity of the landfill is illustrated in **Figure 5**. The 10-, 50- and 100-year discharges at this location are 98,000, 167,000 and 225,000 cfs, respectively. Thus, the 1966 flood event was less than 10-year magnitude, and the 1980 event was approximately a 50-year event. The January 1993 peak discharge of 124,000 was about at the 20-year level.

The current FEMA map for the project vicinity is shown in **Figure 6**. This map was prepared using 1982 topography and low Manning n assumptions (channel n = 0.025). As shown in the 1986 topographic map (**Figure 7**), mining has occurred within the river bed adjacent to the landfill since the 1982 topography was prepared. The 1992 topographic map indicates that this landfill area had been captured by the river prior to the 1993 event. **Figure 8** compares 1982, 1987 and 1992 cross-sectional views of the Salt River channel near the Tri-City Landfill.

Figure 9 illustrates the recent changes that have occurred along the Salt River bank near the upstream end of the Tri-city Landfill. The January 1993 event eroded the nose of the landfill just downstream of the major channel bend at Horne Road. Figure 9 also illustrates in plan the extent of the interim bank protection measures for the landfill.

The interim banks are composed of riprap (shot rock), with a median diameter (D_{50}) of approximately 8 inches, and a D_{85} of approximately 11 inches (**Figure 10**). The survey of the banks recently performed by The Community indicates that the side slope of the interim bank varies from 1.20:1 to 1.55:1, with 1.5:1 typical at the critical (flow impingement) points. **Figure 11** contains photographs of the study reach during and after the January 1993 event. Grid photos which indicate the size of the lining material are shown in **Figure 12**.

Recent survey information and available topographic information were used to plot the channel profiles in the vicinity of the interim measures (**Figure 13**). As shown in this figure, the channel bottom has lowered considerably in recent years. Thus, the flow levels computed using the current FEMA deck (previously submitted by BRW and compared to the interim bank elevations in **Figure 14**), overestimate the water surface elevations within the study reach under current conditions. A new HEC-2 deck was prepared using 1992 topographic maps, revised to approximate current conditions in the vicinity of the interim measures. Water surface profiles associated with this new hydraulic analysis are illustrated in **Figures 15 and 16**. Hydraulic computations (including an allowance for

superelevation at the bend) indicate the interim bank is of adequate height to contain flood discharges up to approximately 145,000 cfs, or about a 30-year event.

Hydraulic parameters computed for two cross-sections in the vicinity of the interim bank protection measures are summarized in **Table 1**. Channel velocity and flow depth are plotted against discharge in **Figures 17 and 18**. Using this computed hydraulic information, the surveyed side slope data, and a general relation presented by the ASCE Task Committee for Preparation of a Sedimentation Manual, an initial evaluation of the required size for the riprap for each flood condition was conducted. The results, illustrated in **Figure 19**, indicate that at the current side slope of 1.5:1, the existing 8-11 inch rock is expected to be only marginally stable up to 80,000 cfs, and definitely inadequate by the ASCE criteria at discharges exceeding this value. (It should be noted that riprap design criteria typically includes a factor-of-safety of 1.5, which allows for the uncertainties involved in this type of analysis.)

The stability of the existing lining material was further investigated through use of several factor-of-safety procedures (**Figures 20 through 23**). The factor-of-safety analyses indicates that, with the additional shear stress likely due to the effect of the channel bend, loss of material would be highly probable at discharges exceeding about 75,000 cfs, where the factor of safety at section 112 is less than 1.0 for all procedures applied (Figure 23). As the figures illustrate the computed stability of the material varies with the procedure applied, and the factor of safety is a range rather than a precise value. However, considering the steep side slope and curving channel alignment at the upstream end of the interim bank, it is evident that the existing material does not provide a standard factor-of-safety at even the lowest discharge analyzed (10,000 cfs).

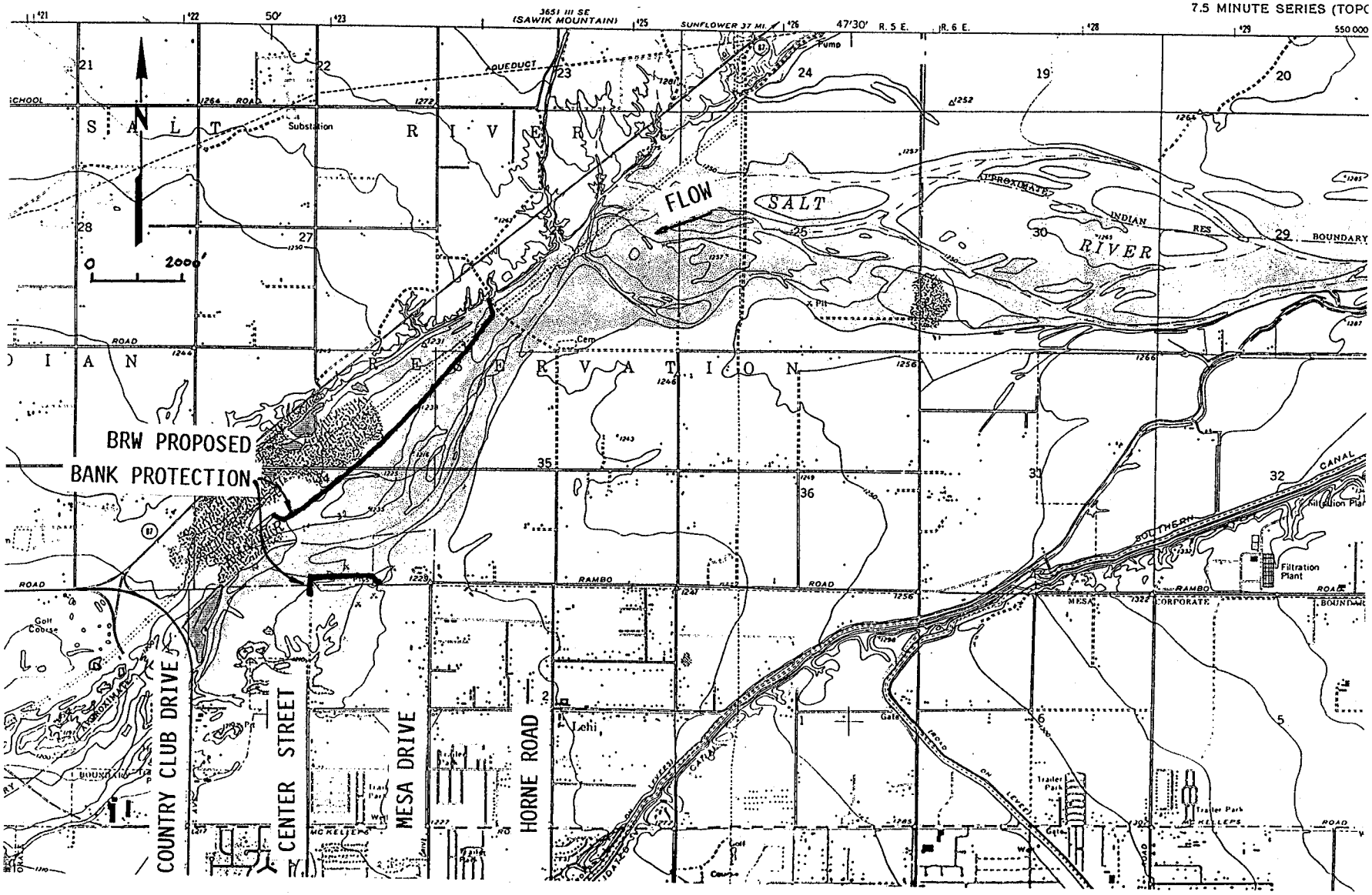


FIGURE 1 USGS QUADRANGLE

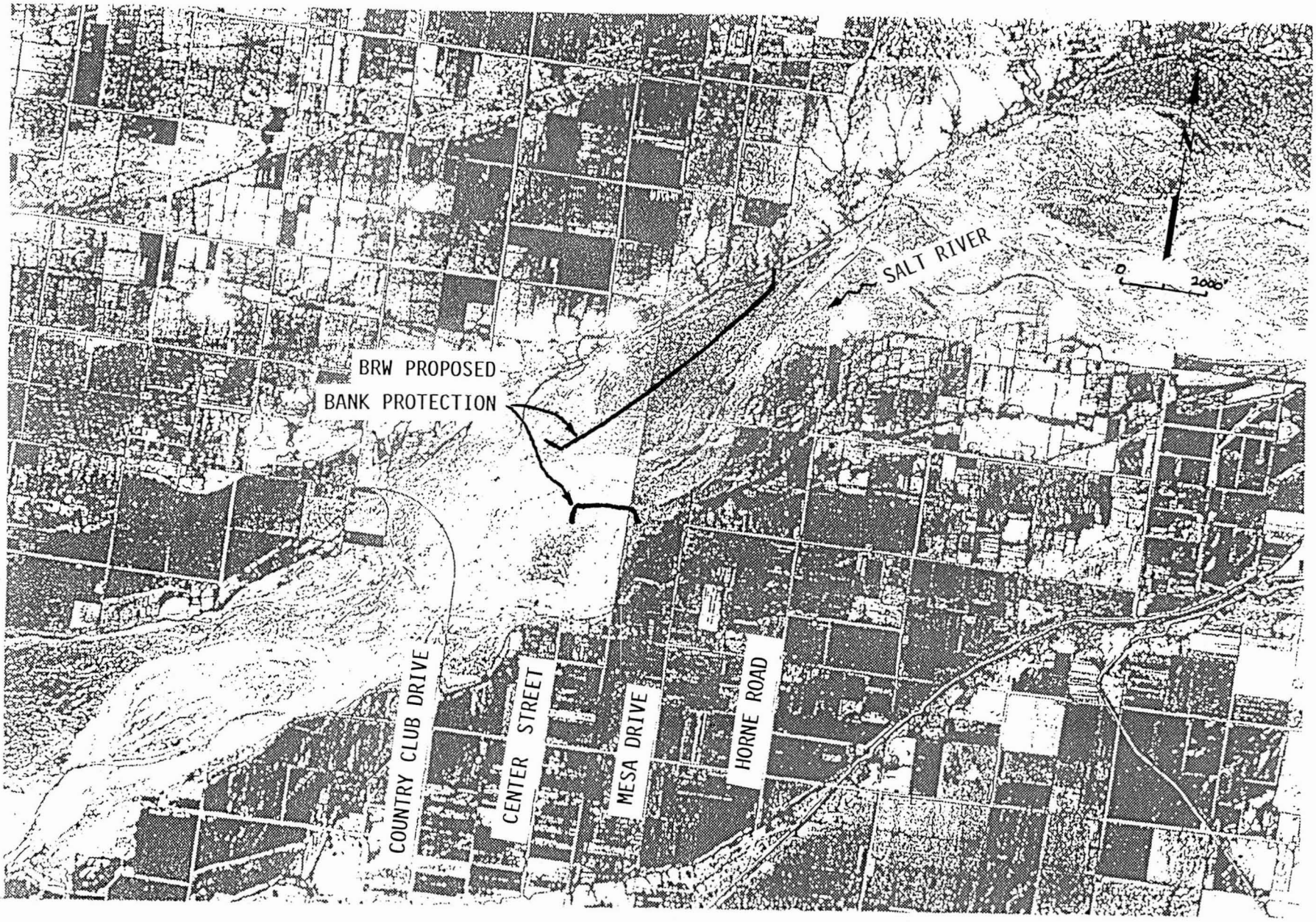


FIGURE 2 1953 AERIAL PHOTOGRAPH

Q = 67,000 CFS
@ GRANITE REEF DAM
PLATE 3
BRW PROPOSED
BANK PROTECTION
MESA DRIVE
HORNE ROAD
MATCH LINE FOR
LEGEND
FLOODED AREA
2000
0
2000
SCALE
FEET
SALT AND GILA RIVERS,
GRANITE REEF DAM TO GILLESPIE DAM, ARIZ.
FLOODED AREA
SALT RIVER GRANITE REEF
DAM TO 83RD AVENUE
FLOOD OF DEC. 1965 – JAN. 1966
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY REPORT DATED: APRIL 1966

