Hole No.CB-CUL-15

DRILLING LOG | DIVISION: South Atlantic | INSTALLATION: Jacksonville District | SHEET 1 OF 3

1. PROJECT: Rio Culebrinas Project, Aguadilla, P.R.
2. LOCATION (Coordinates or Station): X=243,605 Y=204,360
3. DRILLING AGENCY: GEO CIM, INC.
4. HOLE NO. (As shown on drawing title and file number): CB-CUL-15
5. NAME OF DRILLER: Evaristo Santiago
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN: 49.5 Ft.
8. DEPTH DRILLED INTO ROCK: 0 Ft.
9. TOTAL DEPTH OF HOLE: 49.5 Ft.
10. SIZE AND TYPE OF BIT: See Remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 34 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES: 1
15. ELEVATION GROUND WATER: N/A
16. DATE HOLE STARTED COMPLETED: 06/23/98 06/25/98
17. ELEVATION TOP OF HOLE: 112.76 Ft.
18. TOTAL CORE RECOVERY FOR BORING: 49.3 %
19. SIGNATURE OF ENGINEER: Jorge R. Parra, P.E.

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5'
112.8	0.0					112.8	
			Limestone Formation, (Wackestone), slightly weathered, moderately hard to hard, moderately strong, reddish brown to brown to pink; some recrystallization and trace red clay. (GW)	72.2	1	SPLIT SPOON	29 33 50
111.3	1.5					111.3	
			Sampled as CLAYEY GRAVEL thoroughly weathered limestone fragments, hard, brown. (GC)	72.2	2	SPLIT SPOON	33 28 35
			-as above.			109.8	
				77.8	3	SPLIT SPOON	13 13 34
108.3	4.5					108.3	
			-hard rock encountered, refusal to penetration of the split spoon sampler	0	4	SPLIT SPOON	50/0
			-as above			107.3	
			-as above	0	5	SPLIT SPOON	50/0
						106.3	
				0	6	SPLIT SPOON	50/0
105.3	7.5					105.3	
			Limestone (Packstone), hard, strong to moderately strong, slightly weathered, brown to pink, some recrystallization. (GW)	16.7	7	SPLIT SPOON	50/3
103.8	9.0					103.8	
			Limestone (Grainstone), hard to moderately hard, moderately strong, slightly to moderately weathered, brown to pink. (GW)	22.2	8	SPLIT SPOON	50/5
102.3	10.5					102.3	
			Limestone sampled as calcareous SILT with some limestone fragments, hard, pale brown. (MH)	33.3	9	SPLIT SPOON	63/6
100.8	12.0					100.8	
			Limestone (Packstone), sampled as Silty-Clayey Sand and Gravel, moderately hard, moderately strong, moderately weathered, pale brown. (SC-SM)	22.2	10	SPLIT SPOON	50/4
			-as above.			99.3	
			-brown to pink.	16.7	11	SPLIT SPOON	50/4
						97.8	
				16.7	12	SPLIT SPOON	50/5
			-little calcareous silt and trace clay.			96.3	
				27.8	13	SPLIT SPOON	50/5
			-some calcareous silt.			94.8	
				22.2	14	SPLIT SPOON	50/5
93.3	19.5					93.3	
			Sampled as Calcareous SILT with some highly weathered limestone fragments, hard, very pale brown. (ML)	94.4	15	SPLIT SPOON	15 28 28
			-trace clay.			91.8	
				94.4	16	SPLIT SPOON	15 22 16
						90.3	
						(continued)	

0 | 2.5 | 5 | 7.5 | 10 | 12.5 | 15 | 17.5 | 20 | 22.5

Hole No.CB-CUL-15

DRILLING LOG (Cont. Sheet)

ELEVATION TOP OF HOLE: 112.76 Ft.

PROJECT: Rio Culebrinas Project, Aguadilla, P.R.

INSTALLATION: Jacksonville District

ELEV.	DEPTH	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5'
90.3	22.5	~~as above.~~			90.3	
			33.3	17	SPLIT SPOON	50/6
					88.8	
		-little brown clay, limestone fragments are slightly weathered and hard.	61.1	18	SPLIT SPOON	50/6
					87.3	
		-as above.	83.3	19	SPLIT SPOON	19 20 30
					85.8	
		-limestone fragments are moderately weathered.	83.3	20	SPLIT SPOON	26 26 30
84.3	28.5				84.3	
		Thoroughly weathered limestone sampled as calcareous silty Sand and Gravel, hard, pink to brown. (SM)	33.3	21	SPLIT SPOON	50/6
					82.8	
		-highly to moderately weathered.	27.8	22	SPLIT SPOON	50/5
					81.3	
		-thoroughtly weathered.	22.2	23	SPLIT SPOON	50/4
					79.8	
		-as above.	27.8	24	SPLIT SPOON	50/6
78.3	34.5				78.3	
		Sampled as CLAY with some hard limestone fragments, hard, brown. (CL)	94.4	25	SPLIT SPOON	16 30 29
76.8	36.0				76.8	
		Thoroughly to highly weathered limestone (packstone), sampled as calcareous SILT with some moderately hard limestone fragments, hard, brown. (ML)	83.3	26	SPLIT SPOON	25 31 40
75.3	37.5				75.3	
		Sampled as CLAY with some hard limestone fragments, hard, brown. (CH)	33.3	27	SPLIT SPOON	50/6
73.8	39.0				73.8	
		Thoroughly weathered limestone (Packstone) sampled as calcareous SILT with little limestone fragments, hard, very pale brown. (ML)	94.4	28	SPLIT SPOON	16 22 35
72.3	40.5				72.3	
		Limestone (Packstone) with some clay, moderately hard, moderately weathered, weak, brown. (GC)	5.6	29	SPLIT SPOON	50/6
70.8	42.0				70.8	
		Thoroughly weathered limestone (Packstone) sampled as calcareous SILTY GRAVEL, hard, very pale brown. (GM)	83.3	30	SPLIT SPOON	32 50/6
					69.3	
		-little limestone fragments.	100	31	SPLIT SPOON	29 30 35
		-highly weathered.			67.8	
			77.8	32	SPLIT SPOON	23 50/6
		-thoroughly weathered.			66.3	
			94.4	33	SPLIT SPOON	14 20 26
		-some clay.			64.8	
			50	34	SPLIT SPOON	20 20 40
63.3	49.5				63.3	
		END OF BORING CB-CUL-15 AT 49.5 FEET DEPTH.			*(continued)*	

22.5 25 27.5 30 32.5 35 37.5 40 42.5 45 47.5 50

Hole No.CB-CUL-15

DRILLING LOG (Cont. Sheet)

ELEVATION TOP OF HOLE 112.76 Ft.

SHEET 3 OF 3

PROJECT: Rio Culebrinas Project, Aguadilla, P.R.

INSTALLATION: Jacksonville District

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/ .5'

NOTES:

Soils are field visually classified in accordance with the Unified Soils Classification System.

140# Hammer with 30" drop used on 2.0 foot split spoon (1-3/8" I.D. x 2" O.D.)

X and Y Coordinates are given in feet.

Sample No.	Moisture Content%	Spec. Gravity	Att. Limits L.L.	P.I.
3	14.0	2.80	38.7	23.9
12	13.1	2.69	15.5	3.3
23	13.8	2.68	--	--
30	14.3	2.79	--	--

50
52.5
55
57.5
60
62.5
65
67.5
70
72.5
75
77.5

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT: Rio Culebrinas Project, Aguadilla, P.R.

HOLE NUMBER: CB-CUL-15

TEST PIT LOGS

Hole No.TP-CUL-01

DRILLING LOG

DIVISION: South Atlantic

INSTALLATION: Jacksonville District

SHEET 1 OF 1

1. PROJECT: Rio Culebrinas Project, Aguadilla, P.R.
2. LOCATION (Coordinates or Station): X=243,609 Y=204,370
3. DRILLING AGENCY: GEO CIM, INC.
4. HOLE NO. (As shown on drawing title and file number): TP-CUL-01
5. NAME OF DRILLER: Evaristo Santiago
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN: 4.5 Ft.
8. DEPTH DRILLED INTO ROCK: 0 Ft.
9. TOTAL DEPTH OF HOLE: 4.5 Ft.
10. SIZE AND TYPE OF BIT: See Remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: John Deere 310-digger
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 1 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES: 1
15. ELEVATION GROUND WATER: N/A
16. DATE HOLE STARTED COMPLETED: 06/24/98 06/24/98
17. ELEVATION TOP OF HOLE: 112.64 Ft.
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF ENGINEER: Jorge R. Parra, P.E.

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel
112.6	0.0					112.6
			Limestone Formation sampled as Crystalline Limestone, gravel-sized, some clay, little sand, hard, moderately strong, lightly to moderatley weathered, intensely to closely fractured, brown; large amount of cavities filled with clay. (GC)		1	BACKHOE
108.1	4.5					108.1
			END OF TEST PIT TP-CUL-01 AT 4.5 FEET DEPTH.			

NOTES:

Soils are field visually classified in accordance with the Unified Soils Classification System.

Backhoe could not penetrate deeper than 4'6" due to the presence of very hard and very strong cristalline limestone unit.

X and Y Coordinates are given in feet.

Sample No.	Moisture Content%	Spec. Gravity	Att. Limits L.L.	P.I.
1	17.9	2.74	63.6	43.6

Sample No.	Max. Dry Density (pcf)	Opt. Moisture Content
1	111.9	15.2%

0 2.5 5 7.5 10 12.5 15 17.5 20 22.5

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT: Rio Culebrinas Project, Aguadilla, P.R.

HOLE NUMBER: TP-CUL-01

Prepared by: C. Santoni Reviewed by: R. Davila Date: 11/13/97

GEO CIM, INC.

GEOTECHNICAL TESTING SERVICES

LABORATORY TEST DATA SUMMARY TABLE

PROJECT: Rio Culebrinas Project **LOCATION:** San Juan, P.R. **JOB NO.:** 2174-98

SAMPLE IDENTIFICATION			INDEX PROPERTIES TESTS									ENGINEERING PROPERTY TESTS											REMARKS
			ATTERBERG LIMITS			GRAIN SIZE									STRENGTH					CONSOLIDATION			
																				INITIAL COND			
BORING NO	SAMPLE NO.	DEPTH (ft)	Liquid Limit	Plastic Limit	Plasticity Index	Gravel %	Sand %	Silt %	Clay %	USCS CLASIFICATION	SPECIFIC GRAVITY	ORGANIC CONTENT %	WATER CONTENT %	TOTAL UNIT WEIGHT (pcf)	TORVANE Su (tsf)	POCKET PENETRO-METER q (tsf)	Type Test	PEAK DEVIATOR STRESS (tsf)	AXIAL STRAIN @ PEAK STRESS %	VOID RATIO	SATURA-TION %	Est.max. Past Pressure (tsf)	
CB-CUL-1	2-A	1.5-3.0	50.0	25.0	24.9		51.5	48.5		SC	2.71		33.4										
	6-A	7.5-9.0					93.2	6.8		SP-SM	2.77		32.4										
CB-CUL-2	5-A	6.0-7.5					98.9	1.2		SP	2.73		27.7										
CB-CUL-3	2-A	1.5-3.0	47.8	22.9	24.9		49.5	50.5		CL	2.86		37.9										
	5-A	6.0-7.5				30.5	61.9	7.6		SW-SM	2.72		18.1										
	10-A	13.5-15.0				13.6	69.1	17.3		SM	2.72		19.9										
CB-CUL-4	2-A	1.5-3.0	73.0	40.7	32.3		19.9	80.1		MH	2.78		46.9										
	5-A	6.0-7.5	87.0	44.7	42.3	0.1	11.2	88.7		MH	2.70		66.3										
CB-CUL-5	2-A	1.5-3.0	76.0	34.0	41.9		14.8	85.2		CH	2.77		38.5										
	7-A	9.0-10.5	61.6	39.8	21.8		26.0	74.0		MH	2.68		53.2										
CB-CUL-6	5-A	6.0-7.5	92.6	29.9	62.7		1.3	98.7		CH	2.69		58.1										
	7-A	9.0-10.5	73.0	42.7	30.3		8.8	91.2		MH	2.71		55.7										
CB-CUL-7	3-A	3.0-4.5	33.8	13.0	20.8	19.3	41.9	38.8		SC	2.72		20.3										
	5-A	6.0-7.5	87.0	29.8	57.2	0.3	6.9	92.8		CH	2.78		60.0										
	6-A	7.5-9.0	86.0	68.2	17.8		32.8	67.2		MH	2.60		90.5										
	8-A	10.5-12.0	60.0	45.8	14.2		20.8	79.2		MH	2.73		74.5										
	10-A	13.5-15.0	62.8	34.5	28.3		19.9	80.1		MH	2.74		51.2										
CB-CUL-8	2-A	1.5-3.0	61.9	28.4	33.5		25.7	74.3		CH	2.79		31.9										
	8-A	10.5-12.0				41.3	50.0	8.7		SP-SM	2.77		15.7										
CB-CUL-9	7-A	9.0-10.5				22.2	73.3	4.5		SP	2.70		17.3										
CB-CUL-10	2-A	1.5-3.0	19.1	16.2	2.9		82.5	17.5		SM	2.69		12.1										
	8-A	10.5-12.0				4.2	91.1	4.7		SP	2.69		25.4										
CB-CUL-11	8-A	10.5-12.0				18.6	74.3	7.1		SP-SM	2.74		14.5										

Amelia Distribution Center - Lot 26-A EmmaStreet - Guaynabo, PR 00968 - *Tel. (787) 792-2626 - *Fax. (787) 782-5990

GEO CIM, INC.