FIGURE 3

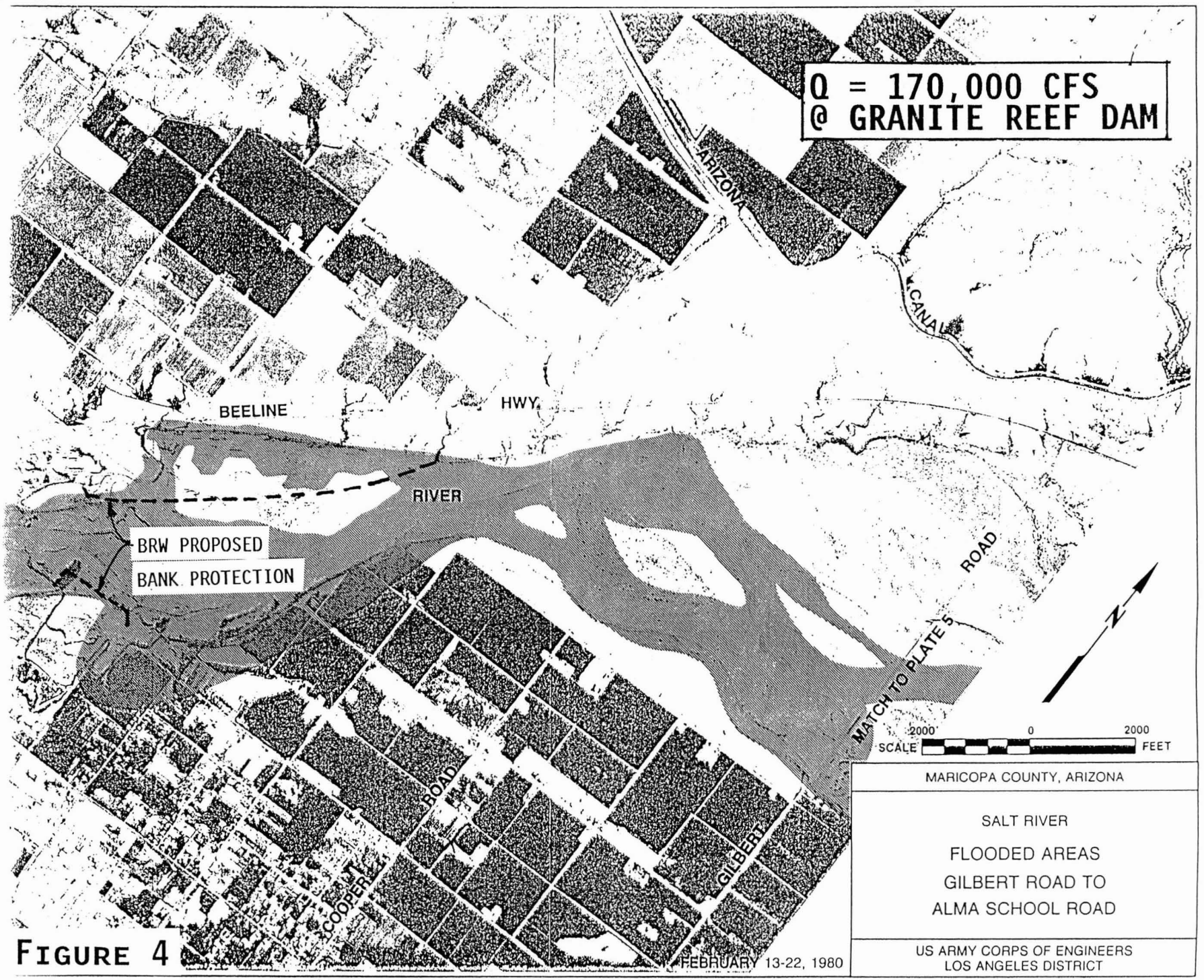
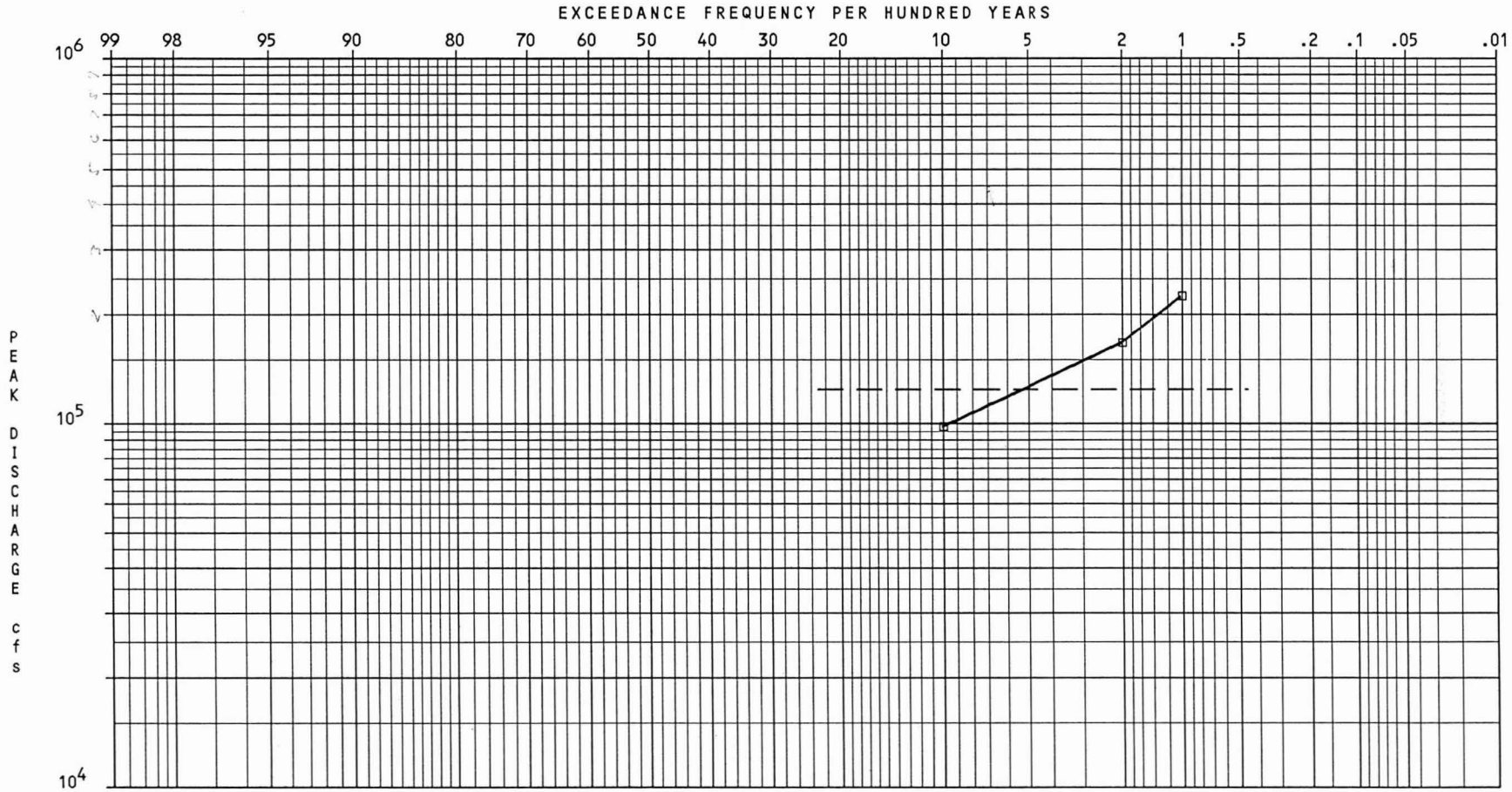

Q = 170,000 CFS
@ GRANITE REEF DAM
ARIZONA CANAL
BEELINE HWY
RIVER
BRW PROPOSED
BANK PROTECTION
ROAD
MATCH TO PLATE 5
N
2000' 0 2000
SCALE FEET
COOPER ROAD
GILBERT
FEBRUARY 13-22, 1980
MARICOPA COUNTY, ARIZONA
SALT RIVER
FLOODED AREAS
GILBERT ROAD TO
ALMA SCHOOL ROAD
US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

FIGURE 4



SALT RIVER FLOW FREQUENCY

COUNTRY CLUB to GILBERT ROAD

FREQUENCY CURVE

JANUARY 1993 EVENT

Source for flow-frequency data:
Salt River Hydraulic Design Information Report -- Hayden Road to Val Vista Road (June, 1987); prepared by Simons, Li & Associates, Inc.