GEOTECHNICAL TESTING SERVICES

LABORATORY TEST DATA SUMMARY TABLE

PROJECT: Rio Culebrinas Project **LOCATION:** San Juan, P.R. **JOB NO.:** 2174-98

SAMPLE IDENTIFICATION			INDEX PROPERTIES TESTS									ENGINEERING PROPERTY TESTS											REMARKS
			ATTERBERG LIMITS			GRAIN SIZE									STRENGTH					CONSOLIDATION			
																				INITIAL COND			
BORING NO.	SAMPLE NO.	DEPTH (ft)	Liquid Limit	Plastic Limit	Plasticity Index	Gravel %	Sand %	Silt %	Clay %	USCS CLASIFICATION	SPECIFIC GRAVITY	ORGANIC CONTENT %	WATER CONTENT %	TOTAL UNIT WEIGHT (pcf)	TORVANE Su (tsf)	POCKET PENETRO-METER q (tsf)	Type Test	PEAK DEVIATOR STRESS (tsf)	AXIAL STRAIN @ PEAK STRESS %	VOID RATIO	SATURA-TION %	Est.max. Past Pressure (tsf)	
CB-CUL-12	2-A	1.5-3.0	35.5	16.5	19.7		65.4	34.6		SC	2.68		22.3										
	5-A	6.0-7.5	(*)	(*)	(*)	16.6	80.6	2.8		SP	2.70		27.7										
CB-CUL-13	2-A	1.5-3.0	90.0	42.7	47.3	2.0	5.7	92.3		MH	2.58		55.8										
	4-A	4.5-6.0	84.5	48.7	35.8		0.6	99.4		MH	2.64		76.2										
	8-A	10.5-12.0	71.5	36.9	34.6		0.3	99.7		MH	2.72		70.0										
CB-CUL-14	4-A	4.5-6.0	114.5	42.3	72.2		5.9	94.1		CH	2.71		96.6										
	8-A	10.5-12.0	97.9	38.3	59.6		13.7	86.3		CH	2.74		92.0										
CB-CUL-15	3-A	3.0-4.5	38.7	14.8	23.9	42.9	19.7	37.4		GC	2.80		14.0										
	12-A	19.5-21.0	15.5	12.2	3.3	13.6	37.7	48.7		SC-SM	2.69		13.1										
	23-A	36.0-37.6				31.2	31.8	37.0		SM	2.68		13.8										
	30-A	46.5-48.0				45.9	20.7	27.1		GM	2.79		14.3										
TP-CUL-1	1-A	0.0-4.5	63.6	20.0	43.6	53.4	19.5	27.1		GC	2.74		17.9										Max Dry Dens 111.9pcf @ 15.2% OPt Moisture
TP-CUL-2	1-A	0.0-4.16				67.0	17.1	15.9		GM	2.75		4.0										Max Dry Dens 116.3pcf @ 11.3% Opt Moisture
	2-A	4.16-9.5	34.0	14.1	19.9	56.6	18.8	24.6		GC	2.79		20.7										Max Dry Dens 111.7pcf @ 12.3% Opt Moisture

REMARKS: (*) (N/P) Non Plastic

PARTICLE SIZE DISTRIBUTION TEST REPORT

% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	51.5	48.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.6		
#40	88.6		
#100	52.0		
#200	48.5		

* (no specification provided)

Soil Description

Clayey SAND, olive green.

Atterberg Limits

PL= 25.0 LL= 50.0 PI= 24.9

Coefficients

D_{85}= 0.379 D_{60}= 0.198 D_{50}= 0.101
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SC AASHTO=

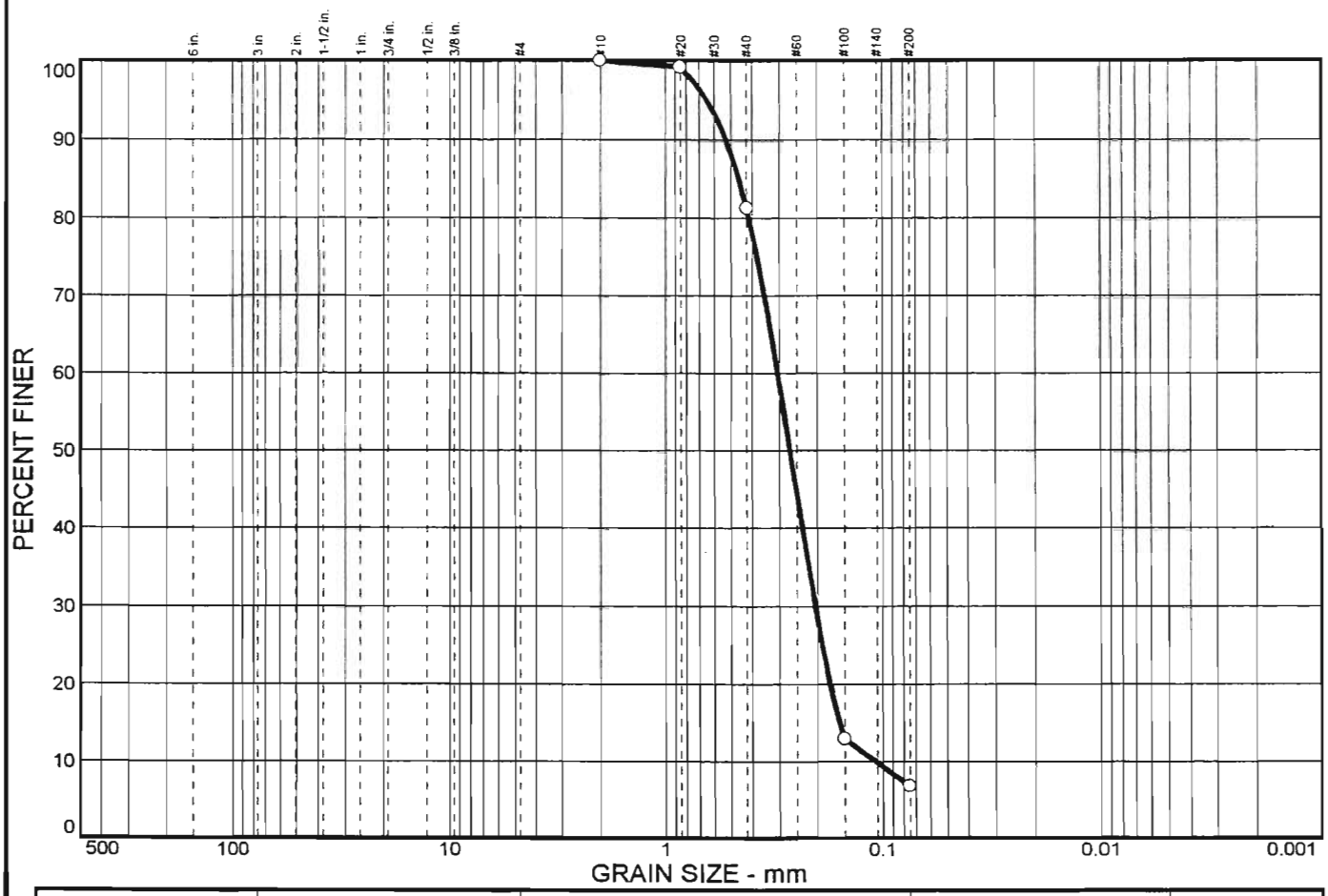
Remarks

Sample No.: 2-A **Source of Sample:** CB-CUL-1 **Date:** 7/13/98
Location: X=248651.1010 Y=212522.8620 **Elev./Depth:** 1.5' @ 3.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	93.2	6.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.2		
#40	81.3		
#100	12.9		
#200	6.8		

* (no specification provided)

Soil Description

SAND, trace silt, dark gray.

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.460 D_{60}= 0.305 D_{50}= 0.268
D_{30}= 0.204 D_{15}= 0.158 D_{10}= 0.108
C_u= 2.83 C_c= 1.26

Classification

USCS= SP-SM AASHTO=

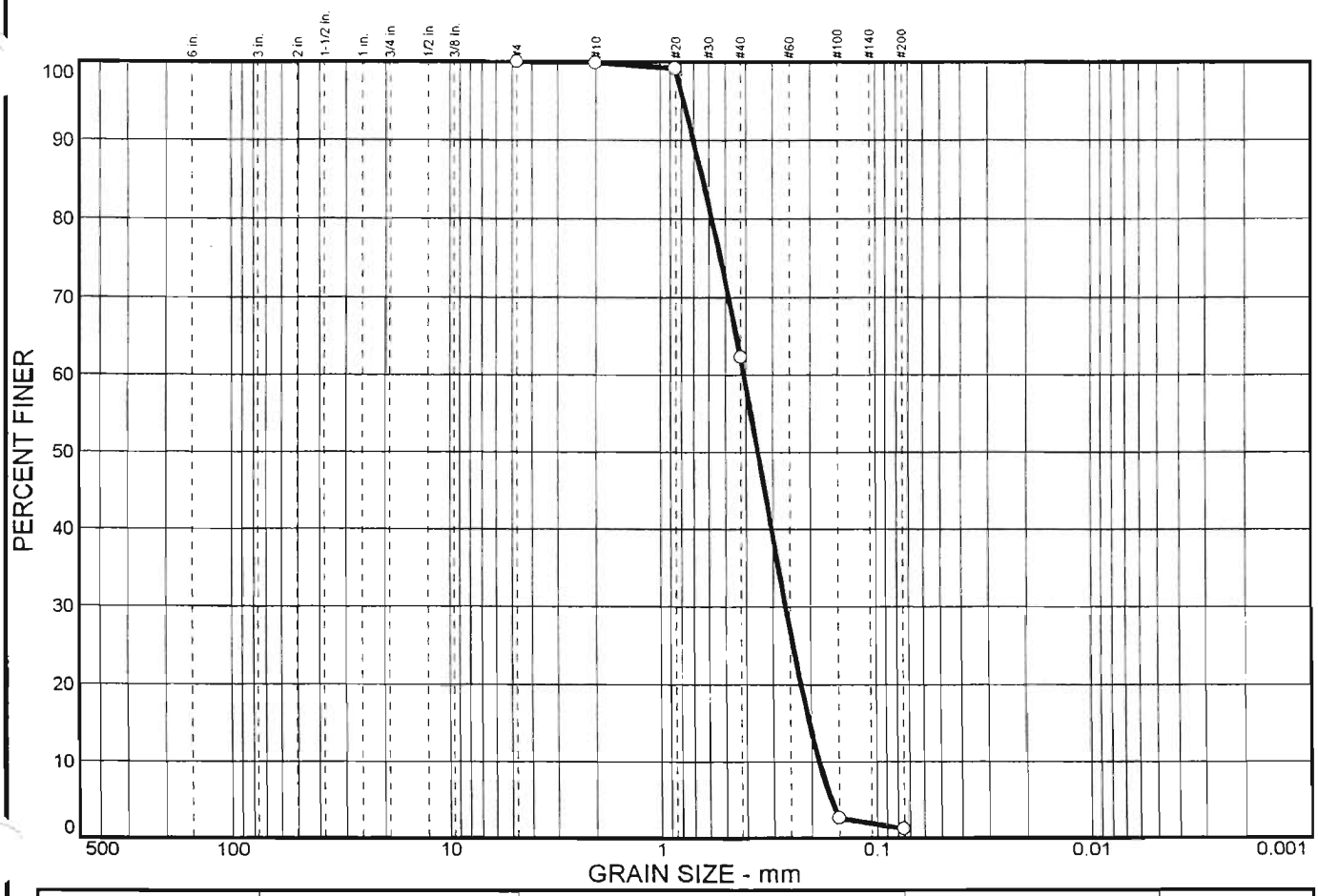
Remarks

Sample No.: 6-A **Source of Sample:** CB-CUL-1 **Date:** 7/13/98
Location: X=248651.1010 Y=212522.8620 **Elev./Depth:** 7.5'@ 9.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	98.8	1.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.9		
#20	99.2		
#40	62.3		
#100	2.6		
#200	1.2		

* (no specification provided)

Soil Description

SAND, trace silt, brown.

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.638 D_{60}= 0.410 D_{50}= 0.352
D_{30}= 0.261 D_{15}= 0.203 D_{10}= 0.183
C_u= 2.23 C_c= 0.91

Classification

USCS= SP AASHTO=

Remarks

Sample No.: 5-A **Source of Sample:** CB-CUL-2 **Date:** 7/13/98
Location: X=248794.8650 Y=211803.9720 **Elev./Depth:** 6.0' @ 7.5'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT

% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	13.6	69.1	17.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.5 in.	92.2		
.375 in.	88.1		
#4	86.4		
#10	82.9		
#20	77.3		
#40	45.8		
#100	18.6		
#200	17.3		

* (no specification provided)

Soil Description

SAND, little clay, and gravel, dark gray to brown.

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 3.41 D_{60}= 0.589 D_{50}= 0.470
D_{30}= 0.269 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SC AASHTO=

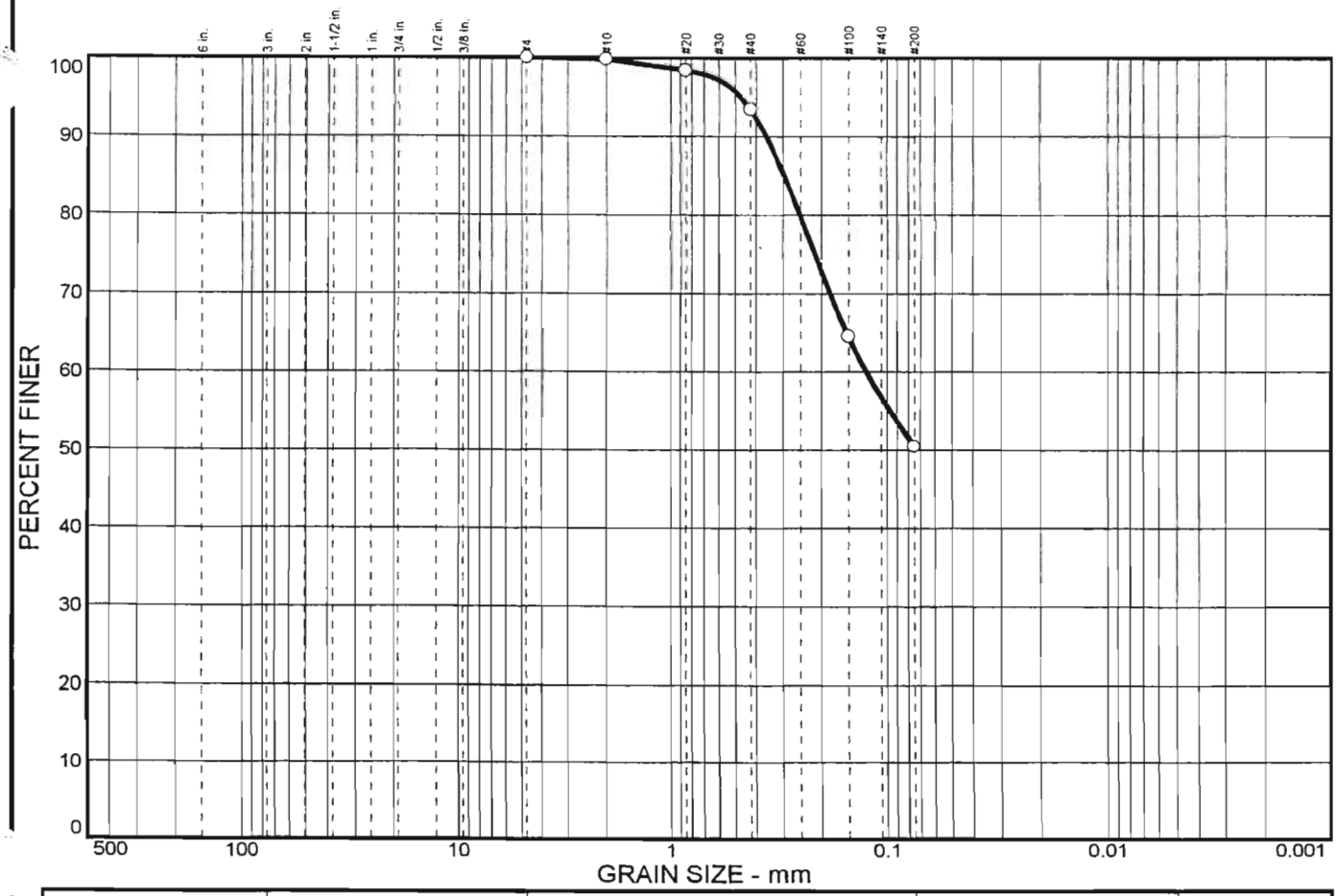
Remarks

Sample No.: 10-A **Source of Sample:** CB-CUL-3 **Date:** 7/13/98
Location: X=248954.5380 Y=211084.4600 **Elev./Depth:** 13.5' @ 15.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	49.5	50.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.8		
#20	98.4		
#40	93.5		
#100	64.6		
#200	50.5		

* (no specification provided)

Soil Description

Sandy CLAY, dark gray to brown.

Atterberg Limits

PL= 22.9 LL= 47.8 PI= 24.9

Coefficients

D_{85}= 0.296 D_{60}= 0.124 D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CL AASHTO=

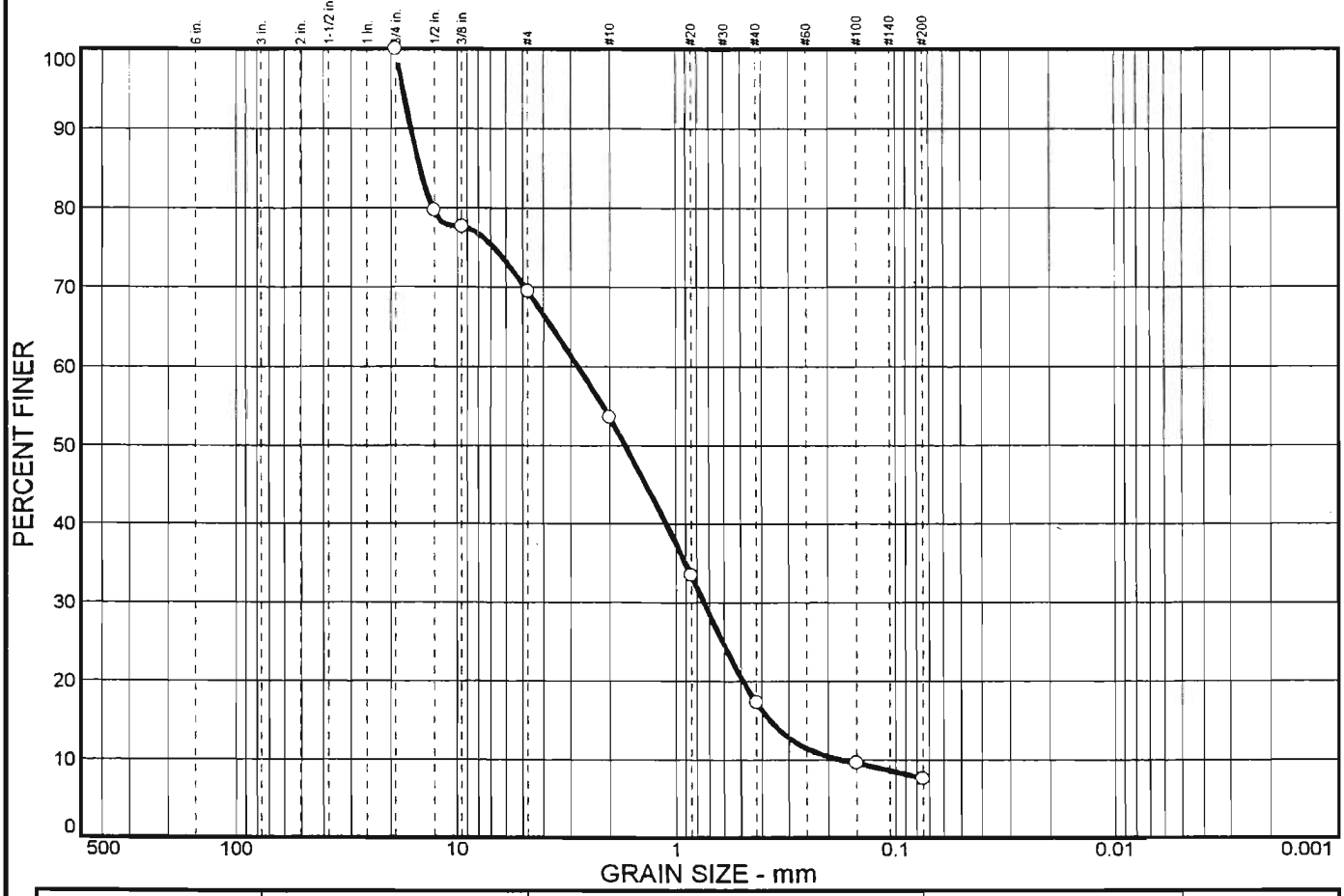
Remarks

Sample No.: 2-A **Source of Sample:** CB-CUL-3 **Date:** 7/13/98
Location: X=248954.5380 Y=211084.4600 **Elev./Depth:** 1.5' @ 3.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	30.5	61.9	7.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.5 in.	79.7		
.375 in.	77.7		
#4	69.5		
#10	53.6		
#20	33.5		
#40	17.3		
#100	9.6		
#200	7.6		

* (no specification provided)

Soil Description

SAND, some gravel, trace silt, dark gray.

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 14.7 D_{60}= 2.77 D_{50}= 1.69
D_{30}= 0.742 D_{15}= 0.365 D_{10}= 0.174
C_u= 15.97 C_c= 1.15

Classification

USCS= SW-SM AASHTO=

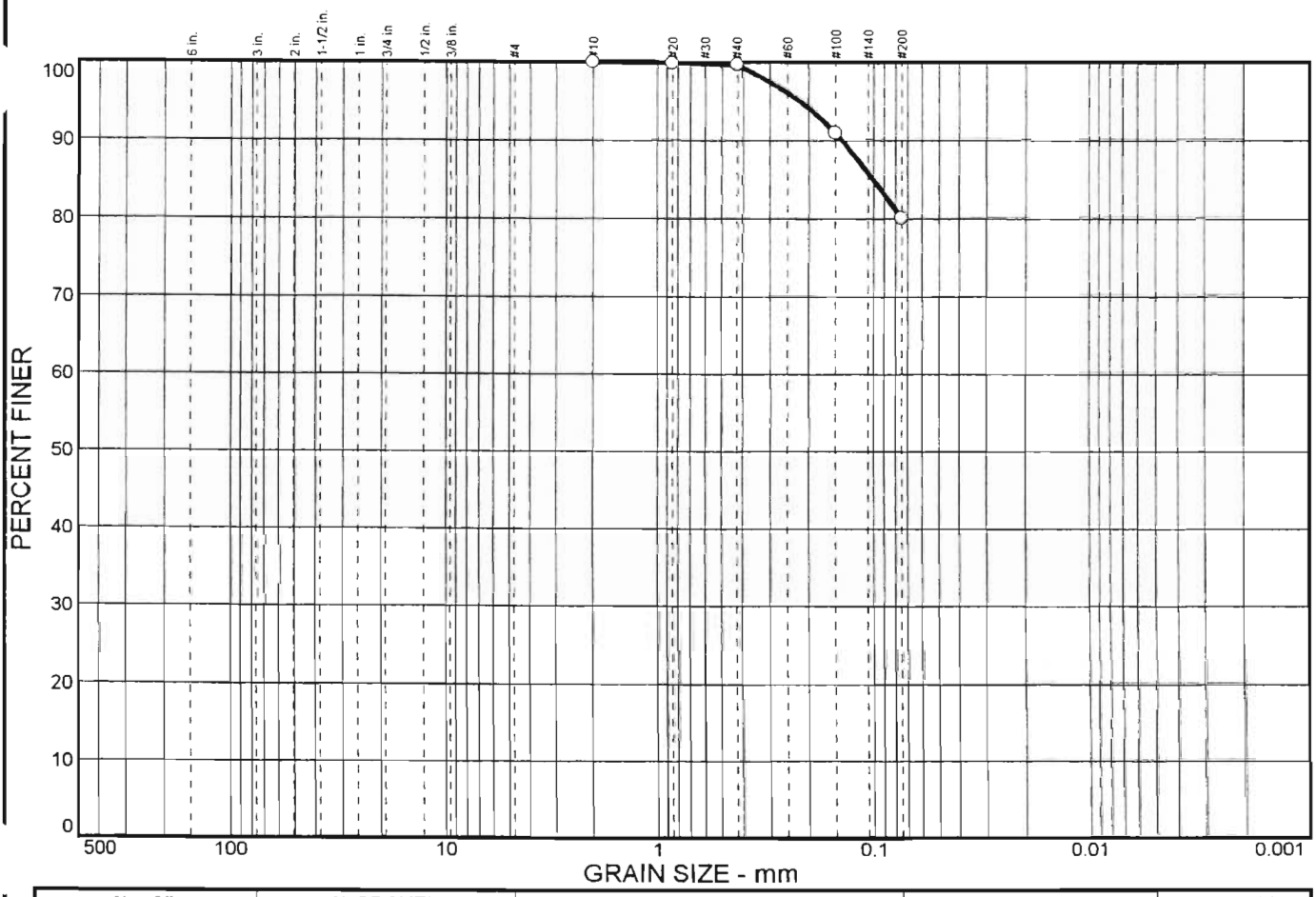
Remarks

Sample No.: 5-A **Source of Sample:** CB-CUL-3 **Date:** 7/13/98
Location: X=248954.5380 Y=211084.4600 **Elev./Depth:** 6.0' @ 7.5'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	19.9	80.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.9		
#40	99.7		
#100	91.0		
#200	80.1		

* (no specification provided)

Soil Description

SILT, little sand, dark gray.

Atterberg Limits

PL= 40.7 LL= 73.0 PI= 32.3

Coefficients

D_{85}= 0.100 D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

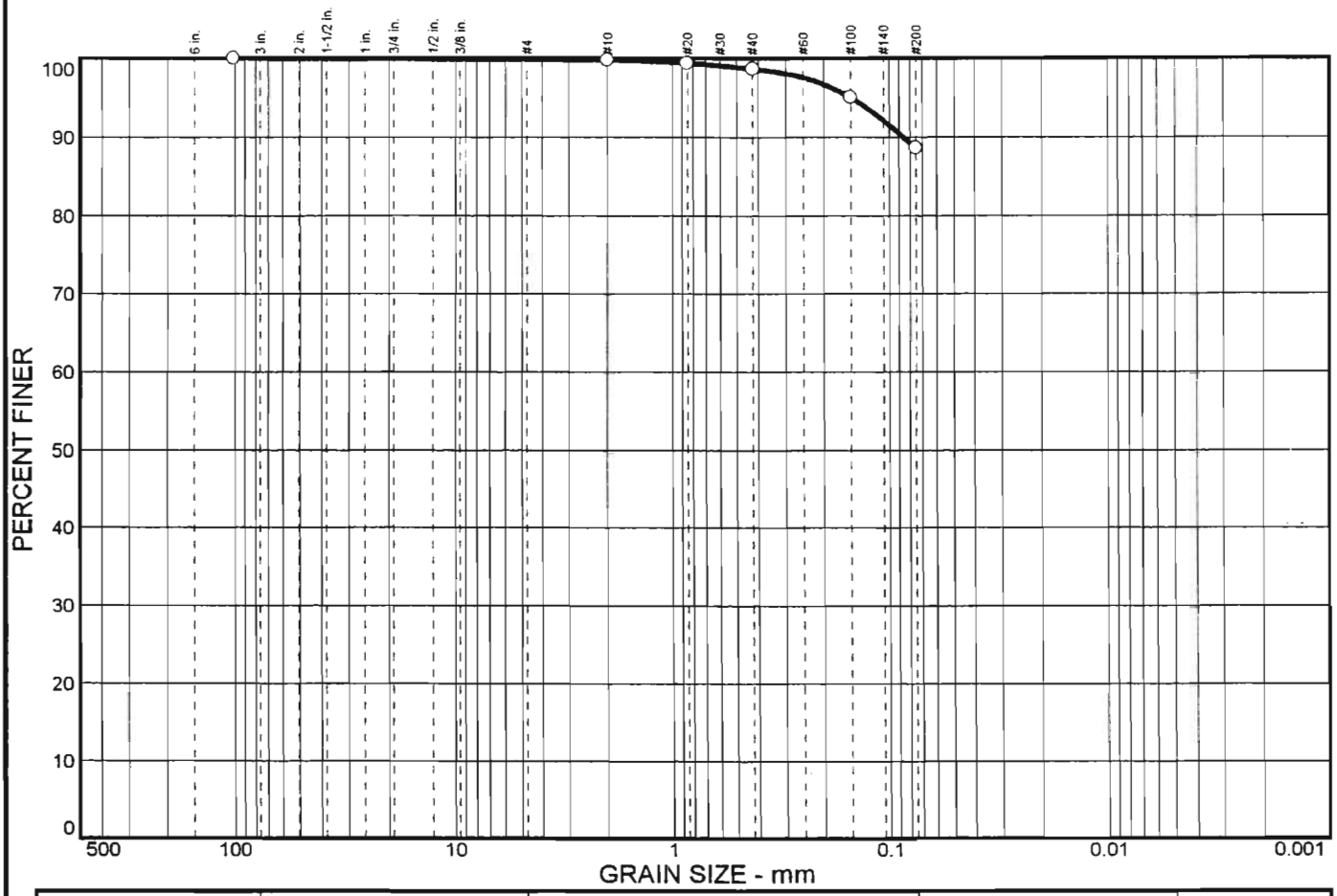
Remarks

Sample No.: 2-A **Source of Sample:** CB-CUL-4 **Date:** 7/13/98
Location: X=248335.6840 Y=210707.2820 **Elev./Depth:** 1.5' @ 3.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.1	11.2	88.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
4 in.	100.0		
#10	99.8		
#20	99.4		
#40	98.7		
#100	95.1		
#200	88.6		

* (no specification provided)

Soil Description

SILT, little sand, trace gravel, dark gray.