FIGURE 5

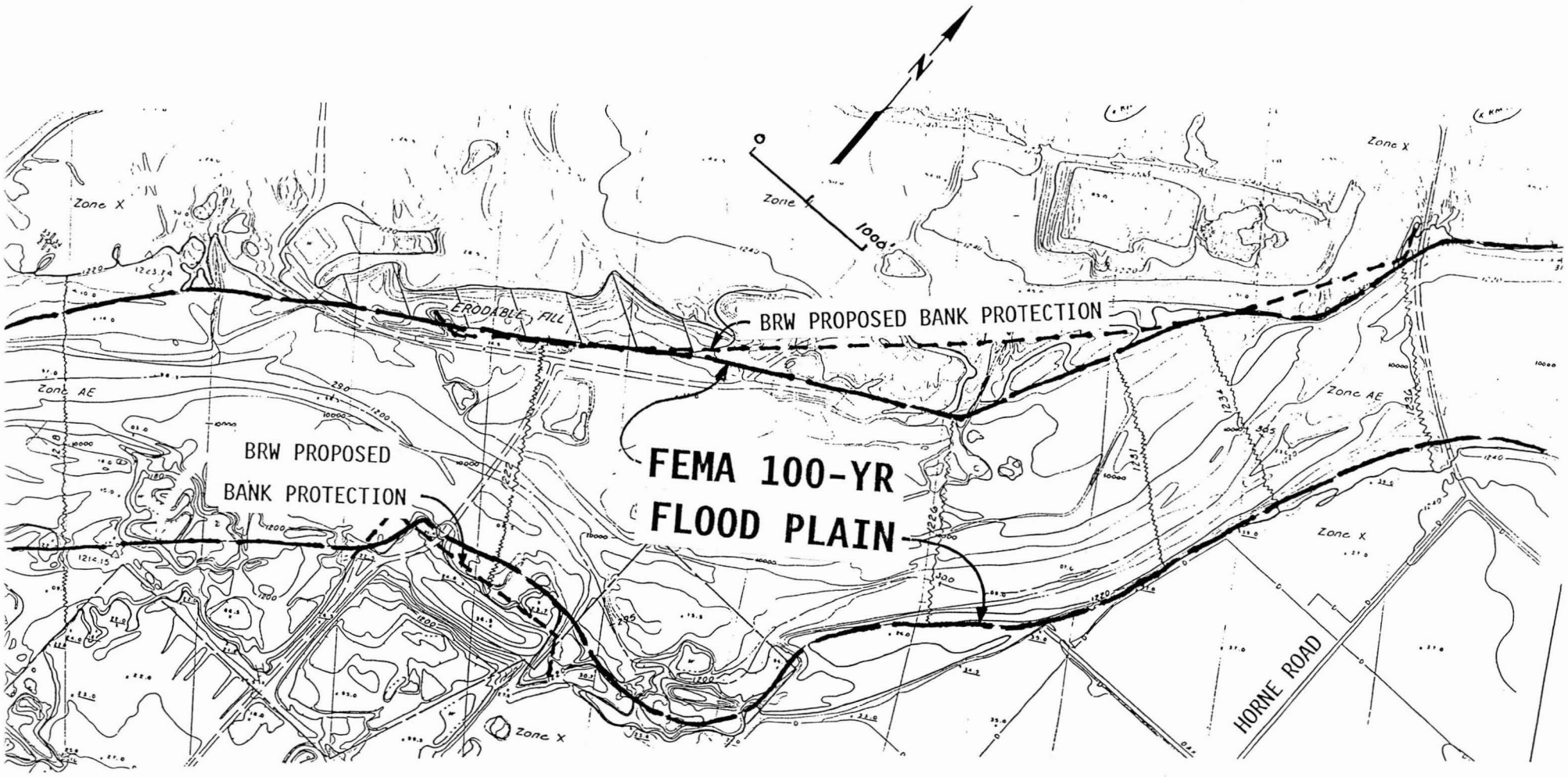


FIGURE 6 1982 TOPOGRAPHY WITH CURRENT FEMA BOUNDARIES

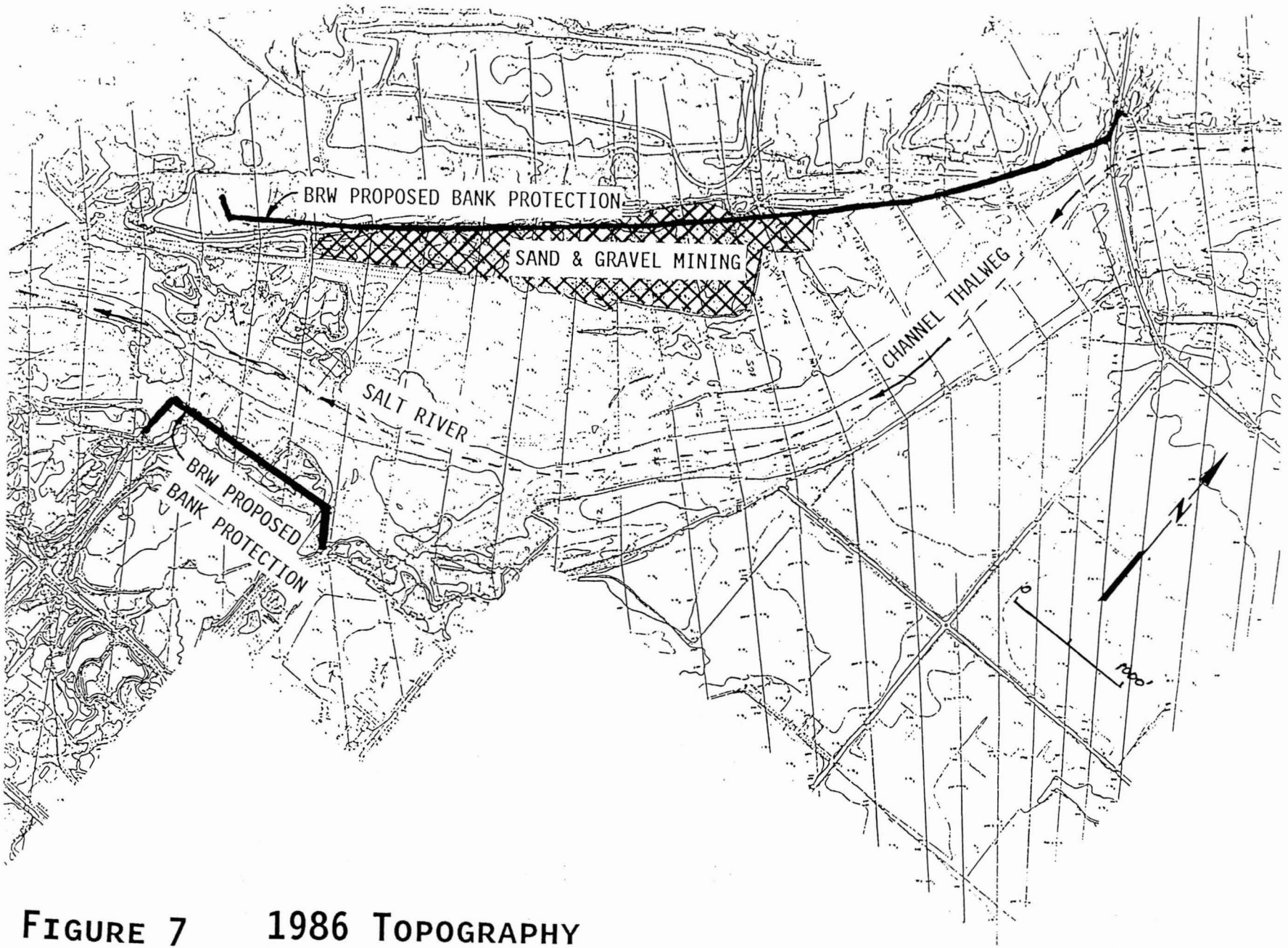


FIGURE 7 1986 TOPOGRAPHY

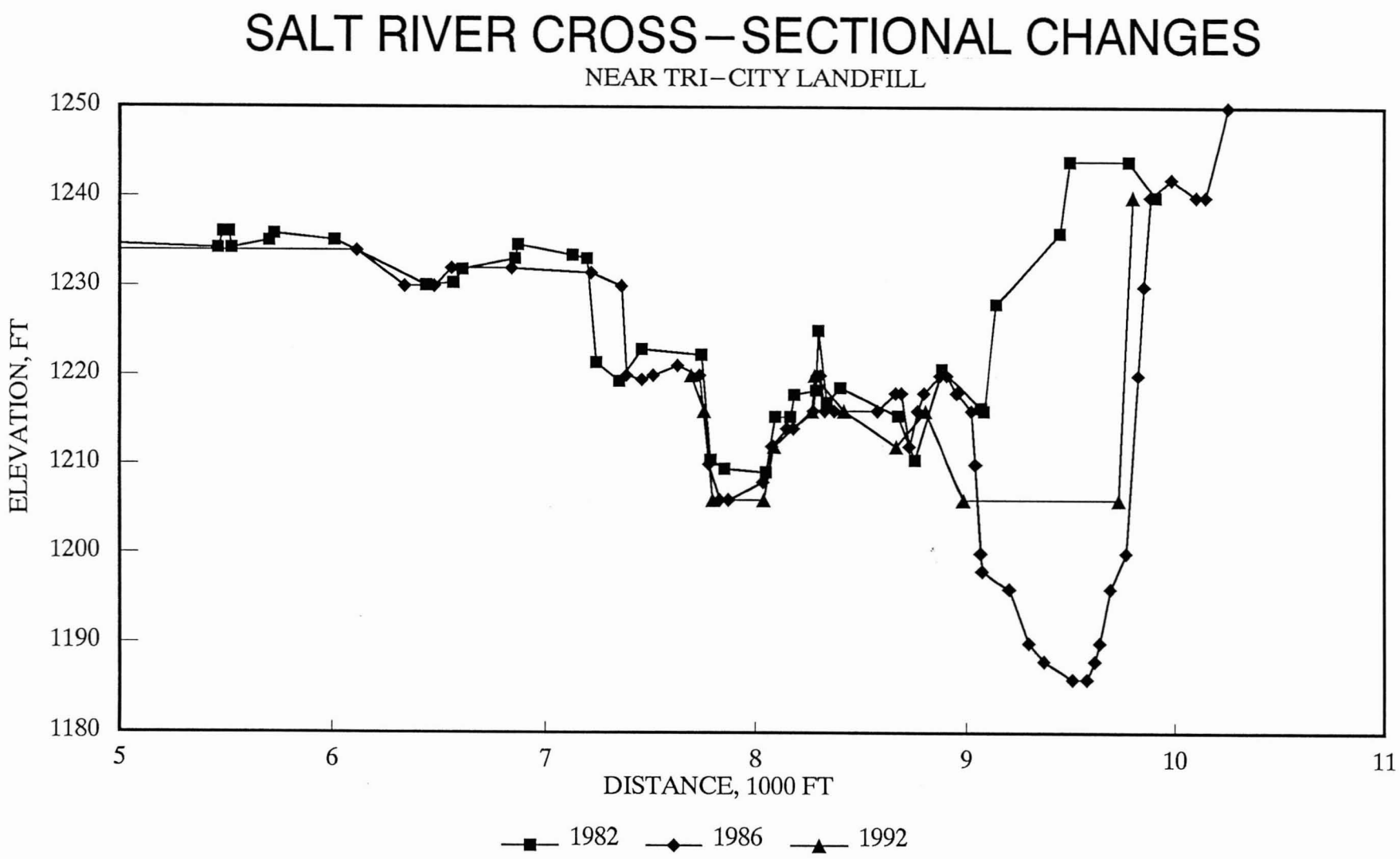
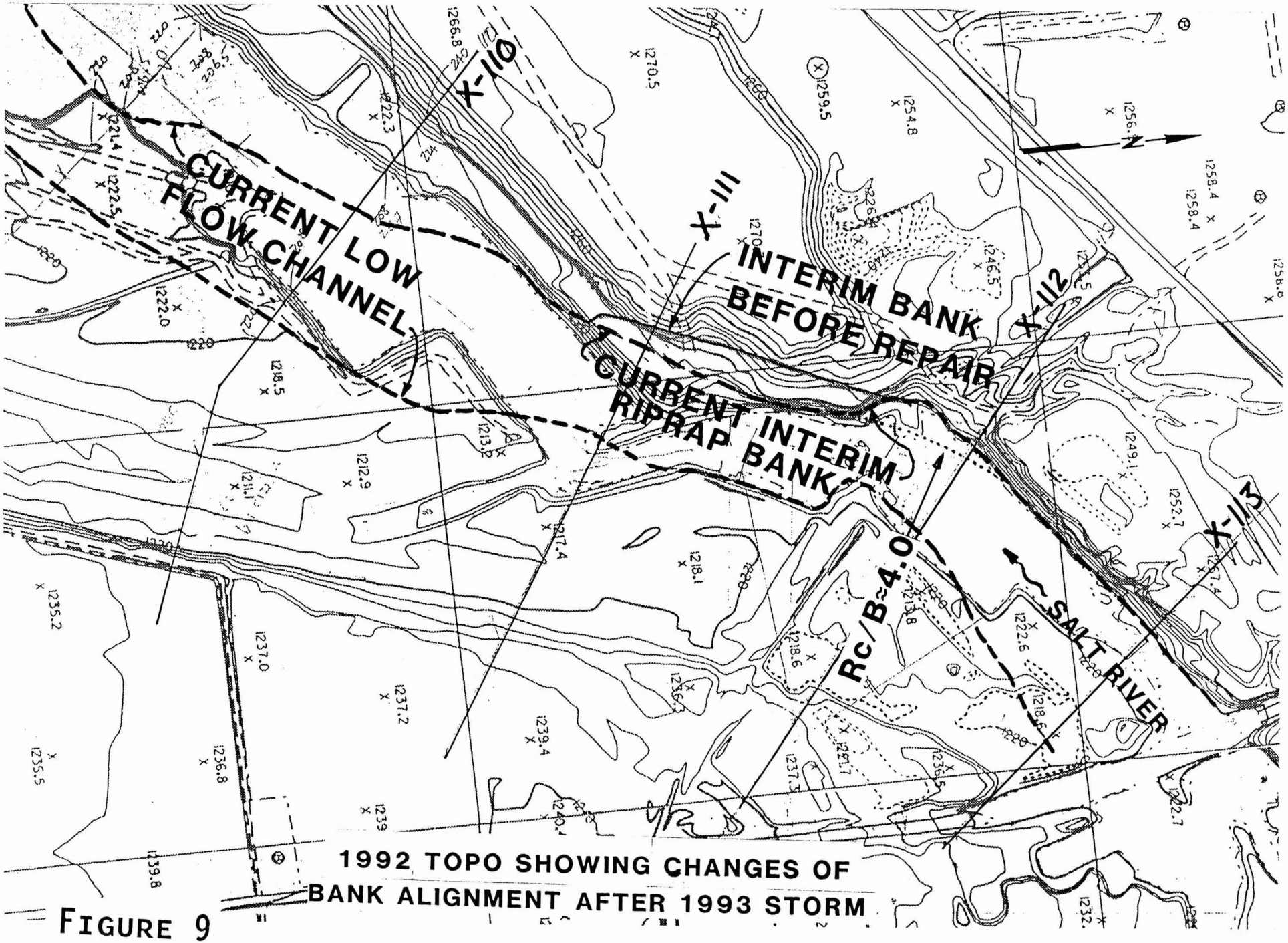

SALT RIVER CROSS–SECTIONAL CHANGES
NEAR TRI–CITY LANDFILL
ELEVATION, FT
1250
1240
1230
1220
1210
1200
1190
1180
5
6
7
8
9
10
11
DISTANCE, 1000 FT
1982
1986
1992

FIGURE 8



1992 TOPO SHOWING CHANGES OF BANK ALIGNMENT AFTER 1993 STORM

FIGURE 9

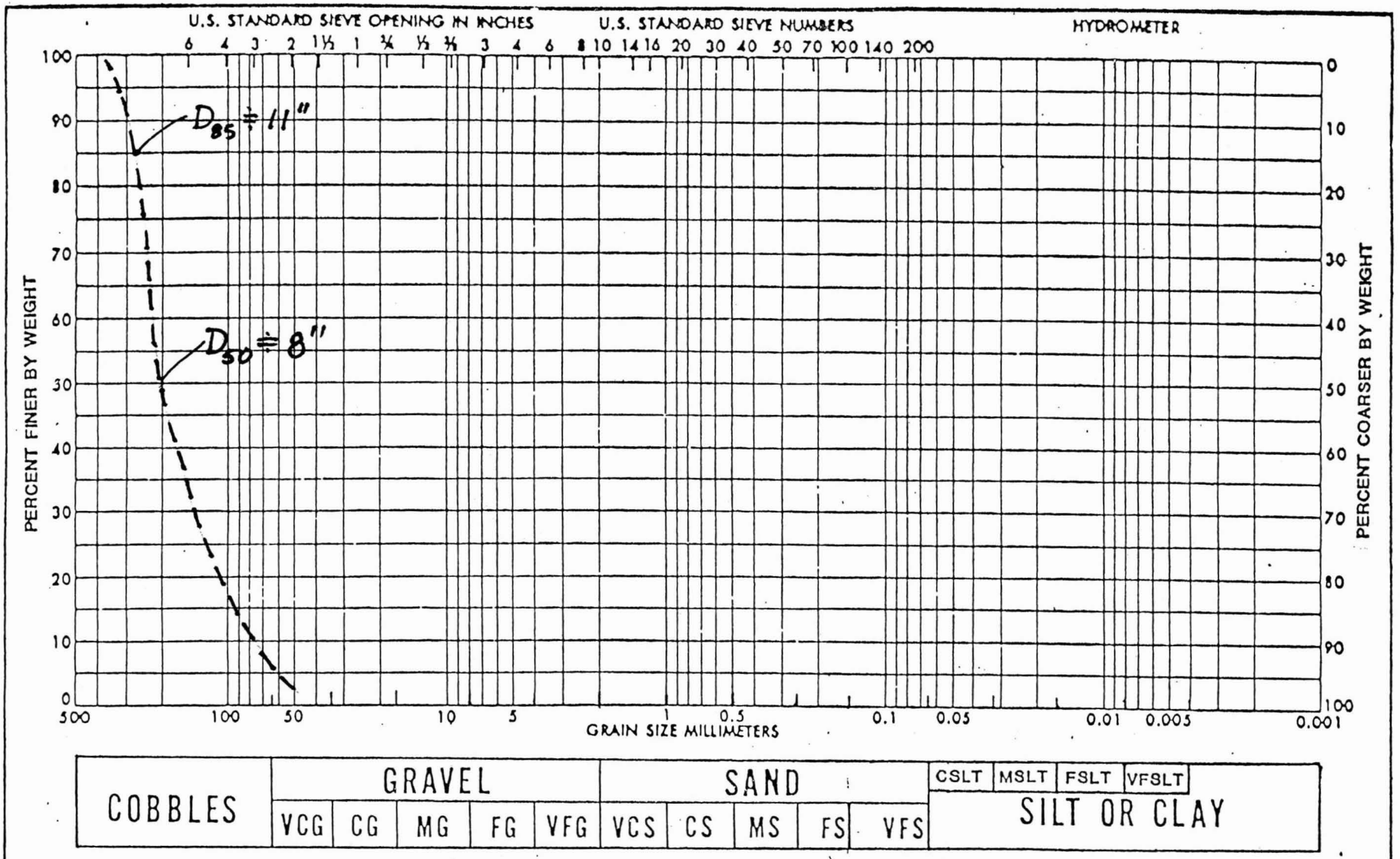


FIGURE 10 TYPICAL SIZE DISTRIBUTION - INTERIM BANK RIPRAP

HEC

FIGURE 11

FIGURE 12

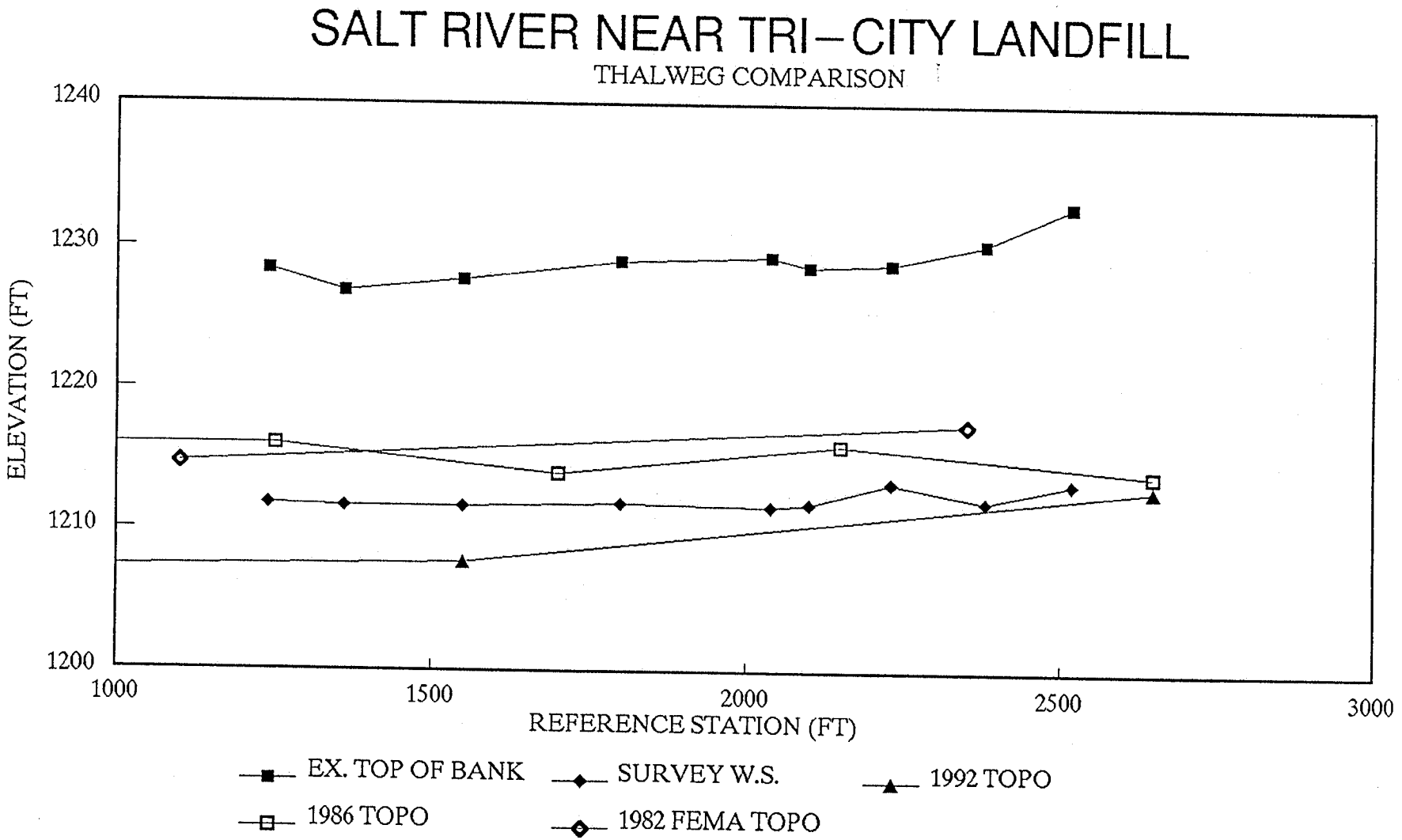

SALT RIVER NEAR TRI–CITY LANDFILL
THALWEG COMPARISON
ELEVATION (FT)
1240
1230
1220
1210
1200
1000
1500
2000
2500
3000
REFERENCE STATION (FT)
EX. TOP OF BANK
SURVEY W.S.
1992 TOPO
1986 TOPO
1982 FEMA TOPO

FIGURE 13

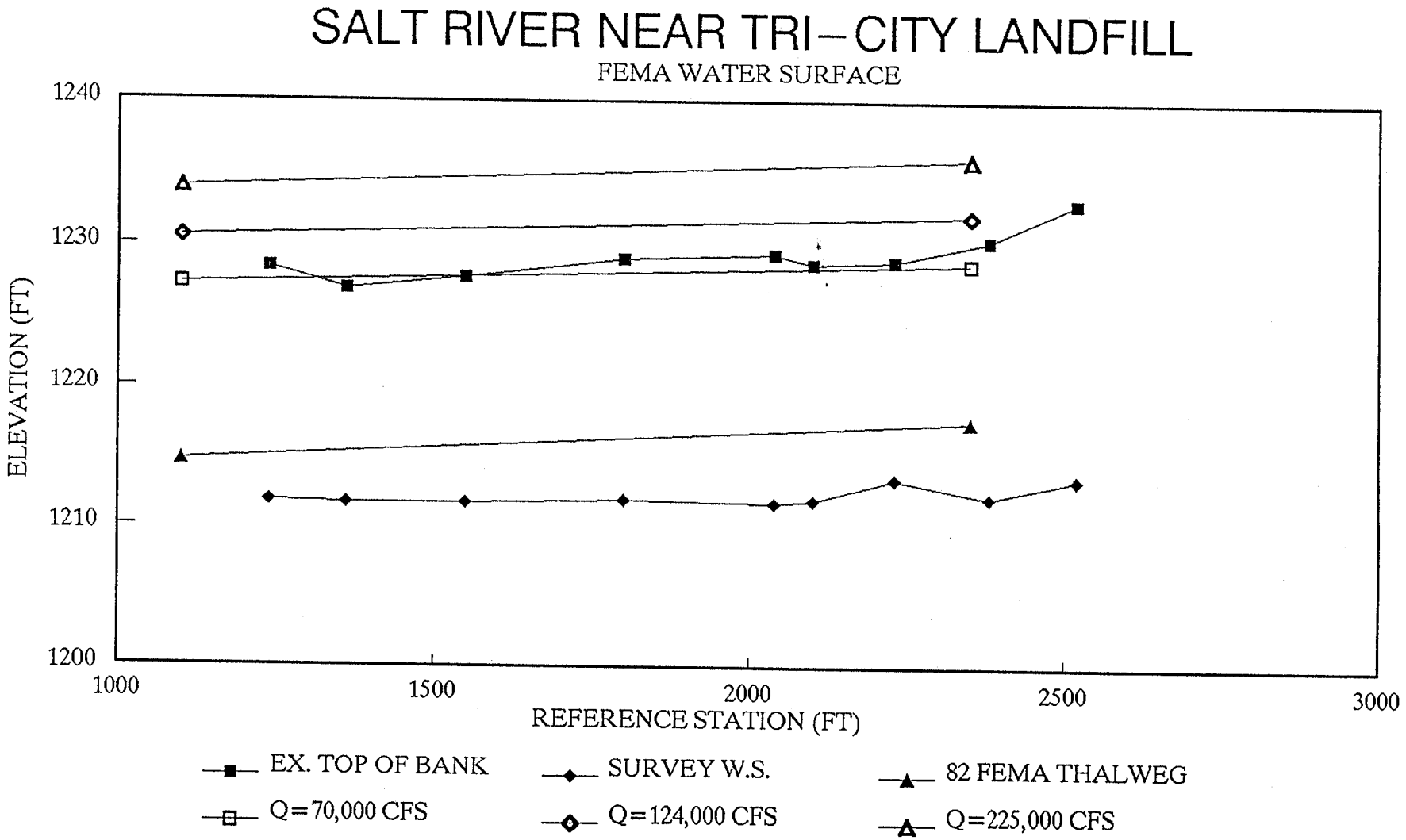

SALT RIVER NEAR TRI–CITY LANDFILL
FEMA WATER SURFACE
ELEVATION (FT)
1240
1230
1220
1210
1200
1000
1500
2000
2500
3000
REFERENCE STATION (FT)
EX. TOP OF BANK
SURVEY W.S.
82 FEMA THALWEG
Q=70,000 CFS
Q=124,000 CFS
Q=225,000 CFS