Atterberg Limits

PL= 44.7 LL= 87.0 PI= 42.3

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

Remarks

Sample No.: 5-A **Source of Sample:** CB-CUL-4 **Date:** 7/13/98
Location: X=248335.6840 Y=210707.2820 **Elev./Depth:** 6.0' @ 7.5'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT

% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	14.8	85.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.6		
#20	98.7		
#40	97.4		
#100	92.3		
#200	85.2		

* (no specification provided)

Soil Description

CLAY, little sand, brown to dark brown.

Atterberg Limits

PL= 34.0 LL= 76.0 PI= 41.9

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CH AASHTO=

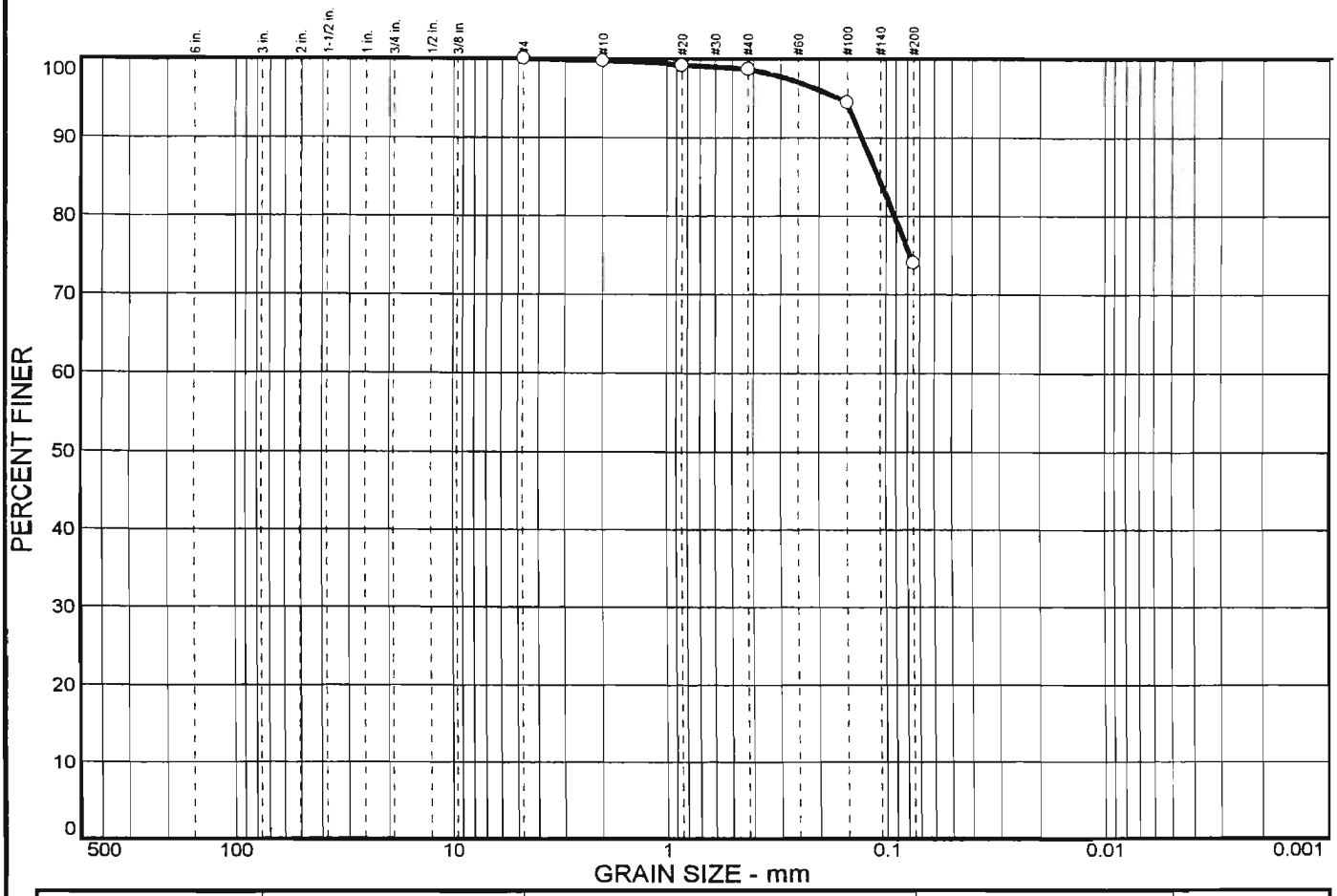
Remarks

Sample No.: 2-A **Source of Sample:** CB-CUL-5 **Date:** 7/9/98
Location: X=249055.4050 Y=210334.2330 **Elev./Depth:** 1.5' @ 3.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	26.0	74.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.7		
#20	99.2		
#40	98.7		
#100	94.5		
#200	74.0		

* (no specification provided)

Soil Description

SILT, some sand, dark gray.

Atterberg Limits

PL= 39.8 LL= 61.6 PI= 21.8

Coefficients

D_{85}= 0.108 D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

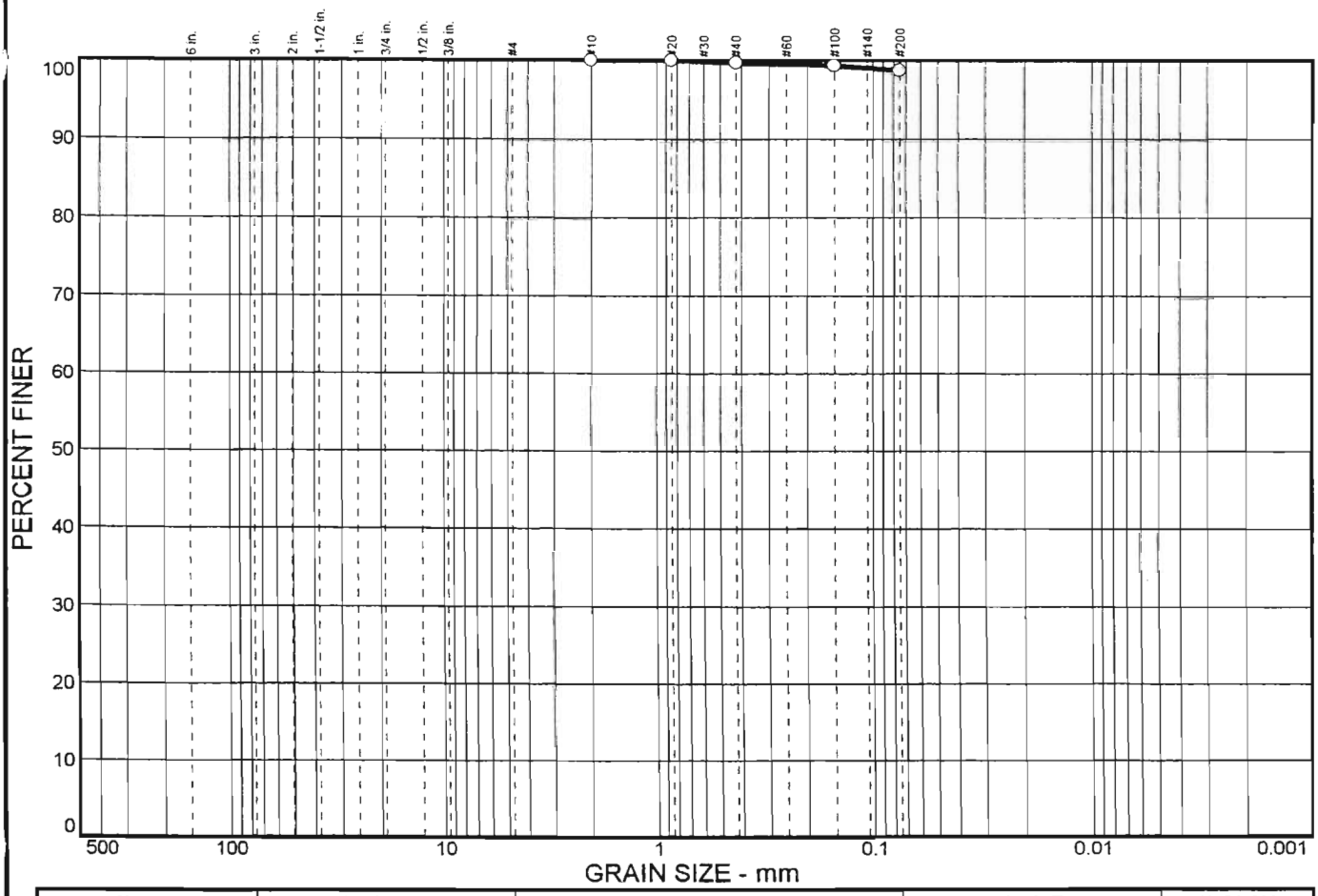
Remarks

Sample No.: 7-A **Source of Sample:** CB-CUL-5 **Date:** 7/9/98
Location: X=249055.4050 Y=210334.2330 **Elev./Depth:** 9.0' @ 10.5'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	1.3	98.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	99.7		
#100	99.3		
#200	98.7		

* (no specification provided)

Soil Description

CLAY, trace sand, gray.

Atterberg Limits

PL= 29.9 LL= 92.6 PI= 62.7

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CH AASHTO=

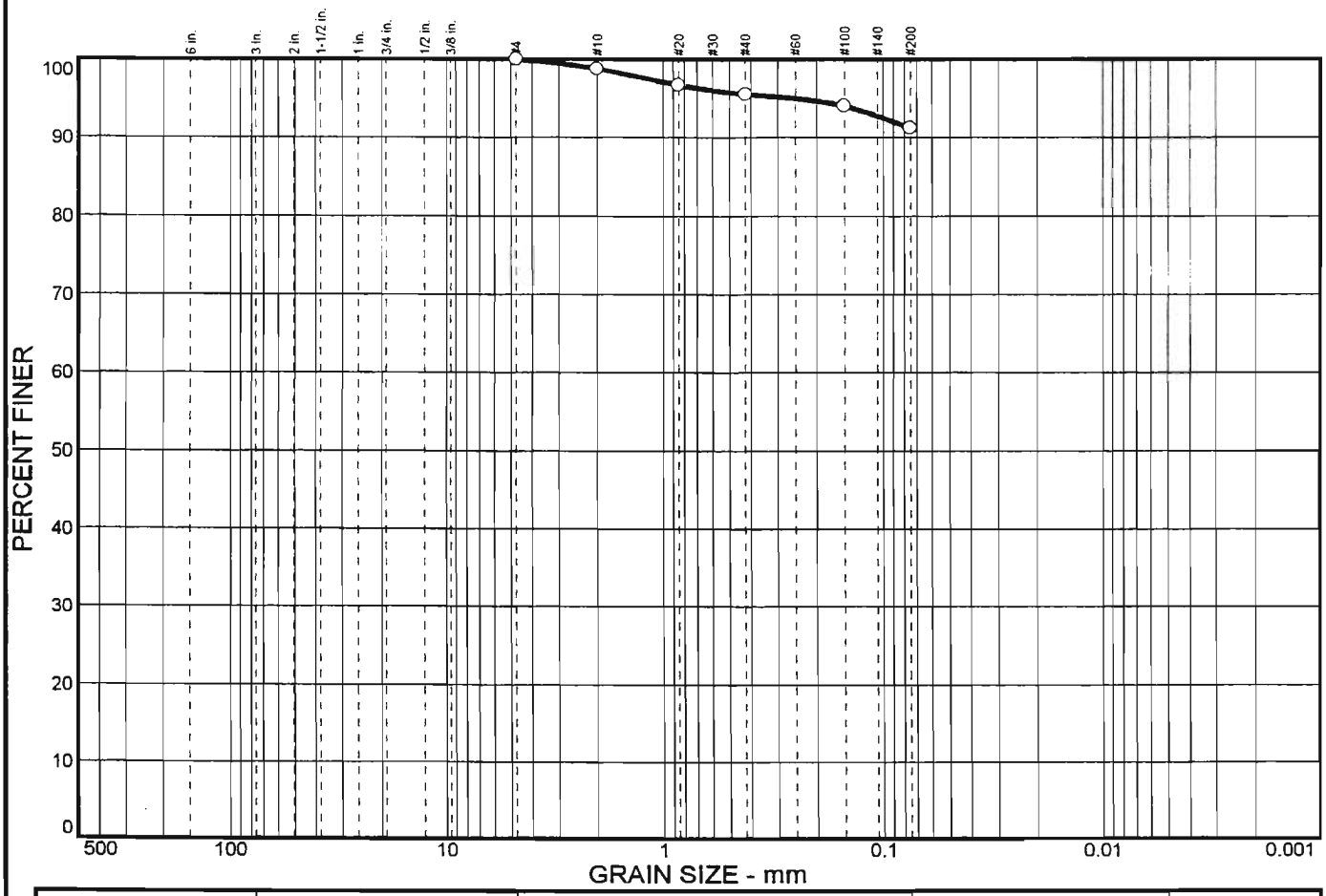
Remarks

Sample No.: 5-A **Source of Sample:** CB-CUL-6 **Date:** 7/9/98
Location: X=249179.6470 Y=209625.8930 **Elev./Depth:** 6.0' @ 7.5'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	8.8	91.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	98.8		
#20	96.7		
#40	95.5		
#100	94.0		
#200	91.2		

* (no specification provided)

Soil Description

SILT, trace sand, gray.