FIGURE 14

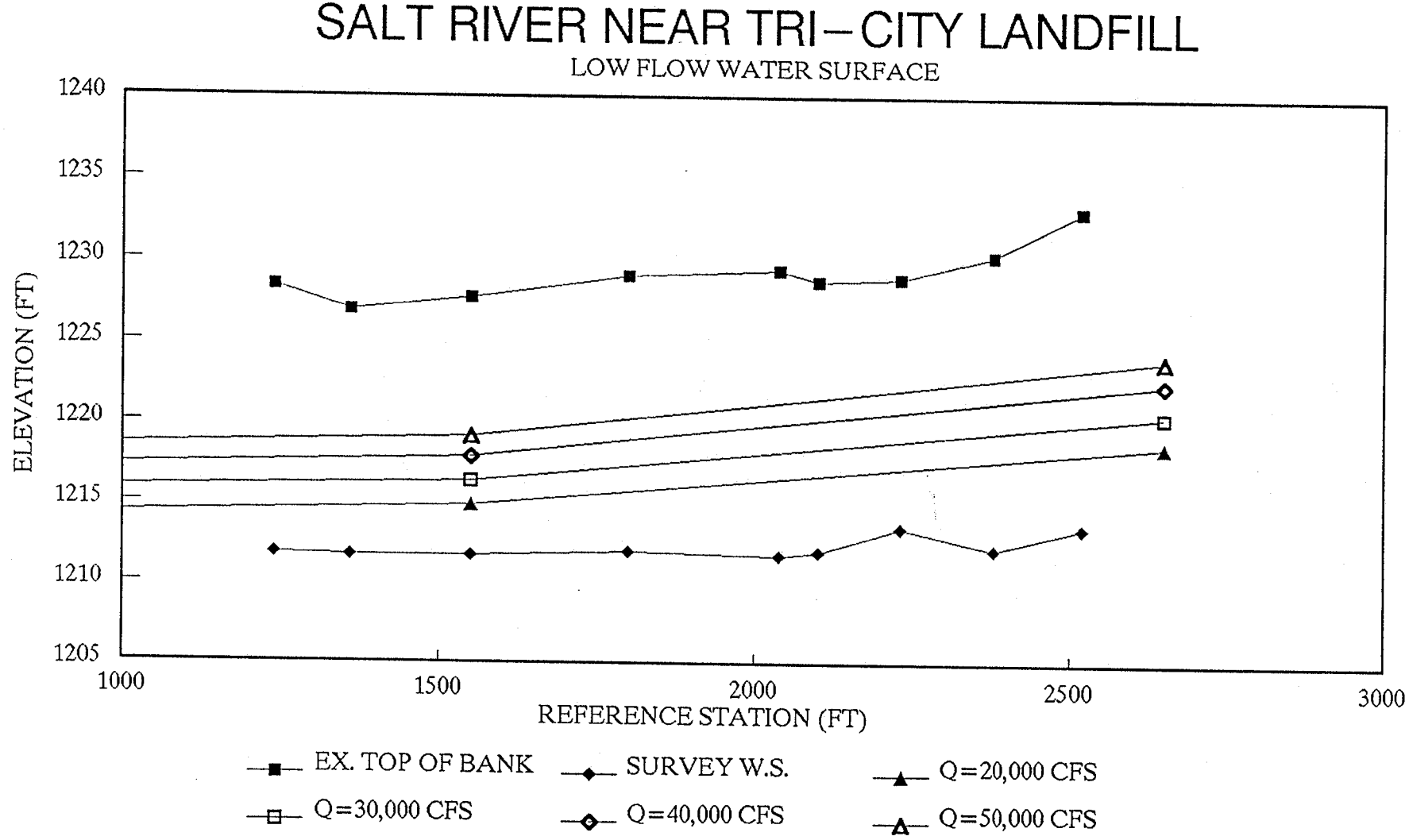

SALT RIVER NEAR TRI-CITY LANDFILL
LOW FLOW WATER SURFACE
ELEVATION (FT)
1240
1235
1230
1225
1220
1215
1210
1205
1000
1500
2000
2500
3000
REFERENCE STATION (FT)
EX. TOP OF BANK
SURVEY W.S.
Q=20,000 CFS
Q=30,000 CFS
Q=40,000 CFS
Q=50,000 CFS

FIGURE 15

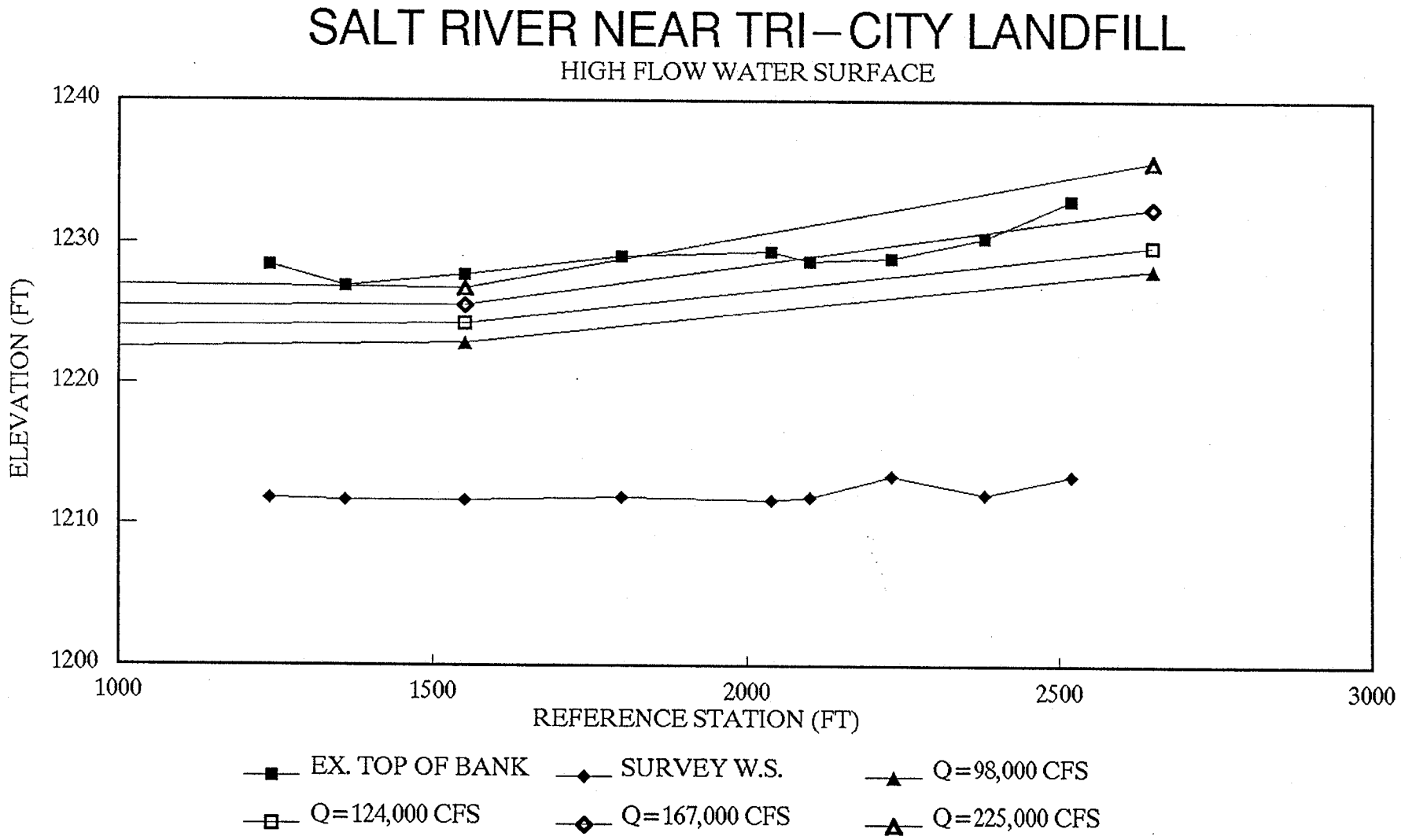

SALT RIVER NEAR TRI–CITY LANDFILL
HIGH FLOW WATER SURFACE
ELEVATION (FT)
1240
1230
1220
1210
1200
1000
1500
2000
2500
3000
REFERENCE STATION (FT)
EX. TOP OF BANK
SURVEY W.S.
Q=98,000 CFS
Q=124,000 CFS
Q=167,000 CFS
Q=225,000 CFS

FIGURE 16

TABLE 1

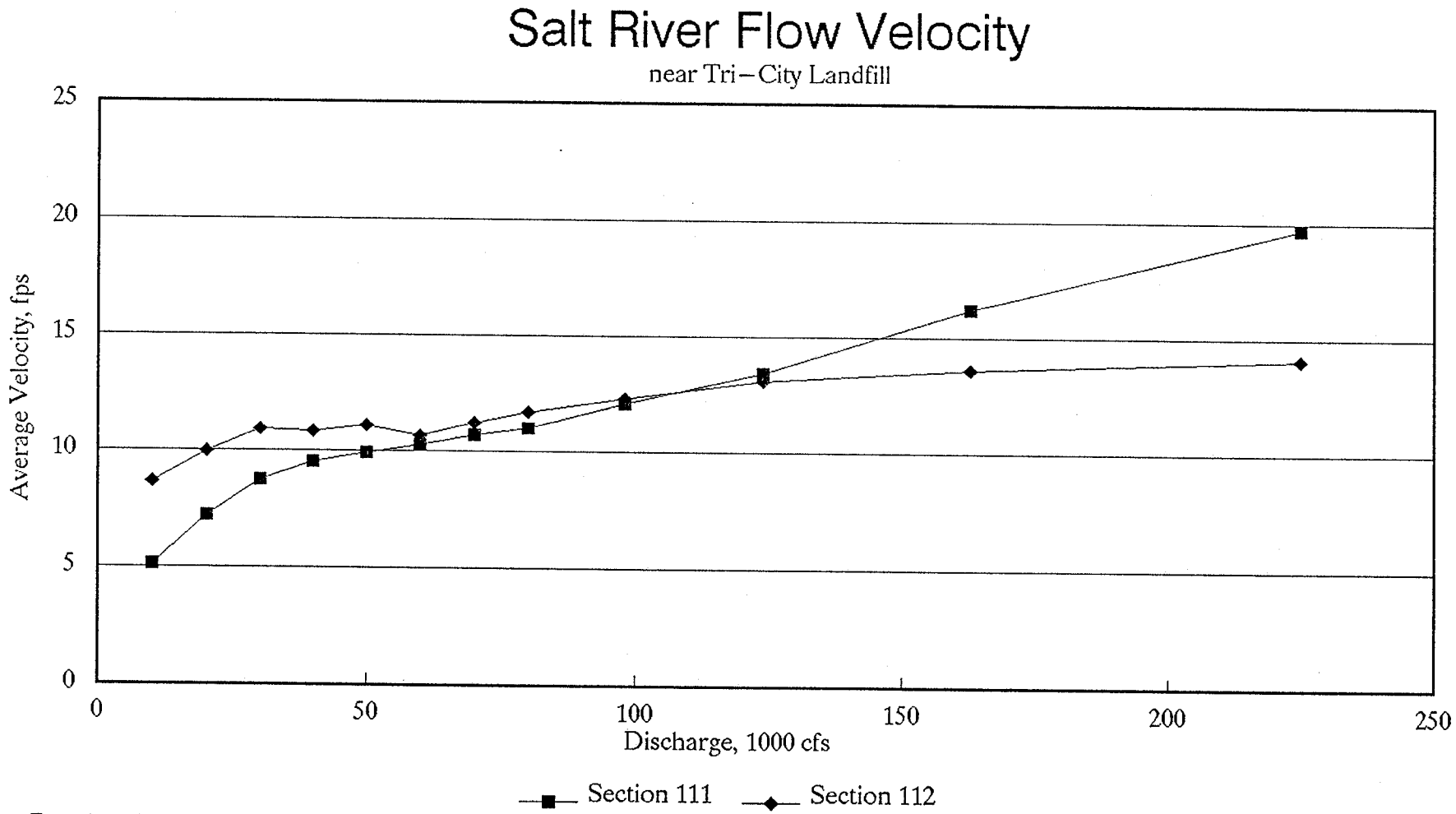
HYDRAULIC CHARACTERISTICS OF SALT RIVER NEAR INTERIM BANK PROTECTION MEASURES ADJACENT TO TRI–CITY LANDFILL

SECNO 111

	DISCHARGE	ENERGY SLOPE	MAXIMUM FLOW DEPTH	HYDRAULIC DEPTH	AVERAGE FLOW VELOCITY
	cfs	ft/ft	ft	ft	fps
	10,000	0.00161	5.04	4.84	5.14
	20,000	0.00205	7.07	6.69	7.21
	30,000	0.00257	8.62	7.56	8.75
	40,000	0.00332	10.10	7.05	9.51
	50,000	0.00365	11.36	7.01	9.93
	60,000	0.00372	12.43	7.23	10.24
	70,000	0.00350	13.28	7.99	10.69
	80,000	0.00325	14.16	8.76	11.02
10–YR	98,000	0.00340	15.19	9.66	12.10
JAN '93	124,000	0.00353	16.56	10.85	13.42
50–YR	167,000	0.00452	17.84	11.86	16.20
100–YR	225,000	0.00620	19.09	12.85	19.76