Atterberg Limits

PL= 42.7 LL= 73.0 PI= 30.3

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

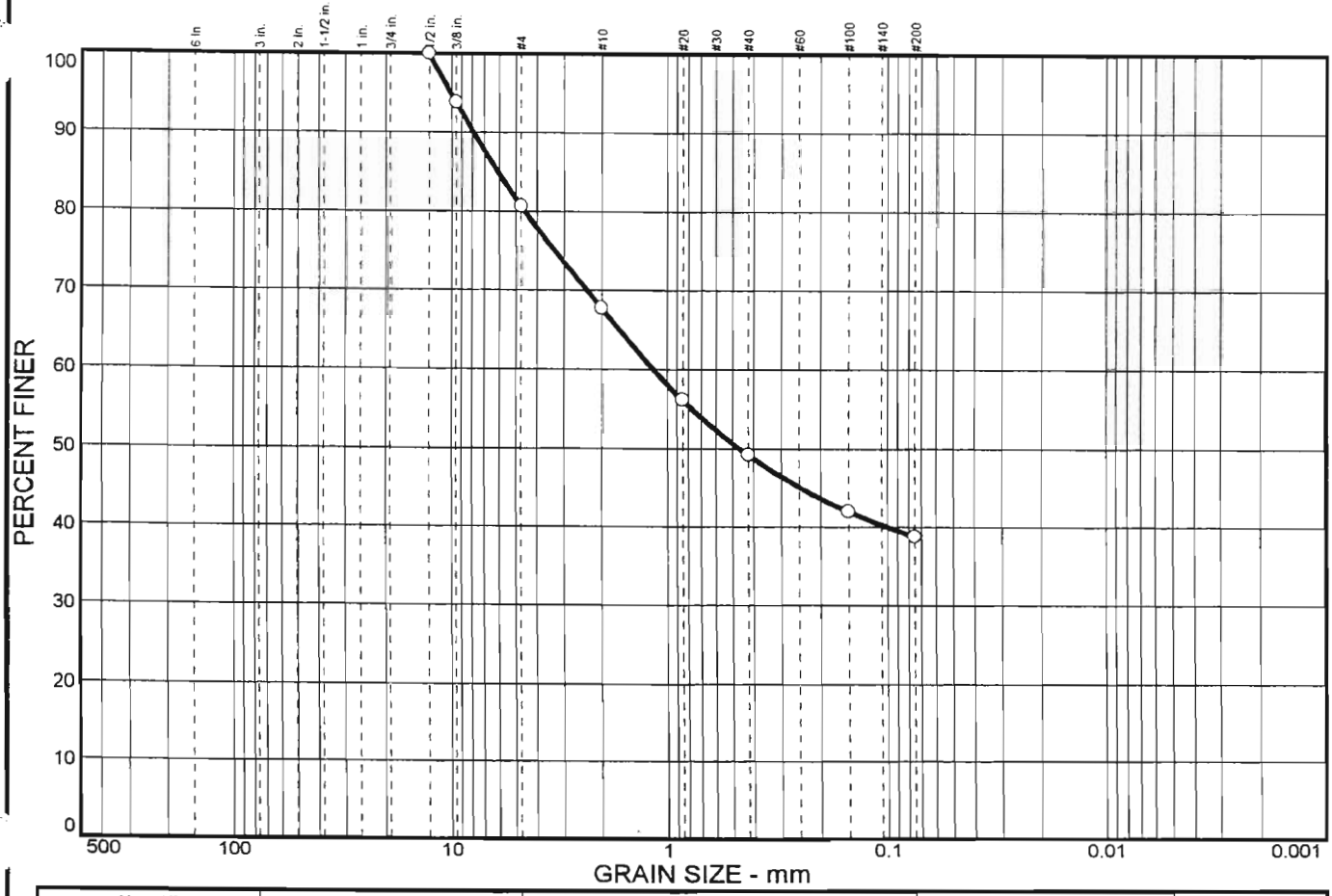
Remarks

Sample No.: 7-A **Source of Sample:** CB-CUL-6 **Date:** 7/9/98
Location: X=249179.6470 Y=209625.8930 **Elev./Depth:** 9.0' @ 10.5'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	19.3	41.9	38.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5 in.	100.0		
.375 in.	93.9		
#4	80.7		
#10	67.8		
#20	56.2		
#40	49.3		
#100	42.0		
#200	38.8		

* (no specification provided)

Soil Description

Clayey SAND, little gravel,pale brown.

Atterberg Limits

PL= 13.0 LL= 33.8 PI= 20.8

Coefficients

D_{85}= 6.06 D_{60}= 1.15 D_{50}= 0.461
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SC AASHTO=

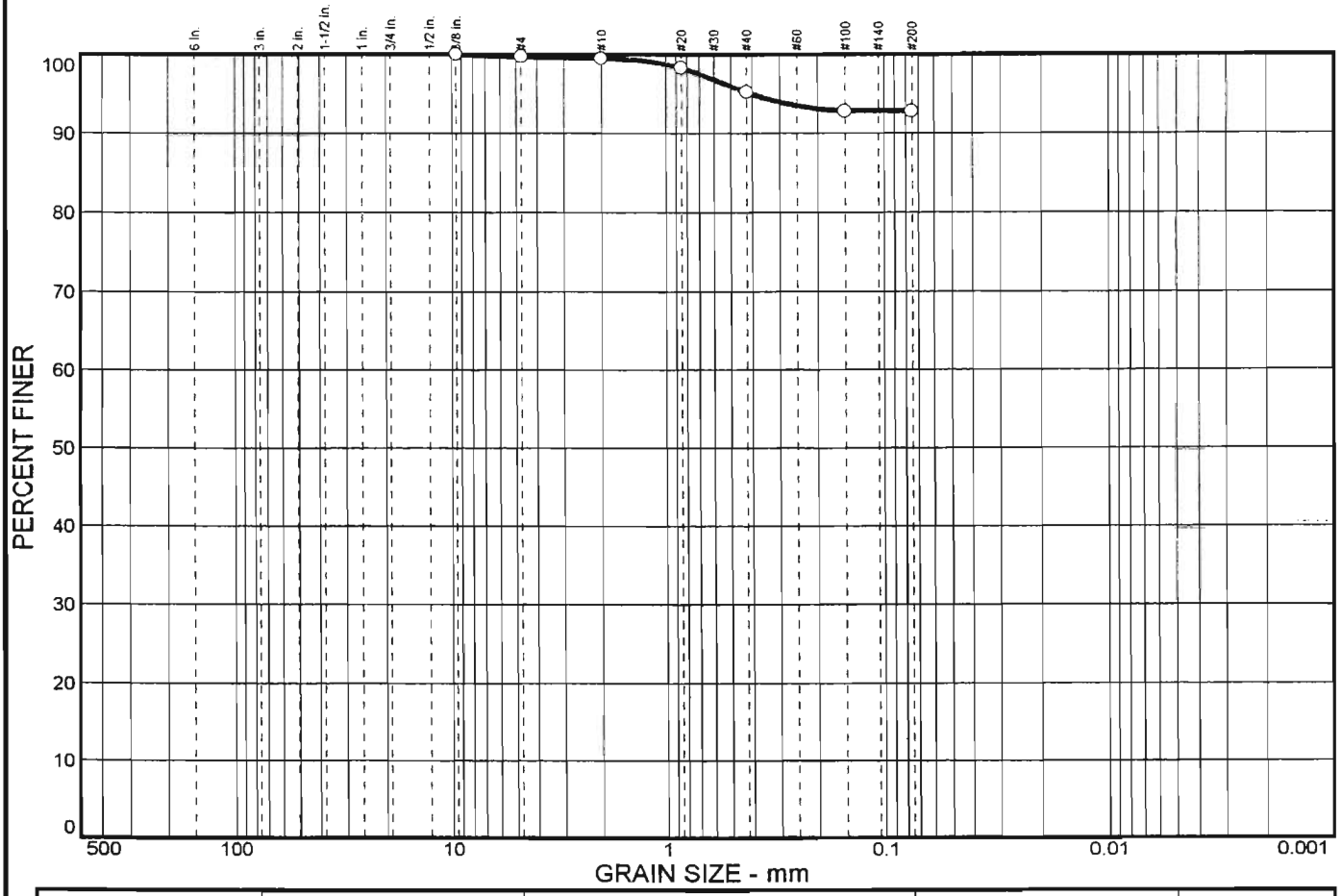
Remarks

Sample No.: 3-A **Source of Sample:** CB-CUL-7 **Date:** 7/16/98
Location: X=249300.8160 Y=208732.9660 **Elev./Depth:** 3.0' @ 4.5'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.3	6.9	92.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375 in.	100.0		
#4	99.7		
#10	99.5		
#20	98.3		
#40	95.2		
#100	92.8		
#200	92.8		

* (no specification provided)

Soil Description

CLAY, trace sand and gravel, dark brown.

Atterberg Limits

PL= 29.8 LL= 87.0 PI= 57.2

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CH AASHTO=

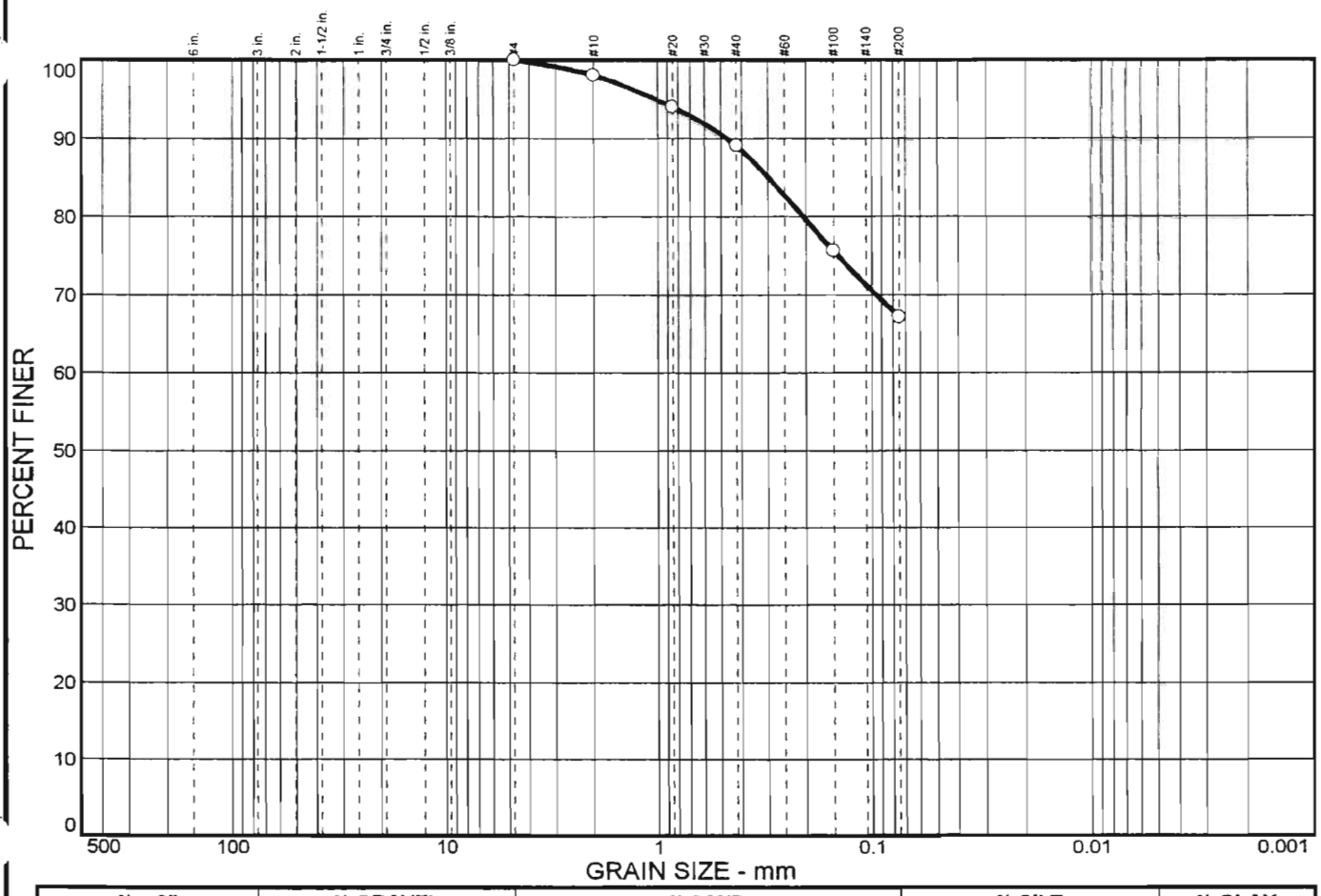
Remarks

Sample No.: 5-A **Source of Sample:** CB-CUL-7 **Date:** 7/13/98
Location: X=249300.8160 Y=208732.9660 **Elev./Depth:** 6.0' @ 7.5'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	32.8	67.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	98.1		
#20	94.0		
#40	89.1		
#100	75.7		
#200	67.2		

* (no specification provided)

Soil Description

SILT, some sand, dark gray.