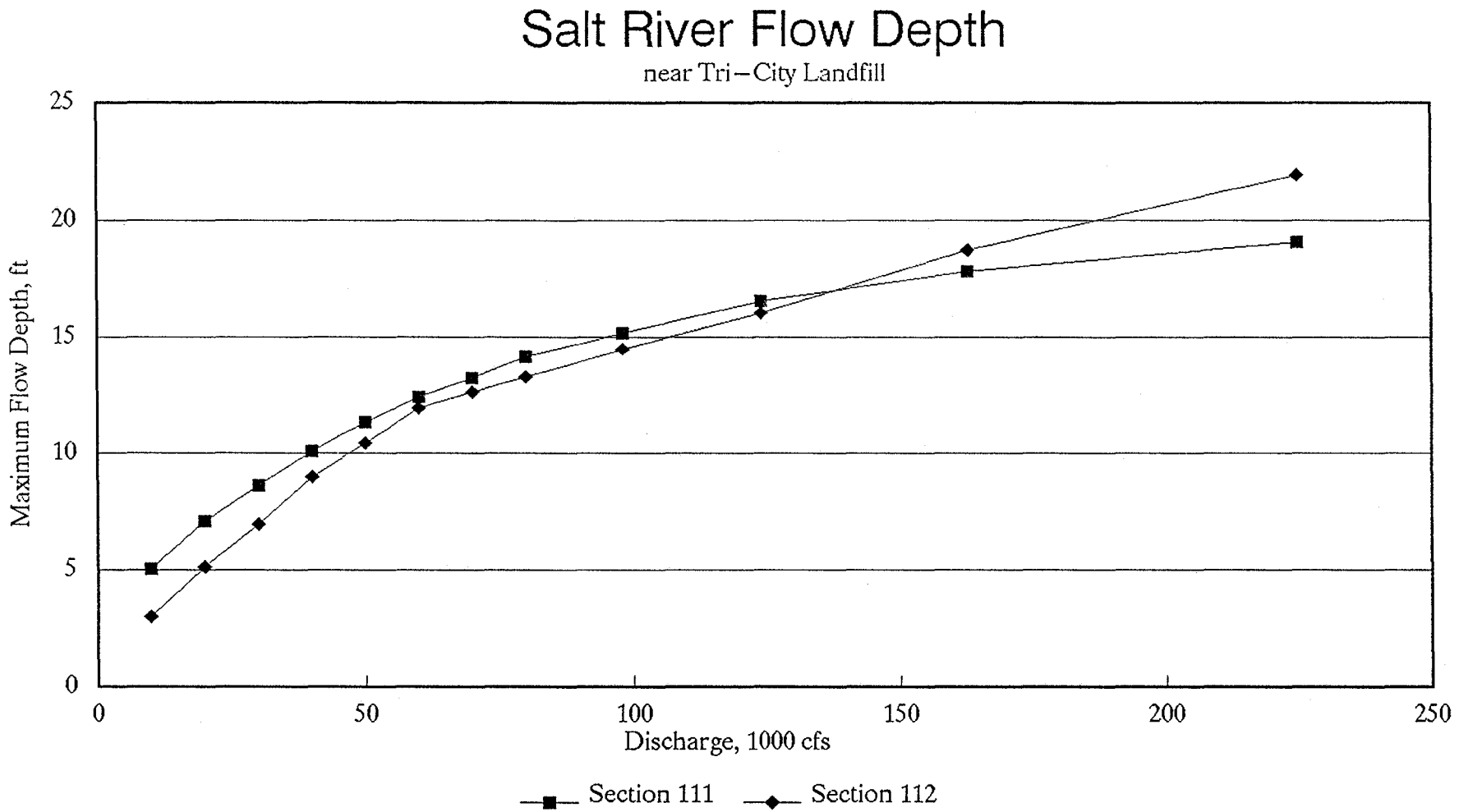
SECNO 112

	DISCHARGE	ENERGY SLOPE	MAXIMUM FLOW DEPTH	HYDRAULIC DEPTH	AVERAGE FLOW VELOCITY
	cfs	ft/ft	ft	ft	fps
	10,000	0.00875	2.99	2.95	8.64
	20,000	0.00577	5.13	4.99	9.95
	30,000	0.00472	6.94	6.69	10.93
	40,000	0.00425	9.00	7.13	10.82
	50,000	0.00414	10.45	7.55	11.09
	60,000	0.00454	11.96	6.59	10.63
	70,000	0.00460	12.66	7.06	11.20
	80,000	0.00463	13.30	7.50	11.70
10–YR	98,000	0.00451	14.50	8.27	12.32
JAN '93	124,000	0.00425	16.04	9.49	13.10
50–YR	167,000	0.00367	18.72	11.21	13.60
100–YR	225,000	0.00294	21.98	13.52	14.09



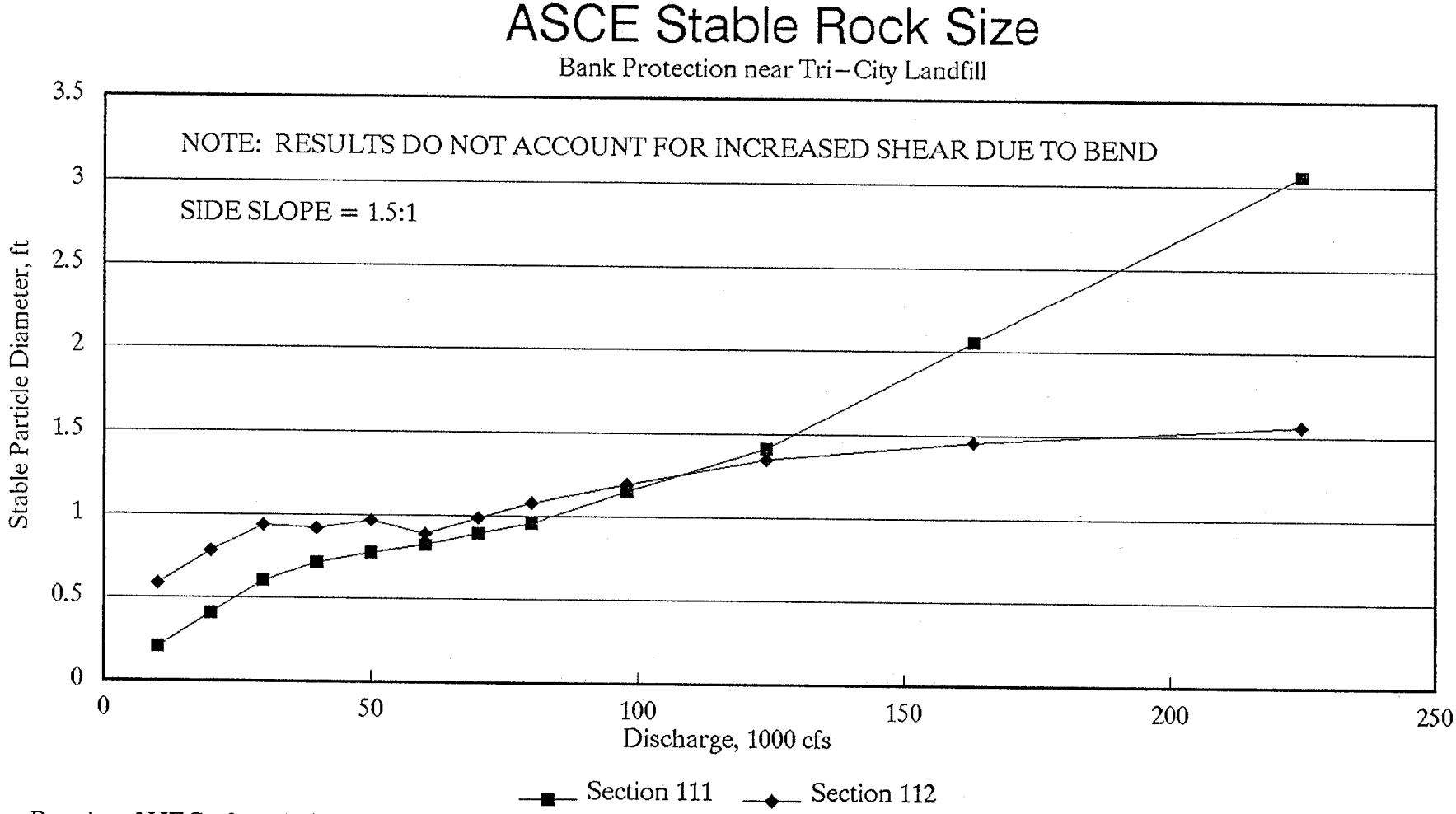
Results of HEC–2 analysis using 1992 topography adjusted near interim bank
Manning n = 0.033 in channel, 0.038 in overbanks

FIGURE 17



Results of HEC–2 analysis using 1992 topography adjusted near interim bank
Manning n = 0.033 in channel, 0.038 in overbanks

FIGURE 18

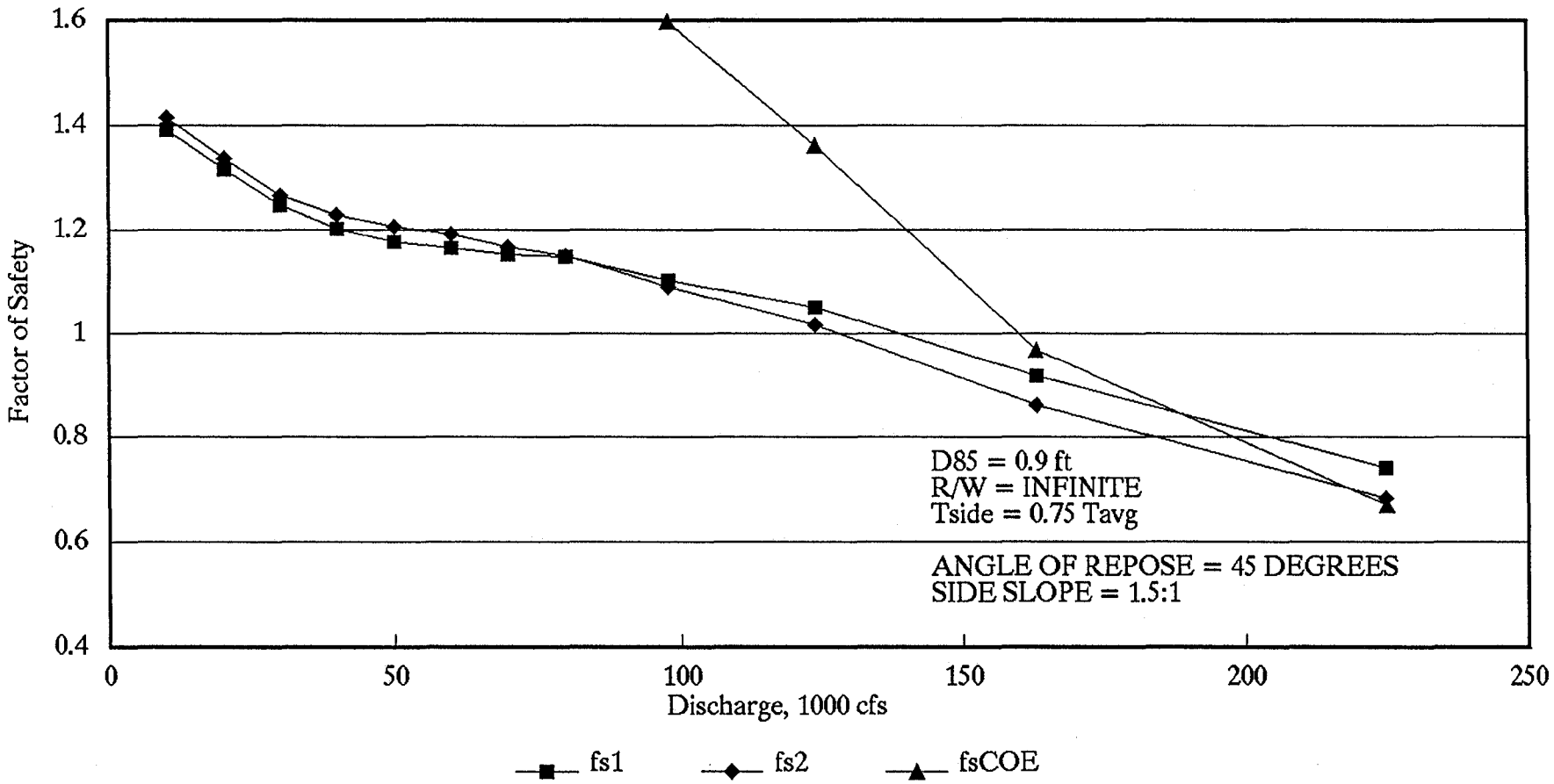


Results of HEC–2 analysis using 1992 topography adjusted near interim bank; Manning n = 0.033 in channel, 0.038 in overbanks
Required size computed using procedure recommended by ASCE Task Committee on Preparation of a Sedimentation Manual

FIGURE 19

STABILITY OF EXISTING RIPRAP AT SECTION 111

WITHOUT BEND EFFECT

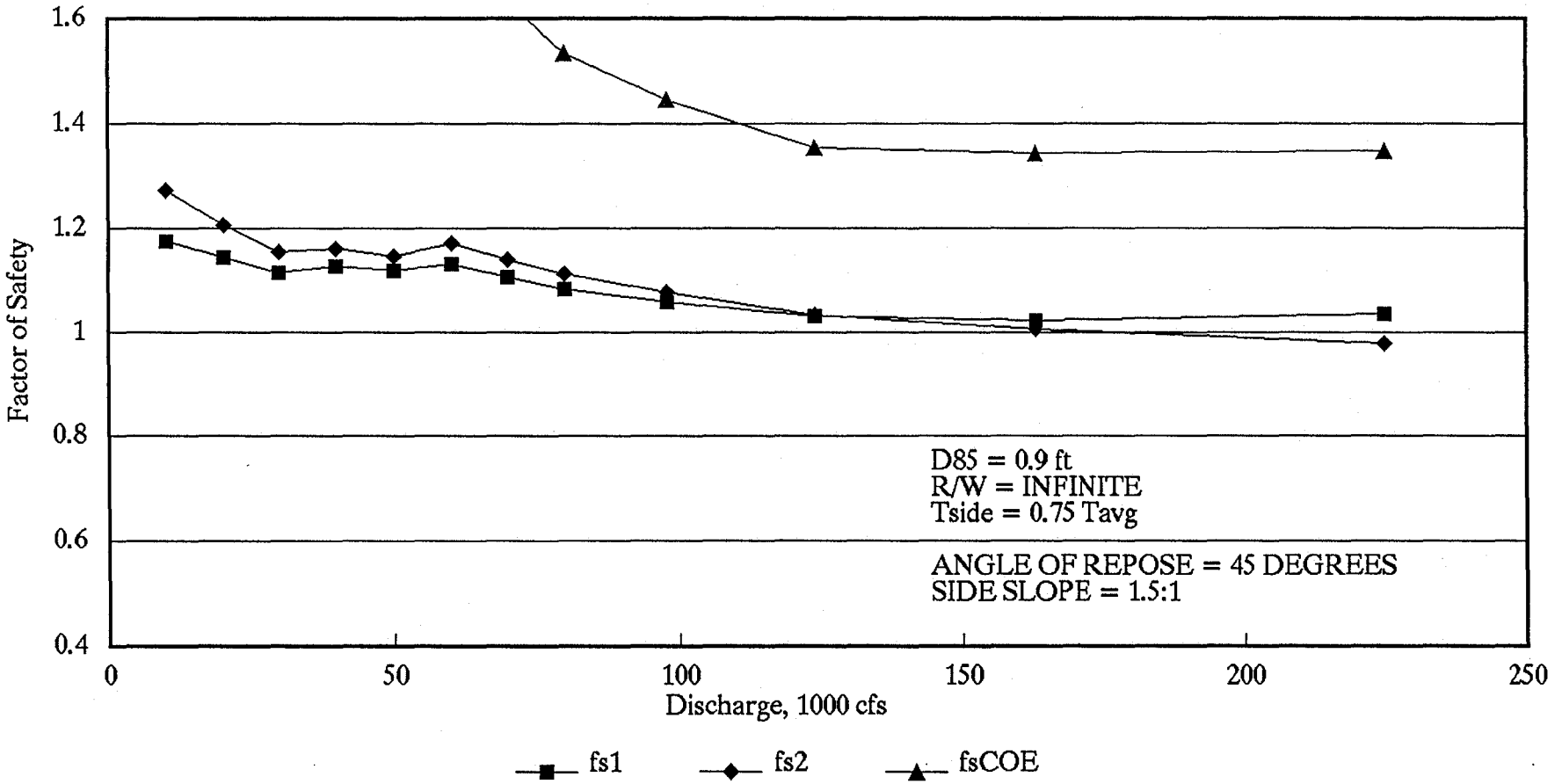


Note: fs1 and fs2 use the Simons and Senturk factor of safety procedure; fs1 shear was calculated using hydraulic depth, slope and ga
fs2 shear was calculated using friction factor and average velocity; fsCOE was computed using EM 1110–2–1601

FIGURE 20

STABILITY OF EXISTING RIPRAP AT SECTION 112

WITHOUT BEND EFFECT

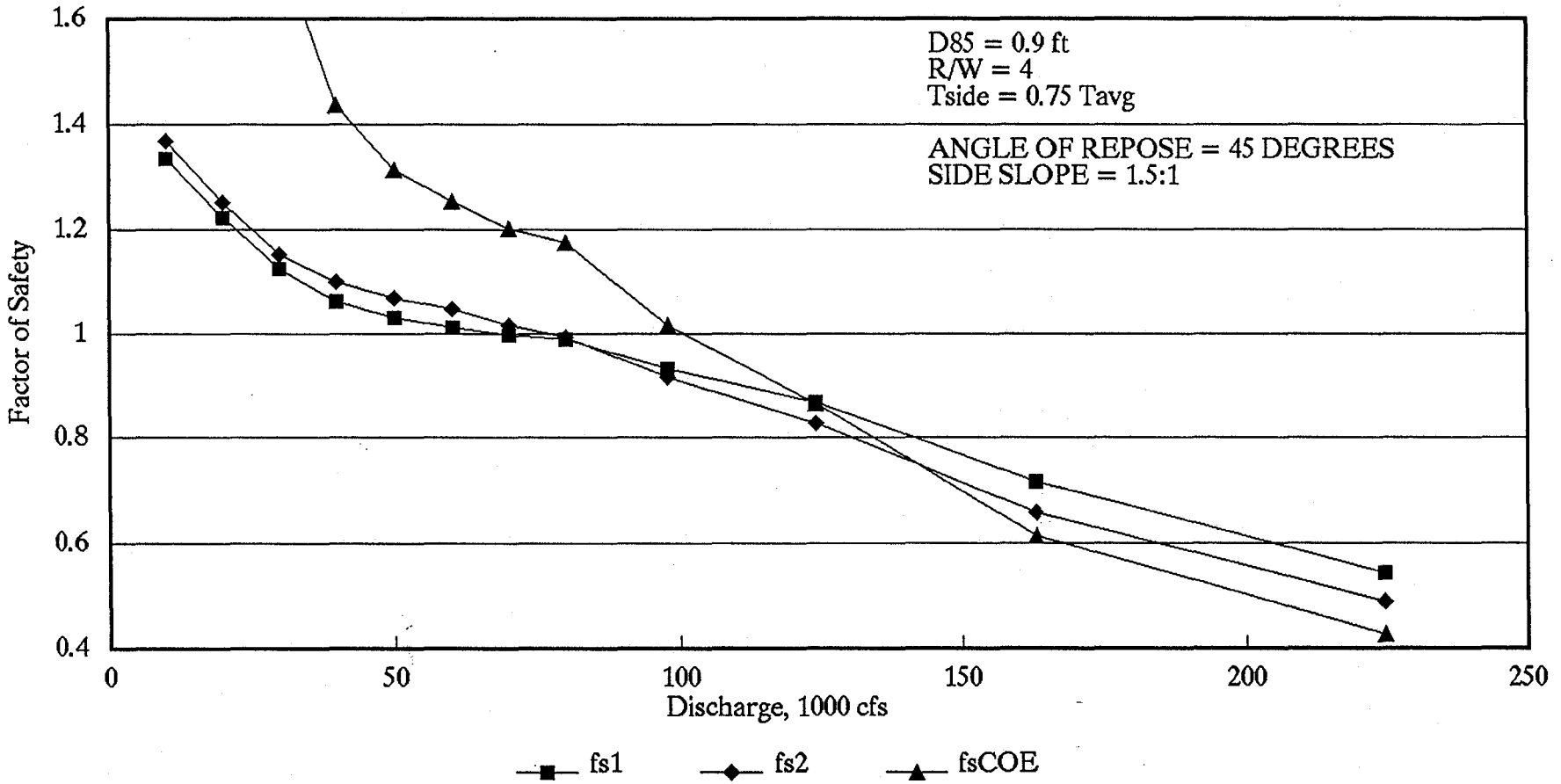


Note: fs1 and fs2 use the Simons and Senturk factor of safety procedure; fs1 shear was calculated using hydraulic depth, slope and ga
fs2 shear was calculated using friction factor and average velocity; fsCOE was computed using EM 1110–2–1601

FIGURE 21

STABILITY OF EXISTING RIPRAP AT SECTION 111

CONSIDERING INCREASE IN SHEAR DUE TO BEND

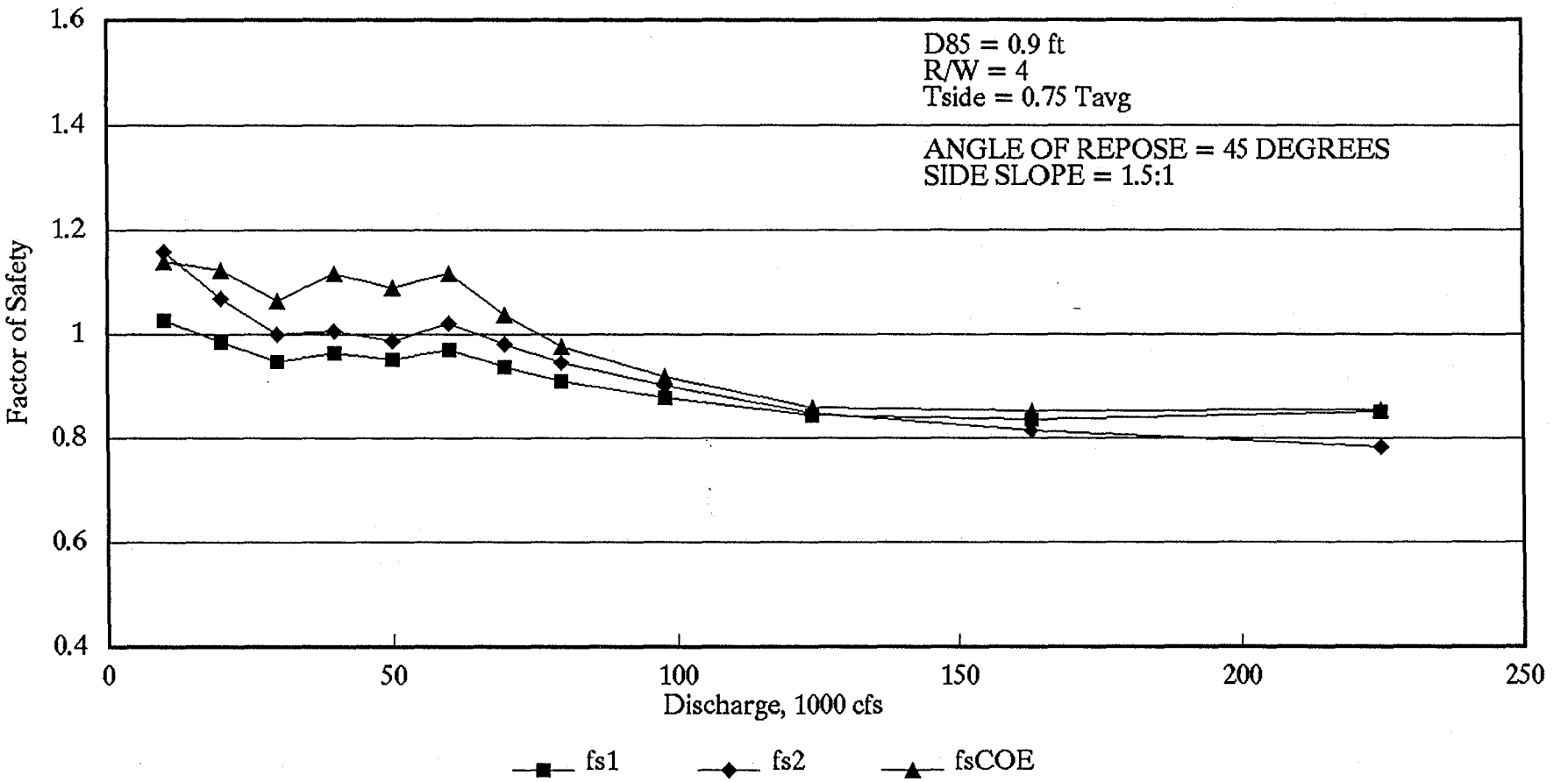


Note: fs1 and fs2 use the Simons and Senturk factor of safety procedure; fs1 shear was calculated using hydraulic depth, slope and ga
fs2 shear was calculated using friction factor and average velocity; fsCOE was computed using EM 1110–2–1601

FIGURE 22

STABILITY OF EXISTING RIPRAP AT SECTION 112

CONSIDERING INCREASE IN SHEAR DUE TO BEND



Note: fs1 and fs2 use the Simons and Senturk factor of safety procedure; fs1 shear was calculated using hydraulic depth, slope and ga
fs2 shear was calculated using friction factor and average velocity; fsCOE was computed using EM 1110–2–1601

FIGURE 23

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SHB AGRA, INC.
Engineering & Environmental Services

3232 West Virginia Avenue
Phoenix, Arizona 85009
Phone: 602-272-6848
Fax: 602-272-7239

April 9, 1993

Simons, Li & Associates, Inc.
4600 South Mill Avenue
Suite 260
Tempe, Arizona 85282-6758

SHB Job No. E93-93

Attention: Dennis L. Richards, P.E.
Vice President

Re: **Stability Evaluation of Interim Dike**
for Existing Landfill
Salt River Pima-Maricopa Indian Community
Maricopa County, Arizona

Gentlemen:

Presented herein is a preliminary report prepared by SHB AGRA, Inc. (SHB) addressing the stability of the interim dike constructed to protect the Salt River Pima-Maricopa Indian Community Landfill from erosion by flows in the Salt River. Included in this report are a description of the field investigation completed and the results of stability analyses of assumed dike configurations. Once complete details of the geometry of the dike and its construction are determined, a final report will be prepared.

The section of the interim dike that is the subject of this report is located at the northern end of the landfill on the north side of the Salt River in an area where the flow in the river transitions from a westerly to a southerly direction. It is our understanding that the existing interim dike was constructed, in part, during a period of relatively high flow in the Salt River to prevent further erosion of landfill material. The dike apparently was constructed by end-dumping various materials, including shot rock and gravel and cobble mixtures, that were derived from several sources.

To further define the types of materials utilized to construct the interim dike, SHB subcontracted a Link Belt LS-4300 track-hoe to excavate four test pits at approximate 300-foot intervals along an approximate 900-foot long section of the dike. The test pits were advanced to depths of 16 to 20 1/2 feet, and were terminated when excessive caving occurred. Locations of the test pits are shown on the attached site plan. Logs of the test pits and typical cross sections also are attached. The test pit exploration was supervised by Richard Bansberg, P.G. of this firm, who also logged and photographed the test pits.

Based on the information gathered during the field exploration, the interim dike apparently was constructed of two types of materials. Shot rock has been placed on the river side of the dike to a variable but, at some locations, undetermined depth. The rock bank protection is angular to very angular and has maximum particle sizes ranging to about 24 inches. The material typically includes considerable sand and gravel and is well graded. The width of the zone of shot rock, as shown on the cross sections, varies from 20 feet to 60 feet at the crest of the dike. Upstream of the shot rock, the fill forming the dike is composed of sand, gravel and cobble mixtures. This material appears to have been quarried from Salt River deposits, since the cobble- and gravel-sized particles are well rounded. This zone apparently extends to the landfill materials, though landfill debris and refuse were not encountered in any of the test pits. The dike is surfaced with a 6- to 18-inch layer of clayey gravel.

Groundwater was encountered in the deeper test pits at a depth of about 20 feet, which contributed to the caving of the fill materials at that depth. The depth to groundwater correlated with the water surface elevation in the Salt River at the time of the field exploration. The depth of flow in the Salt River and, thus, the total height of the dike were not determined.

The slope of the dike on the river side was determined to be on the order of 45°. The total width of the dike, as measured at the crest of the dike from the top of the slope adjacent to the Salt River to the base of the landfill slope, typically is in excess of 80 feet along the section investigated.

For purposes of the stability analyses, both the shot rock and the sand, gravel and cobble fill were assumed to be cohesionless, with their shear strengths defined by friction angles of 36° and 38°, respectively. Saturated unit weights of 138 and 149 pounds per cubic foot (pcf), respectively, were assumed. For the shot rock and granular fill located above the water table, unit weights of 120 and 130 pcf, respectively, were assumed.

Details of the assumed geometry of the interim dike are shown on the attached figures presenting the results of the stability analyses. The width of the zone of shot rock at the crest was assumed to be 30 feet and the slope of the contact between the shot rock and the sand, gravel and cobble fill was assumed to be 45°, the same as the exterior dike slope.

The shot rock was assumed to extend to a depth of 20 or 30 feet, and to be underlain by river deposits of sand, gravel and cobbles. Typical dike sections with heights of 20 feet and 30 feet were analyzed. For each dike height, analyses were made assuming the water level in the river and the dike was coincident with the crest height of the dike and the base of the dike. Thus, a total of four analyses were completed. Considering the very granular characteristics of both types of dike fill, it is likely the material is free-flowing. Further, any changes in the stage of the Salt River will occur over relatively long periods of time, thus, a sudden drawdown condition was not analyzed.

Analysis of dam stability was performed using the computer program STABL5 (Carpenter, 1983)*. STABL5 is based on a two-dimensional limiting equilibrium method. The factor of safety against failure was calculated using a conventional method of slices approach with the modified Bishop method of analysis. The particular procedure employed generates circular shaped slip surfaces between specified coordinate limits. The computed factor of safety is conservative relative to solutions obtained by more accurate methods satisfying complete equilibrium.

Results of the analyses are shown on the cross sections attached to this report. For the 20-foot high dike section, the computed safety factor is 1.28 when the water surface elevation is at the crest of the dike (Case 1A), decreasing to 1.27 when the water surface is at the base of the dike (Case 1B). For the 30-foot high dike section, the computed safety factor is 1.05 when the water surface is at the crest (Case 2A), decreasing to 0.85 when the water surface is at the base (Case 2B). It is noted that for either dike height, an infinite slope failure could be predicted to occur along the slope because the friction angle assumed for the shot rock (36°) is less than the assumed slope angle (45°). The wedge-type failures shown for the 30-foot dike section are representative of this failure mode.

A more detailed analysis would include zoning the dike section based on overburden pressure and assigning friction angles based on the overburden pressure. Typically, the friction angle decreases with increasing overburden pressure, and the shot rock on the face of the slope will have a larger friction angle. Considering the method of placement of the shot rock, the apparent 45° slope angle likely is an approximation of the angle of repose of the material.

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*Carpenter, J.R., 1985, Final Report: STABL5 - The Spencer Method of Slices, Report JHRP-85-17, Purdue University, West Lafayette, IN.

The preliminary analyses completed to date indicate the existing interim dike in the area investigated is marginally stable, particularly if the total height of the dike approaches 30 feet. The stability could be enhanced by reducing the slope of the dike to 1 1/2 to 1 (horizontal to vertical) or flatter. However, the allowable slope angle will be contingent on the impact of flowing water, and not just the static conditions assumed for analyses described herein. Once more detailed information is developed, additional analyses can be completed.

Should you have any questions concerning this preliminary report, please do not hesitate in contacting the undersigned.

Respectfully submitted,
SHB AGRA, Inc.

By _____
Lawrence A. Hansen, Ph.D., P.E. 4/9/93

Registered Professional Engineer (Civil) CERTIFICATE NO. 13972 LAWRENCE A. HANSEN Certified ARIZONA, U.S.A.