Atterberg Limits

PL= 68.2 LL= 86.0 PI= 17.8

Coefficients

D_{85}= 0.297 D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

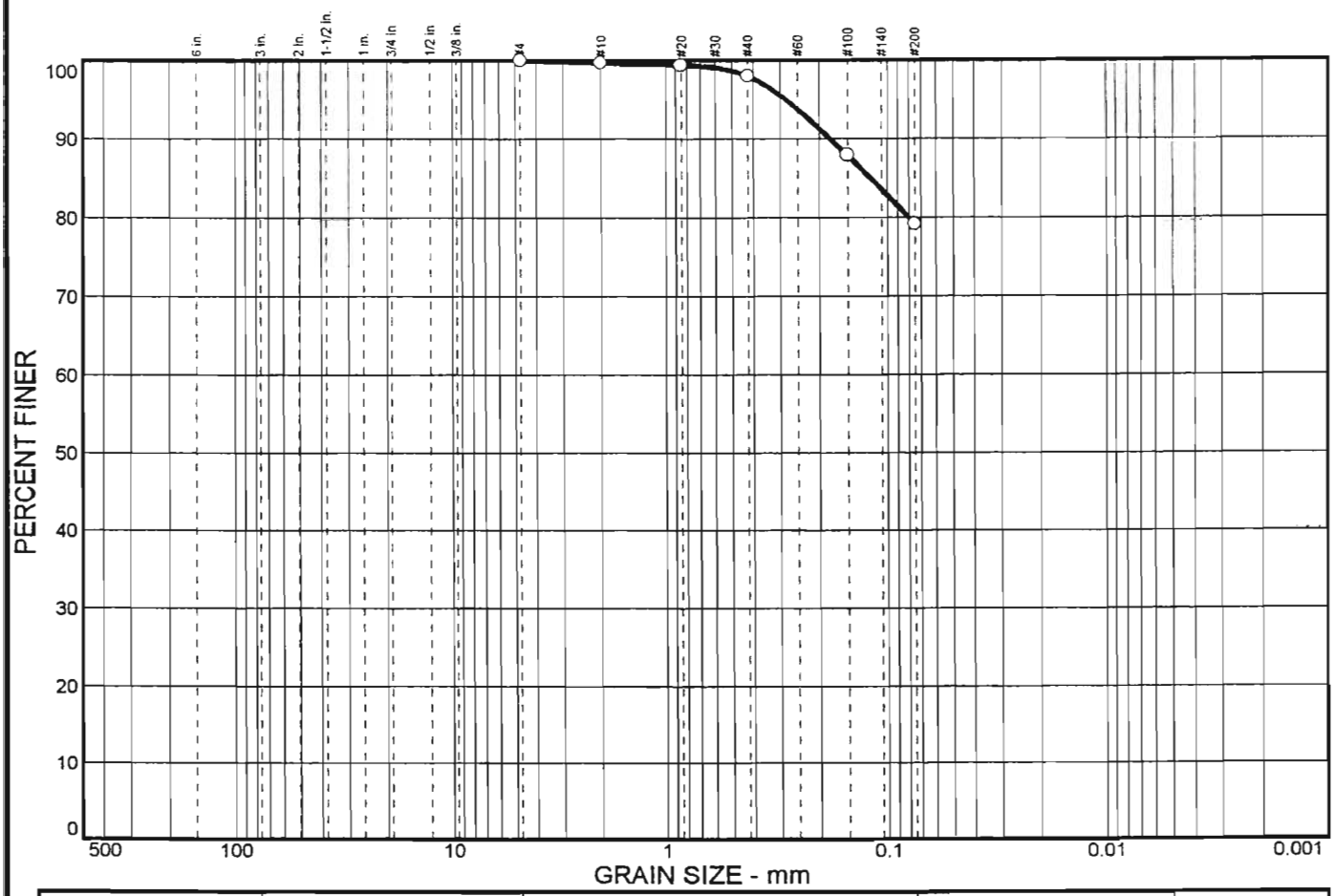
Remarks

Sample No.: 6-A **Source of Sample:** CB-CUL-7 **Date:** 7/13/98
Location: X=249300.8160 Y=208732.9660 **Elev./Depth:** 7.5' @ 9.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	20.8	79.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.7		
#20	99.4		
#40	98.0		
#100	87.9		
#200	79.2		

* (no specification provided)

Soil Description

SILT, some sand, dark gray.

Atterberg Limits

PL= 45.8 LL= 60.0 PI= 14.2

Coefficients

D_{85}= 0.119 D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

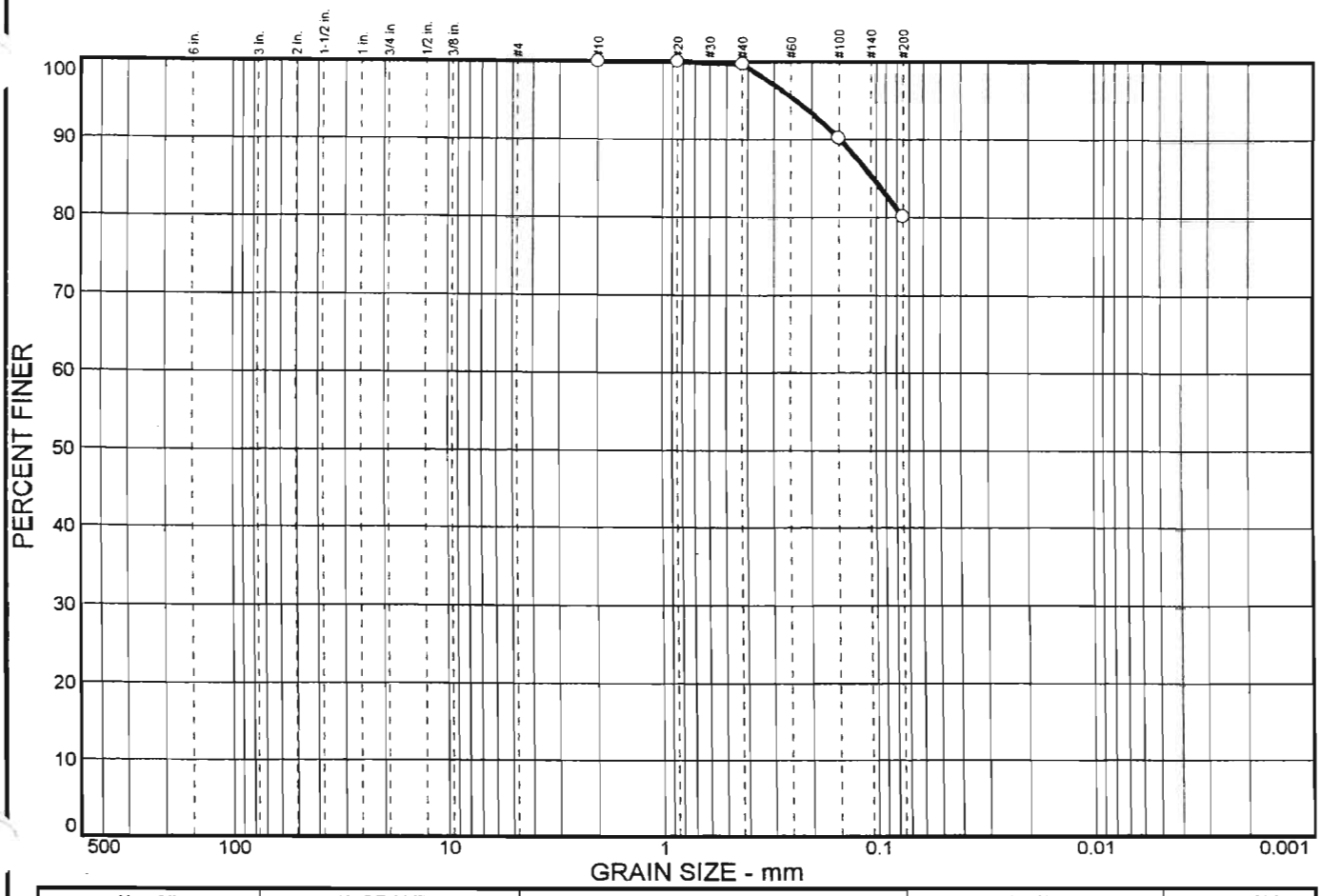
Remarks

Sample No.: 8-A **Source of Sample:** CB-CUL-7 **Date:** 7/14/98
Location: X=249300.8160 Y=208732.9660 **Elev./Depth:** 10.5' @ 12.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	19.9	80.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	99.7		
#100	90.2		
#200	80.1		

* (no specification provided)

Soil Description

SILT, little sand, dark gray.

Atterberg Limits

PL= 34.5 LL= 62.8 PI= 28.3

Coefficients

D_{85}= 0.103 D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

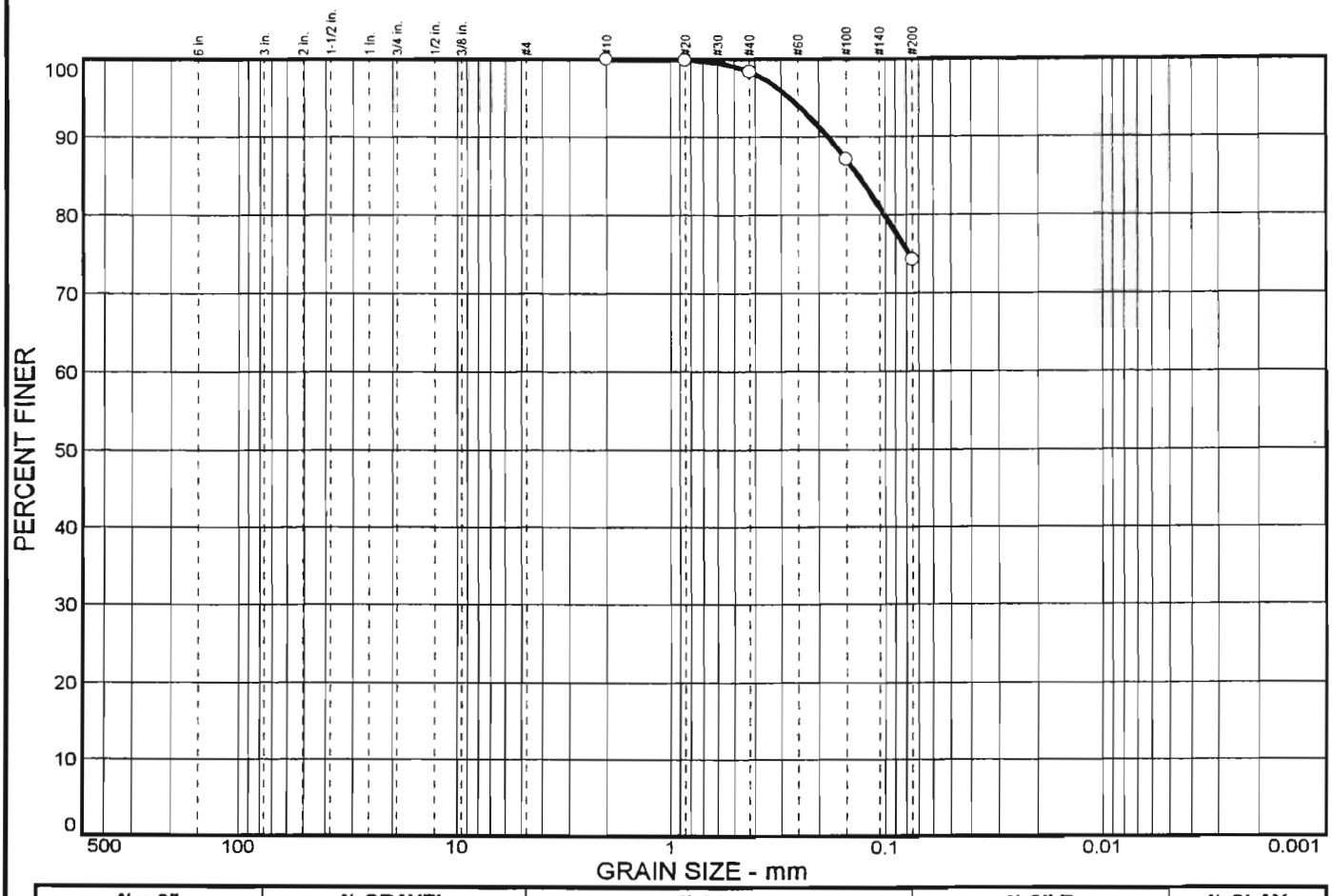
Remarks

Sample No.: 10-A **Source of Sample:** CB-CUL-7 **Date:** 7/13/98
Location: X=249300.8160 Y=208732.9660 **Elev./Depth:** 13.5' @ 14.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	25.7	74.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.9		
#40	98.4		
#100	87.1		
#200	74.3		

* (no specification provided)

Soil Description

CLAY, some sand, dark brown.

Atterberg Limits

PL= 28.4 LL= 61.9 PI= 33.53

Coefficients

D_{85}= 0.132 D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CH AASHTO=

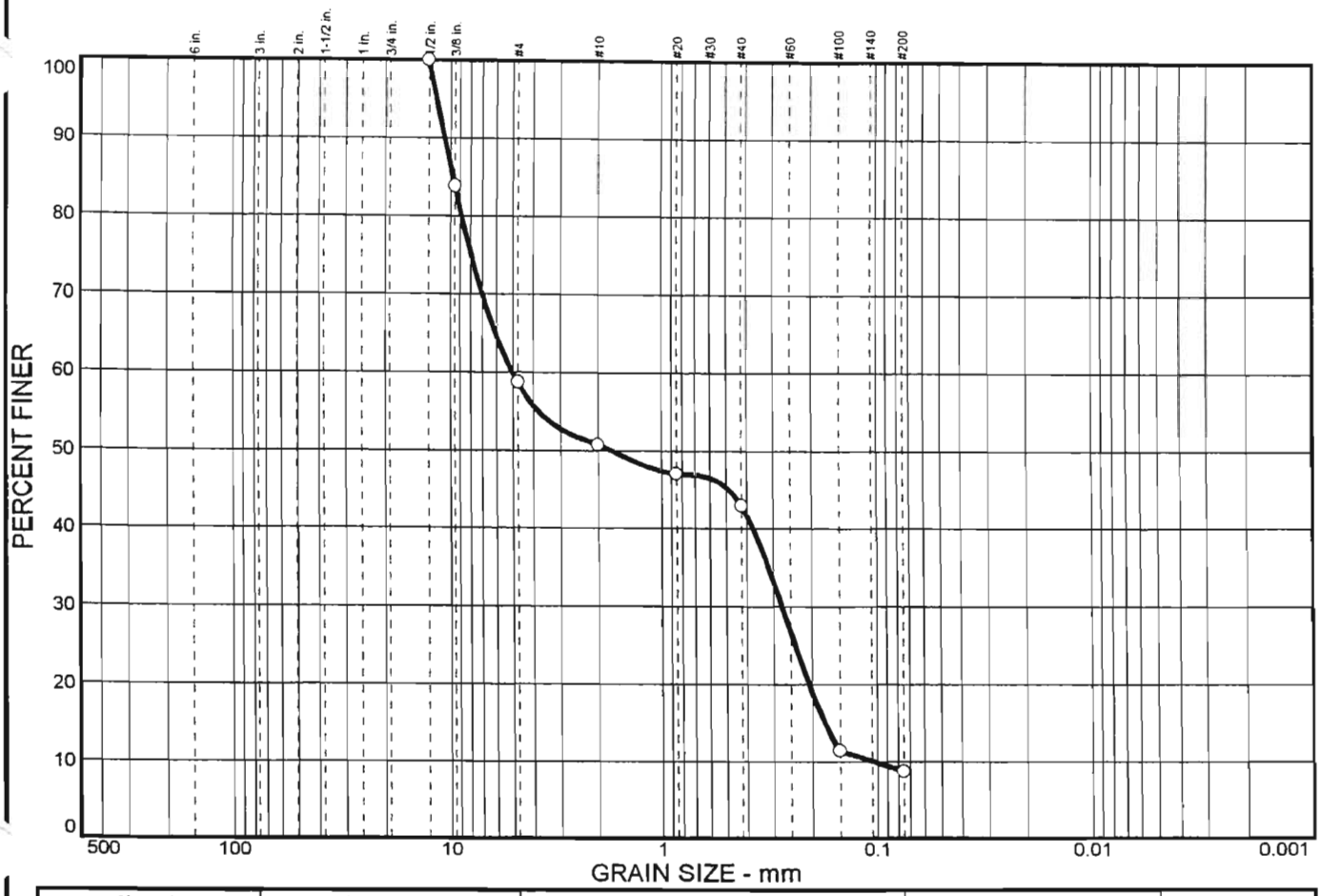
Remarks

Sample No.: 2-A **Source of Sample:** CB-CUL-8 **Date:** 7/13/98
Location: X=249547.2720 Y=207854.5940 **Elev./Depth:** 1.5' @ 3.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	41.3	50.0	8.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5 in.	100.0		
.375 in.	83.8		
#4	58.7		
#10	50.8		
#20	47.1		
#40	43.0		
#100	11.4		
#200	8.7		

* (no specification provided)

Soil Description

Gravelly SAND, trace silt, brown.