Copies: Addressee (3)

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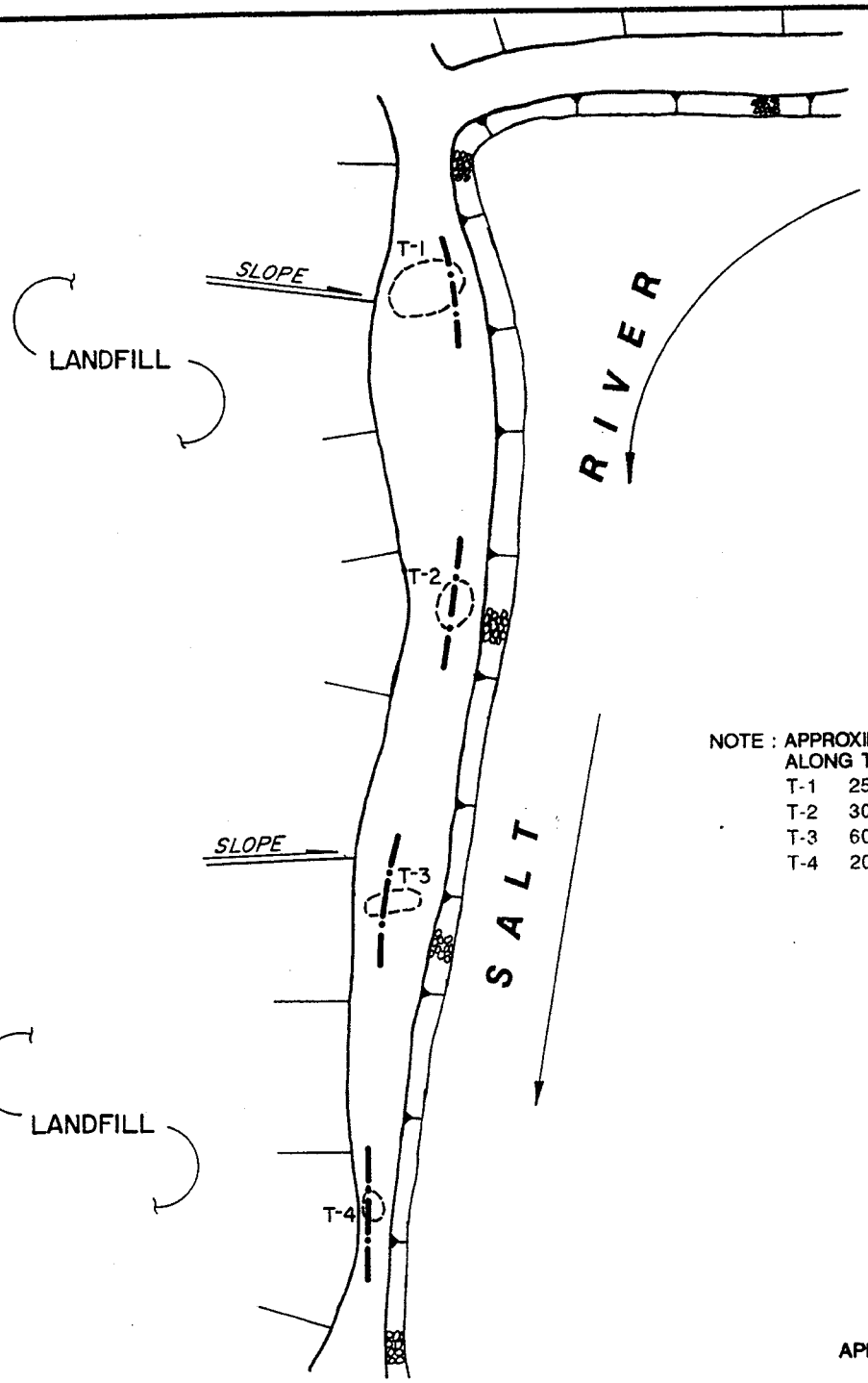

NOTE : APPROXIMATE WIDTH OF SHOT ROCK ALONG TOP OF PROTECTIVE BERM;

T-1	25'
T-2	30'
T-3	60'
T-4	20'

APPROXIMATE NORTH

0 60 120

SCALE : 1 in. = 60 yds.

LEGEND

T-1 APPROXIMATE LOCATION OF TEST TRENCH.

APPROXIMATE LIMIT OF SHOT ROCK ON TOP OF PROTECTIVE BERM.

SHB JOB No. E93-93

SITE PLAN

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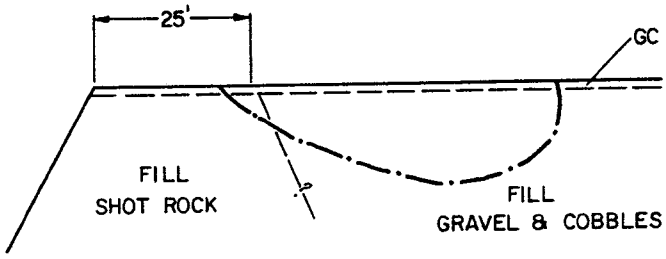


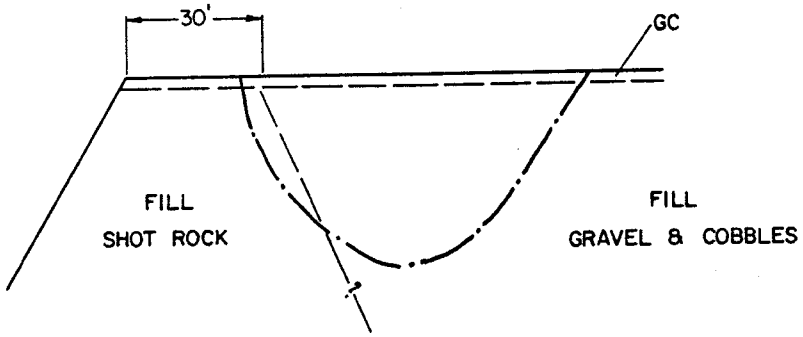
LEGEND

CONTACT

LIMITS OF EXCAVATION

SCALE : 1"= 30'
(APPROX.)

TEST PIT T-1



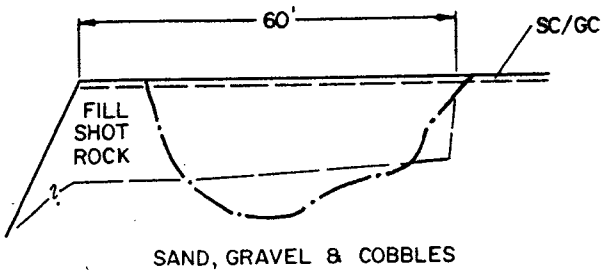
LEGEND

CONTACT

LIMITS OF EXCAVATION

SCALE : 1"= 40'
(APPROX.)

TEST PIT T-2



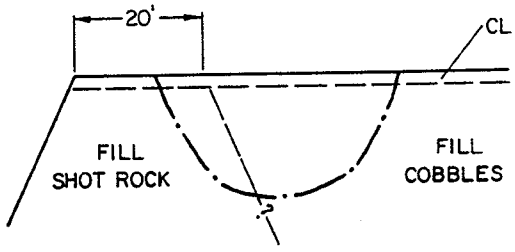
LEGEND

CONTACT

LIMITS OF EXCAVATION

SCALE : 1" = 30'
(APPROX.)

TEST PIT T-3



LEGEND

CONTACT

LIMITS OF EXCAVATION

SCALE : 1" = 30'
(APPROX.)

TEST PIT T-4

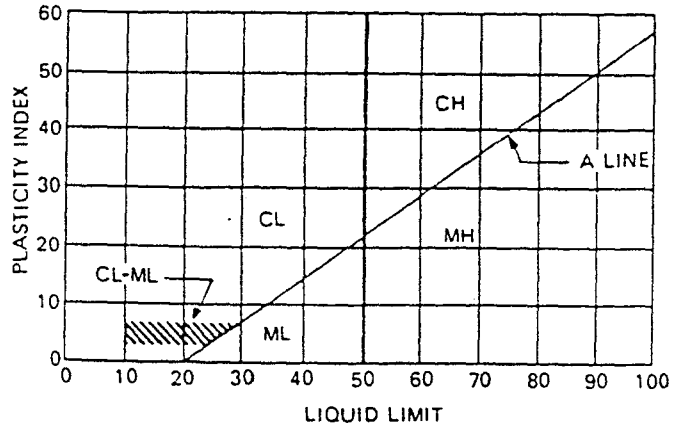
UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified by the Unified Soil Classification system on the boring logs presented in this report. Grain-size analysis and Atterberg Limits Tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see "The Unified Soil Classification System" Corp of Engineers, US Army Technical Memorandum No. 3-357 (Revised April 1960) or ASTM Designation: D2487-66T.

MAJOR DIVISIONS				GRAPHIC SYMBOL	GROUP SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)			GW	Well graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
					GP	Poorly graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		GM	Silty gravels, gravel-sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart		GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 seive)			SW	Well graded sands, gravelly sands.
					SP	Poorly graded sands, gravelly sands.
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		SM	Silty sands, sand-silt mixtures.
			Limits plot above "A" line & hatched zone on plasticity chart		SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS (LIMITS PLOT BELOW "A" LINE & HATCHED ZONE ON PLASTICITY CHART)	SILTS OF LOW PLASTICITY (Liquid Limit Less Than 50)			ML	Inorganic silts, clayey silts with slight plasticity.
		SILTS OF HIGH PLASTICITY (Liquid Limit More Than 50)			MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts.
	CLAYS (LIMITS PLOT ABOVE "A" LINE & HATCHED ZONE ON PLASTICITY CHART)	CLAYS OF LOW PLASTICITY (Liquid Limit Less Than 50)			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid Limit More Than 50)			CH	Inorganic clays of high plasticity, fat clays, sandy clays of high plasticity.

NOTE: Coarse grained soils with between 5% & 12% passing the No. 200 sieve and fine grained soils with limits plotting in the hatched zone on the plasticity chart to have double symbol.

PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Cobbles	Above 3 in.
Gravel	3 in. to No. 4 sieve
Coarse gravel	3 in. to ¾ in.
Fine gravel	¾ in. to No. 4 sieve
Sand	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Fines (silt or clay)	Below No. 200 sieve

PROJECT Bank Protection Adjacent to Landfill

Page 1 of 1

LOG OF TEST PIT NO. T-1

JOB NO. E93-93 DATE 3-27-93

BACKHOE TYPE Link Belt LS-4300

LOCATION

ELEVATION

DATUM

GROUNDWATER

DEPTH	HOUR	DATE
	none	

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture content percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			D		GC	slightly moist	**CLAYEY GRAVEL**, considerable sand, some silt, predominantly fine to medium grained, well rounded, uncemented, low to medium plasticity, grayish brown note: varies from 6" to 1'6" in thickness
5			D			slightly moist	FILL - Bank Protection (shot rock) **COBBLES & BOULDERS**, considerable sand & gravel, trace of clay, well graded, angular to very angular, uncemented, nonplastic, gray FILL **GRAVEL & COBBLES**, considerable sand, trace of clay, occasional boulders, well graded, rounded to well rounded, uncemented, low plasticity to nonplastic, grayish brown
10							
15							
20							Stopped Backhoe at 16' due to excessive caving Backfilled trench
25							

SAMPLE TYPE

B - Undisturbed Block Sample.
D - Disturbed Bulk Sample.
J - Jar Sample

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Page 1 of 1

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LOG OF TEST PIT NO. T-2

JOB NO. E93-93 DATE 3-27-93

BACKHOE TYPE Link Belt LS-4300

LOCATION

ELEVATION

DATUM

GROUNDWATER

DEPTH	HOUR	DATE
20.0	10:45a	3-27-93

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0					GC	slightly moist	**CLAYEY GRAVEL**, considerable sand, some silt, predominantly fine to medium grained, well rounded, uncemented, low to medium plasticity, grayish brown note: varies from 6" to 1'6" in thickness
5						slightly moist	FILL - Bank Protection (shot rock) **COBBLES & BOULDERS**, considerable sand & gravel, trace of clay & silt, well graded cobbles, typically small boulders, angular to very angular, uncemented, nonplastic, gray FILL **SANDY GRAVEL & COBBLES**, trace of clay & silt, occasional boulders, well graded, rounded to well rounded, uncemented, low plasticity to nonplastic, grayish brown
10							
15							
▽ 20							Stopped Backhoe at 20'6" due to excessive caving Backfilled trench
25							

SAMPLE TYPE

B - Undisturbed Block Sample.
D - Disturbed Bulk Sample.
J - Jar Sample

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Page 1 of 1

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LOG OF TEST PIT NO. T-3

JOB NO. E93-93 DATE 3-27-93

GROUNDWATER		
DEPTH	HOUR	DATE
19.0	12:45p	3-27-93

BACKHOE TYPE Link Belt LS-4300
LOCATION
ELEVATION
DATUM

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0					SC/GC	slightly moist	CLAYEY SAND & GRAVEL, considerable silt, predominantly fine grained, angular to subangular, uncemented, low to medium plasticity, grayish brown
			D				
						slightly moist	FILL - Bank Protection (shot rock) COBBLES & BOULDERS, some sand & gravel, trace of clay, well graded, angular to very angular, uncemented, gray
5							
10							
15							
					GW	moist to saturated	SAND, GRAVEL & COBBLES, trace of silt, well graded, rounded to well rounded gravel & cobbles, angular to subangular sand, uncemented, nonplastic, brown note: varies in depth from 16' to 12' (from east to west)
▽ 20							Stopped Backhoe at 20' due to execessive caving Backfilled trench
25							

SAMPLE TYPE
B - Undisturbed Block Sample.
D - Disturbed Bulk Sample.
J - Jar Sample

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Page 1 of 1

PROJECT Bank Protection Adjacent to Landfill

LOG OF TEST PIT NO. T-4

JOB NO. E93-93 DATE 3-27-93

BACKHOE TYPE Link Belt LS-4300

LOCATION

ELEVATION

DATUM

GROUNDWATER

DEPTH	HOUR	DATE
	none	

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0					CL	slightly moist	**SILTY CLAY**, some sand & gravel, uncemented, low to medium plasticity, brown
						slightly moist	FILL - Bank Protection (shot rock) **COBBLES & BOULDERS**, trace of clay, sand & gravel, well graded, angular to very angular, uncemented, nonplastic, gray
5							FILL **COBBLES**, considerable gravel, some clay, silt & sand, occasional boulders, well graded, well rounded, uncemented, nonplastic, brown
10							
15							
20							Stopped Backhoe at 20' due to excessive caving Backfilled trench
25							