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 9.75 D_{60}= 5.04 D_{50}= 1.70
D_{30}= 0.273 D_{15}= 0.175 D_{10}= 0.105
C_u= 48.12 C_c= 0.14

Classification

USCS= SP-SM AASHTO=

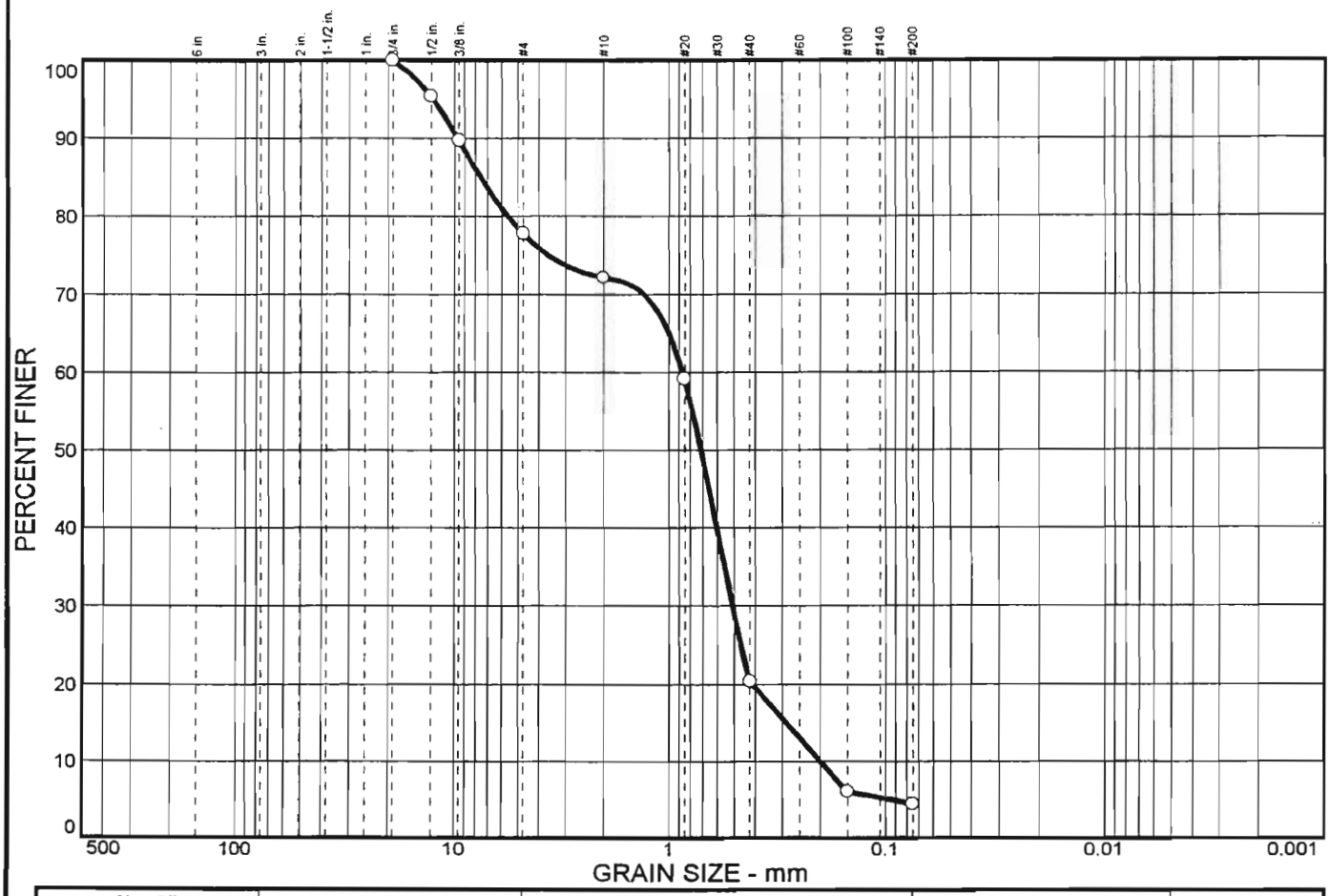
Remarks

Sample No.: 8-A **Source of Sample:** CB-CUL-8 **Date:** 7/13/98
Location: X=249547.2720 Y=207854.5940 **Elev./Depth:** 10.5' @ 12.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	22.2	73.3	4.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.5 in.	95.4		
.375 in.	89.7		
#4	77.8		
#10	72.2		
#20	59.2		
#40	20.4		
#100	6.1		
#200	4.5		

* (no specification provided)

Soil Description

SAND, some gravel, trace silt, brown.

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 7.52 D_{60}= 0.866 D_{50}= 0.710
D_{30}= 0.510 D_{15}= 0.287 D_{10}= 0.199
C_u= 4.35 C_c= 1.51

Classification

USCS= SP AASHTO=

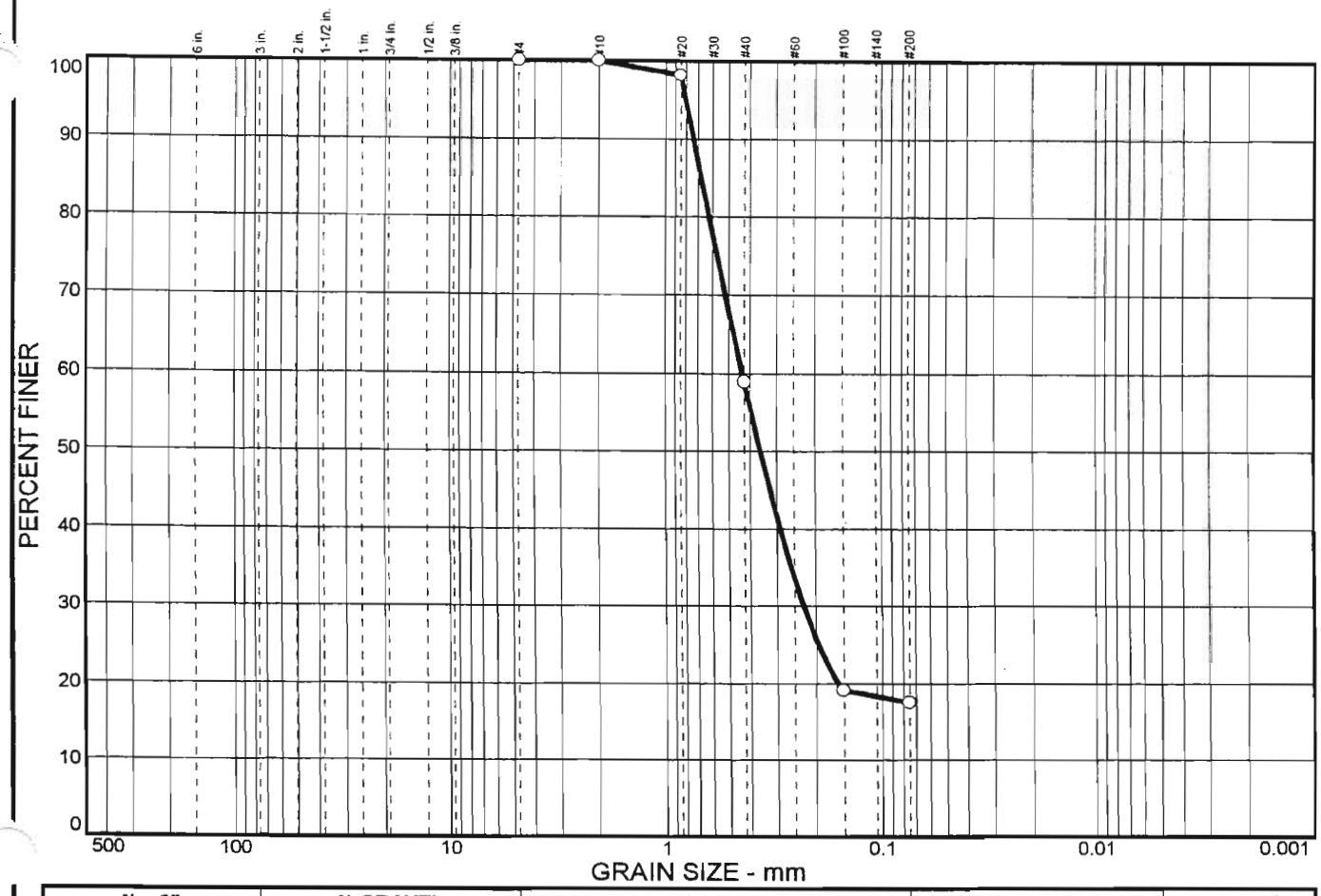
Remarks

Sample No.: 7-A **Source of Sample:** CB-CUL-9 **Date:** 7/13/98
Location: X=246626.7660 Y=207831.6890 **Elev./Depth:** 9.0' @ 10.5'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	82.5	17.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	100.0		
#20	98.2		
#40	59.0		
#100	19.1		
#200	17.5		

* (no specification provided)

Soil Description

SAND, little silt, dark brown.

Atterberg Limits

PL= 16.2 LL= 19.1 PI= 2.9

Coefficients

D_{85}= 0.677 D_{60}= 0.433 D_{50}= 0.357
D_{30}= 0.226 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

Sample No.: 2-A **Source of Sample:** CB-CUL-10 **Date:** 7/13/98
Location: X=247098.7150 Y=207984.1560 **Elev./Depth:** 1.5' @ 3.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT

% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	4.2	91.1	4.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375 in.	100.0		
#4	95.8		
#10	94.8		
#20	90.2		
#40	46.6		
#100	6.5		
#200	4.7		

* (no specification provided)

Soil Description

SAND, trace silt and gravel, dark brown.

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.785 D_{60}= 0.532 D_{50}= 0.451
D_{30}= 0.310 D_{15}= 0.214 D_{10}= 0.179
C_u= 2.97 C_c= 1.01

Classification

USCS= SP AASHTO=

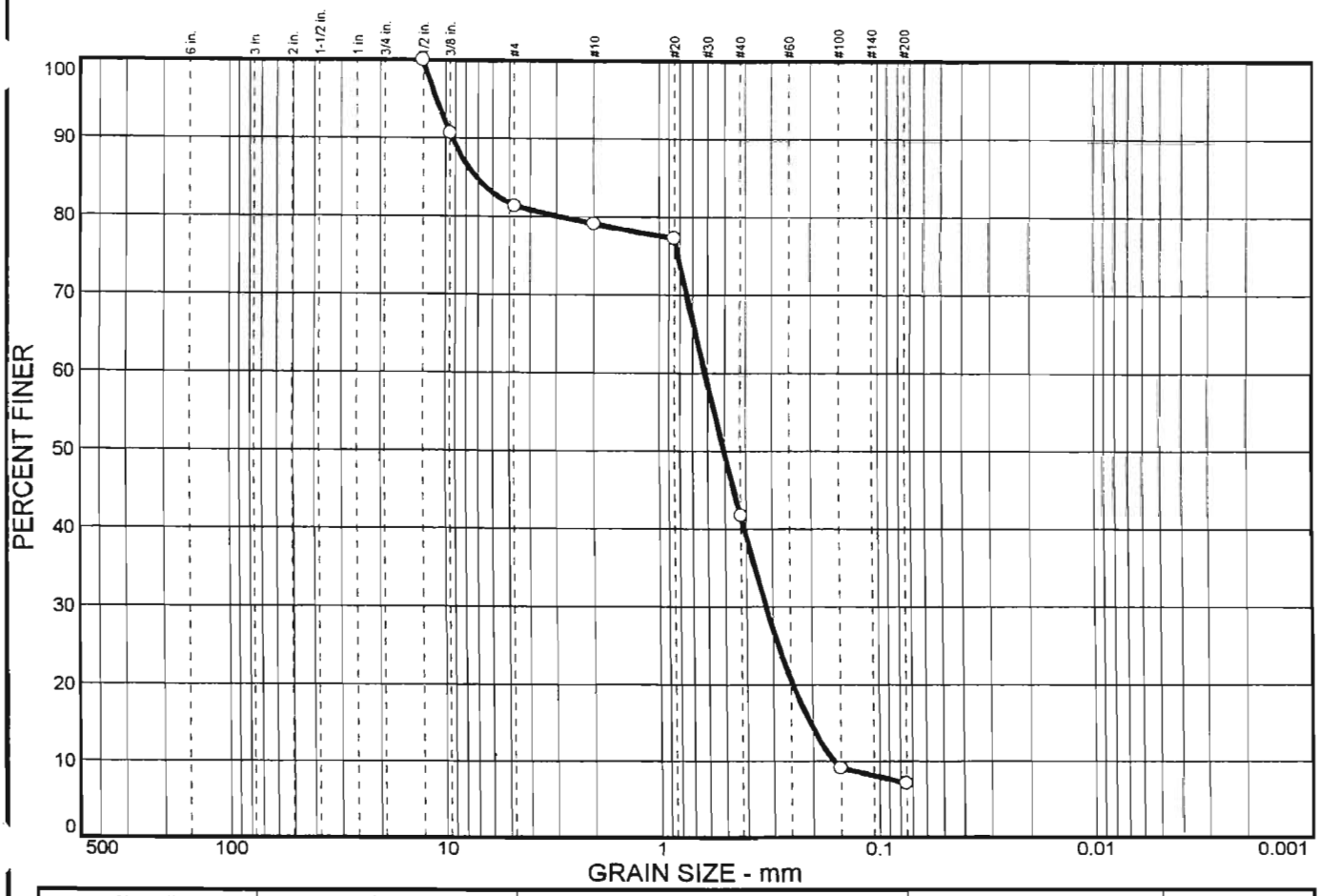
Remarks

Sample No.: 8-A **Source of Sample:** CB-CUL-10 **Date:** 7/13/98
Location: X=247098.7150 Y=207984.1560 **Elev./Depth:** 10.5' @ 12.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	18.6	74.3	7.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5 in.	100.0		
.375 in.	90.7		
#4	81.4		
#10	79.1		
#20	77.3		
#40	41.8		
#100	9.1		
#200	7.1		

* (no specification provided)

Soil Description

SAND, little gravel, trace silt, brown.