SAMPLE TYPE

B - Undisturbed Block Sample.
D - Disturbed Bulk Sample.
J - Jar Sample

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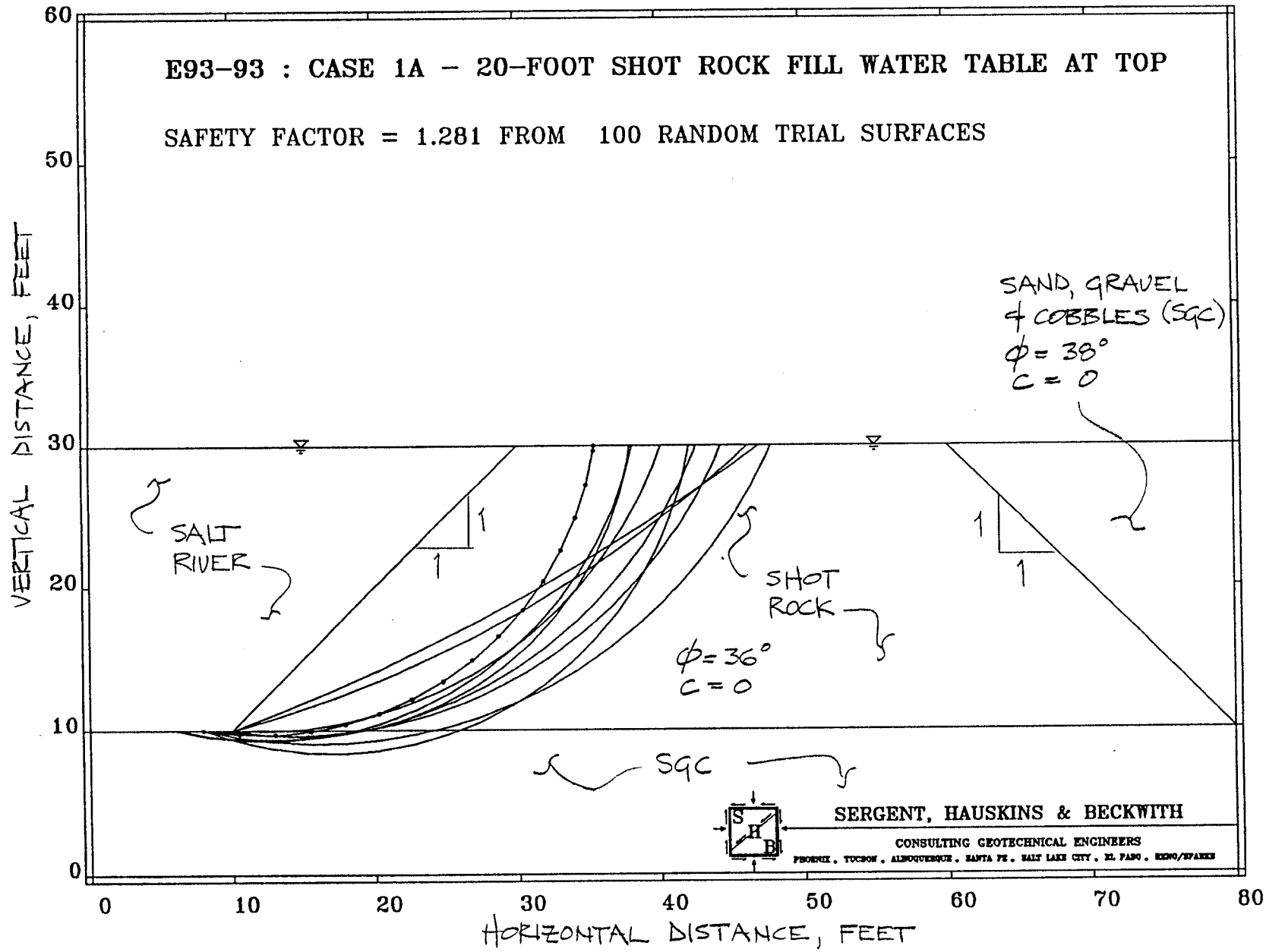
E93-93 : CASE 1A - 20-FOOT SHOT ROCK FILL WATER TABLE AT TOP
SAFETY FACTOR = 1.281 FROM 100 RANDOM TRIAL SURFACES
SAND, GRAVEL & COBBLES (SGC)
φ = 38°
C = 0
SALT RIVER
SHOT ROCK
φ = 36°
C = 0
SGC
1
1
1
1
VERTICAL DISTANCE, FEET
HORIZONTAL DISTANCE, FEET
0
10
20
30
40
50
60
70
80
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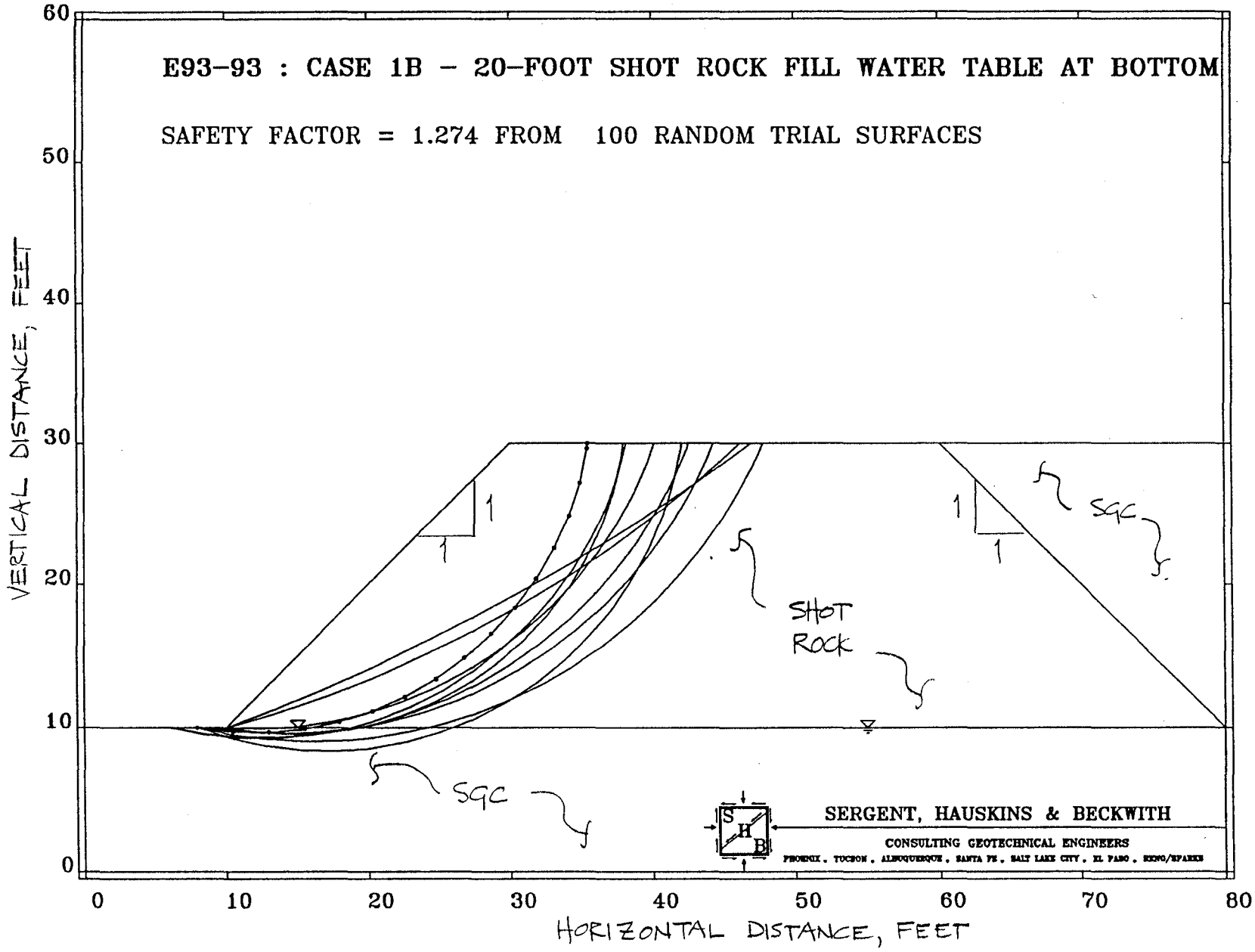
E93-93 : CASE 1B - 20-FOOT SHOT ROCK FILL WATER TABLE AT BOTTOM
SAFETY FACTOR = 1.274 FROM 100 RANDOM TRIAL SURFACES
VERTICAL DISTANCE, FEET
HORIZONTAL DISTANCE, FEET
0
10
20
30
40
50
60
70
80
1
1
1
1
SGC
SHOT ROCK
SGC
SERGENT, HAUSKINS & BECKWITH
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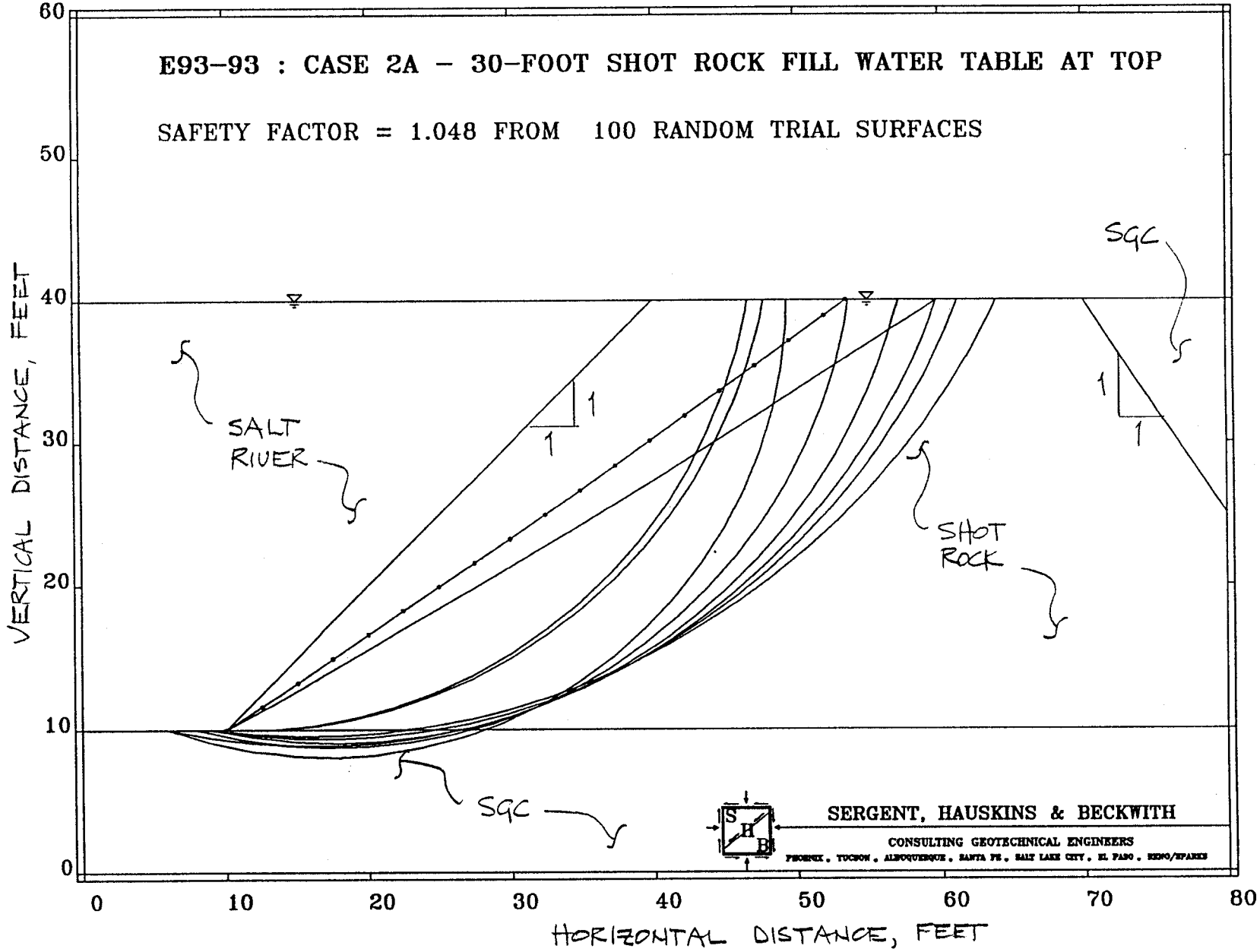
E93-93 : CASE 2A - 30-FOOT SHOT ROCK FILL WATER TABLE AT TOP
SAFETY FACTOR = 1.048 FROM 100 RANDOM TRIAL SURFACES
SGC
SALT RIVER
1
1
1
1
SHOT ROCK
SGC
VERTICAL DISTANCE, FEET
HORIZONTAL DISTANCE, FEET
0
10
20
30
40
50
60
70
80
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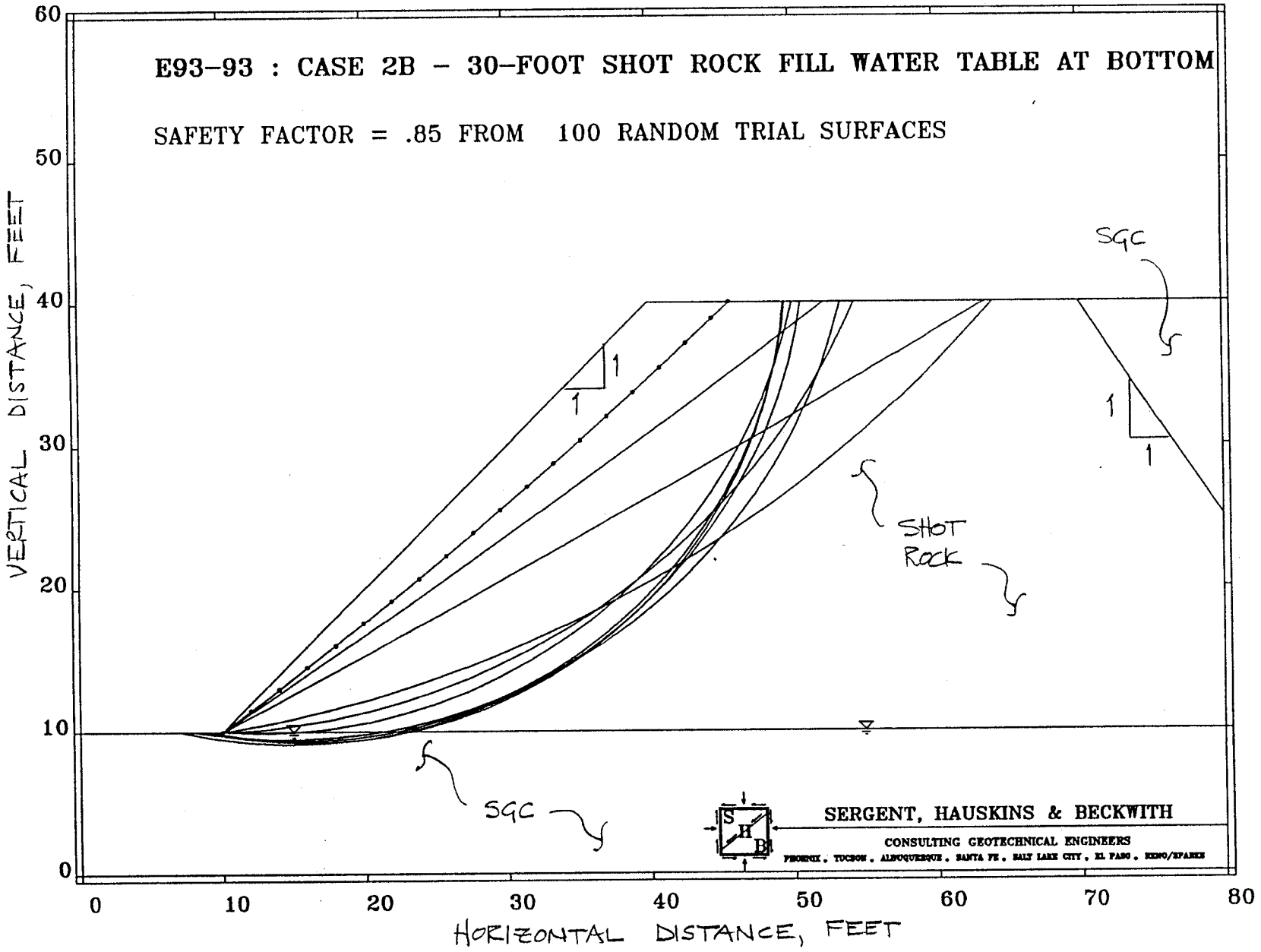
E93-93 : CASE 2B - 30-FOOT SHOT ROCK FILL WATER TABLE AT BOTTOM
SAFETY FACTOR = .85 FROM 100 RANDOM TRIAL SURFACES
VERTICAL DISTANCE, FEET
HORIZONTAL DISTANCE, FEET
0
10
20
30
40
50
60
70
80
1
1
SGC
SHOT ROCK
SGC
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