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 7.11 D_{60}= 0.614 D_{50}= 0.504
D_{30}= 0.323 D_{15}= 0.204 D_{10}= 0.160
C_u= 3.84 C_c= 1.06

Classification

USCS= SP-SM AASHTO=

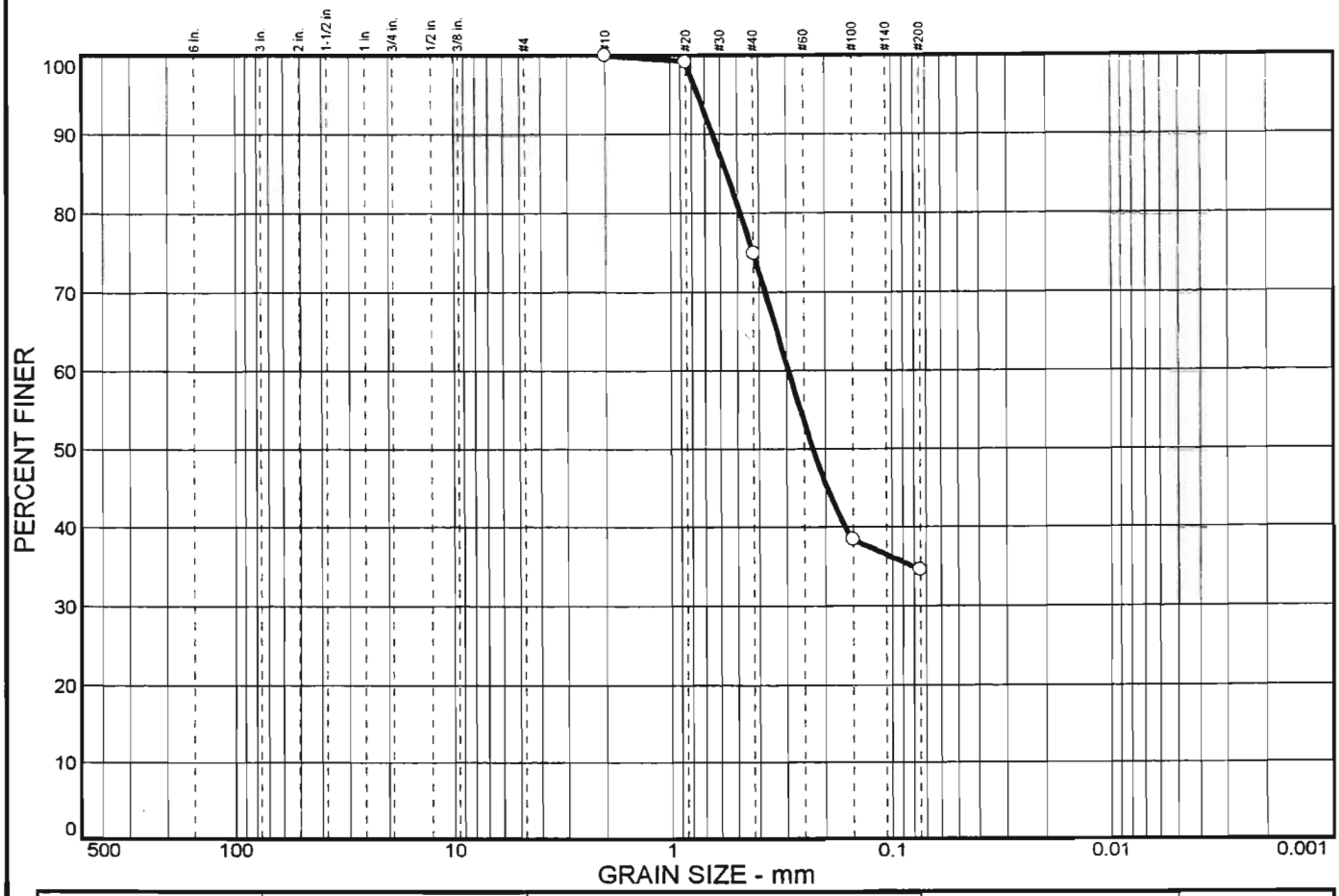
Remarks

Sample No.: 8-A **Source of Sample:** CB-CUL-11 **Date:** 7/13/98
Location: X=247804.8820 Y=208505.7240 **Elev./Depth:** 10.5' @ 12.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	65.4	34.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	99.2		
#40	75.0		
#100	38.4		
#200	34.6		

* (no specification provided)

Soil Description

Clayey SAND, dark brown.

Atterberg Limits

PL= 16.5 LL= 35.5 PI= 19.7

Coefficients

D_{85}= 0.557 D_{60}= 0.294 D_{50}= 0.226
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SC AASHTO=

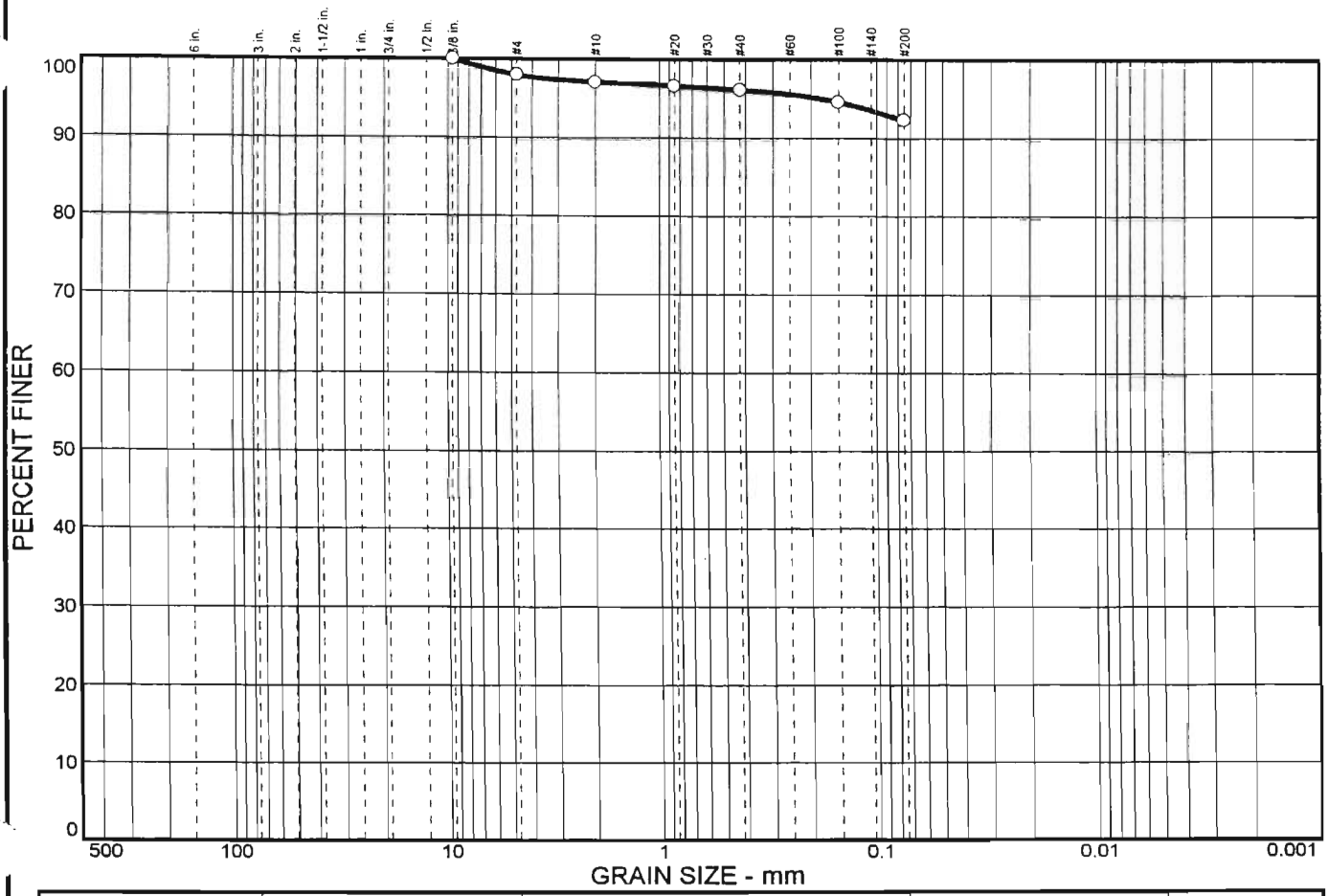
Remarks

Sample No.: 2-A **Source of Sample:** CB-CUL-12 **Date:** 7/14/98
Location: X=247326.1400 Y=209437.8100 **Elev./Depth:** 1.5' @ 3.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	2.0	5.7	92.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375 in.	100.0		
#4	98.0		
#10	97.1		
#20	96.6		
#40	96.1		
#100	94.6		
#200	92.3		

* (no specification provided)

Soil Description

SILT, trace sand and gravel, gray.

Atterberg Limits

PL= 42.7 LL= 90.0 PI= 47.3

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

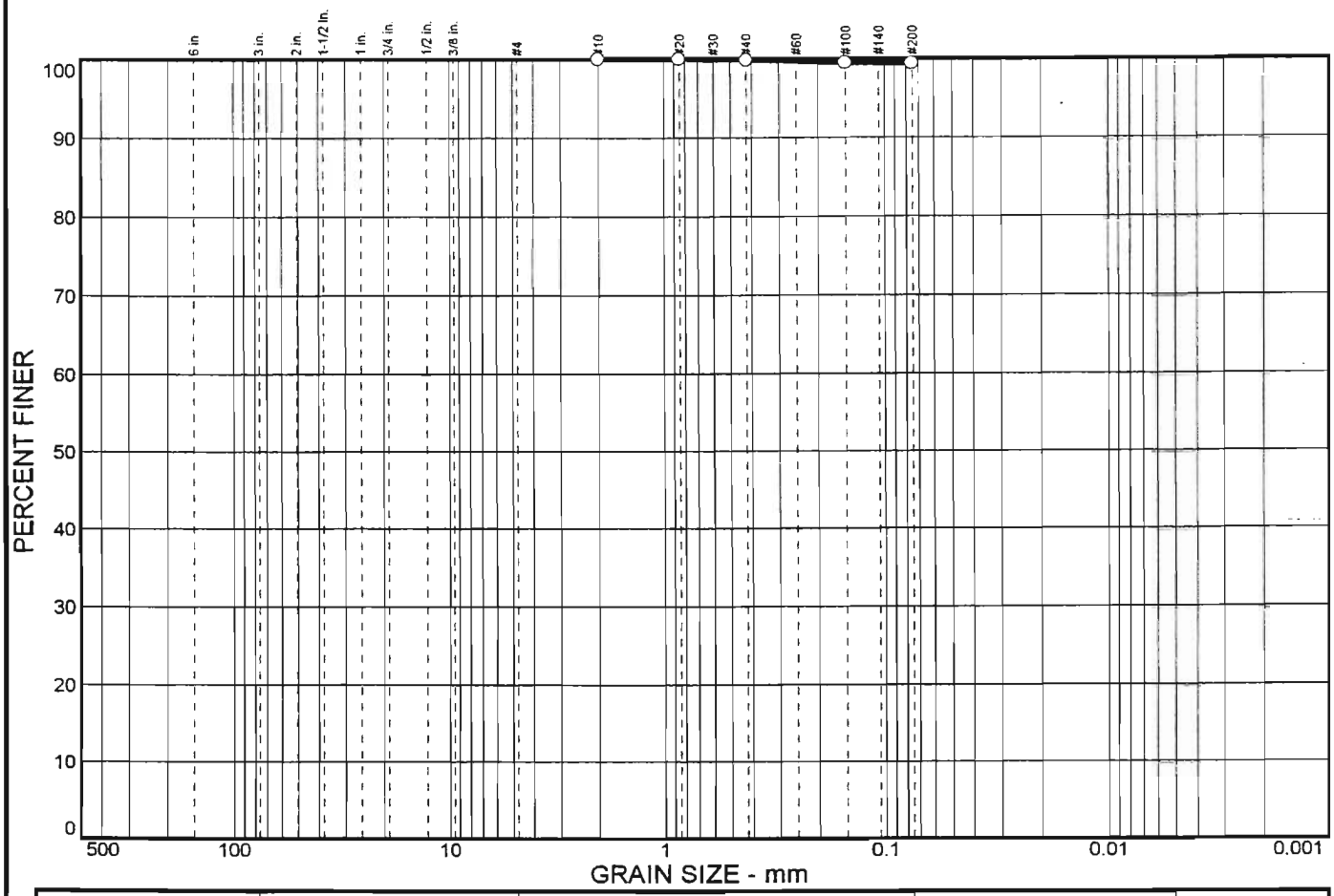
Remarks

Sample No.: 2-A **Source of Sample:** CB-CUL-13 **Date:** 7/8/98
Location: X=247092.2420 Y=210444.4960 **Elev./Depth:** 1.5'-3.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	0.6	99.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	99.9		
#100	99.5		
#200	99.4		

* (no specification provided)

Soil Description

SILT, trace sand, dark gray.

Atterberg Limits

PL= 48.7 LL= 84.5 PI= 35.8

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

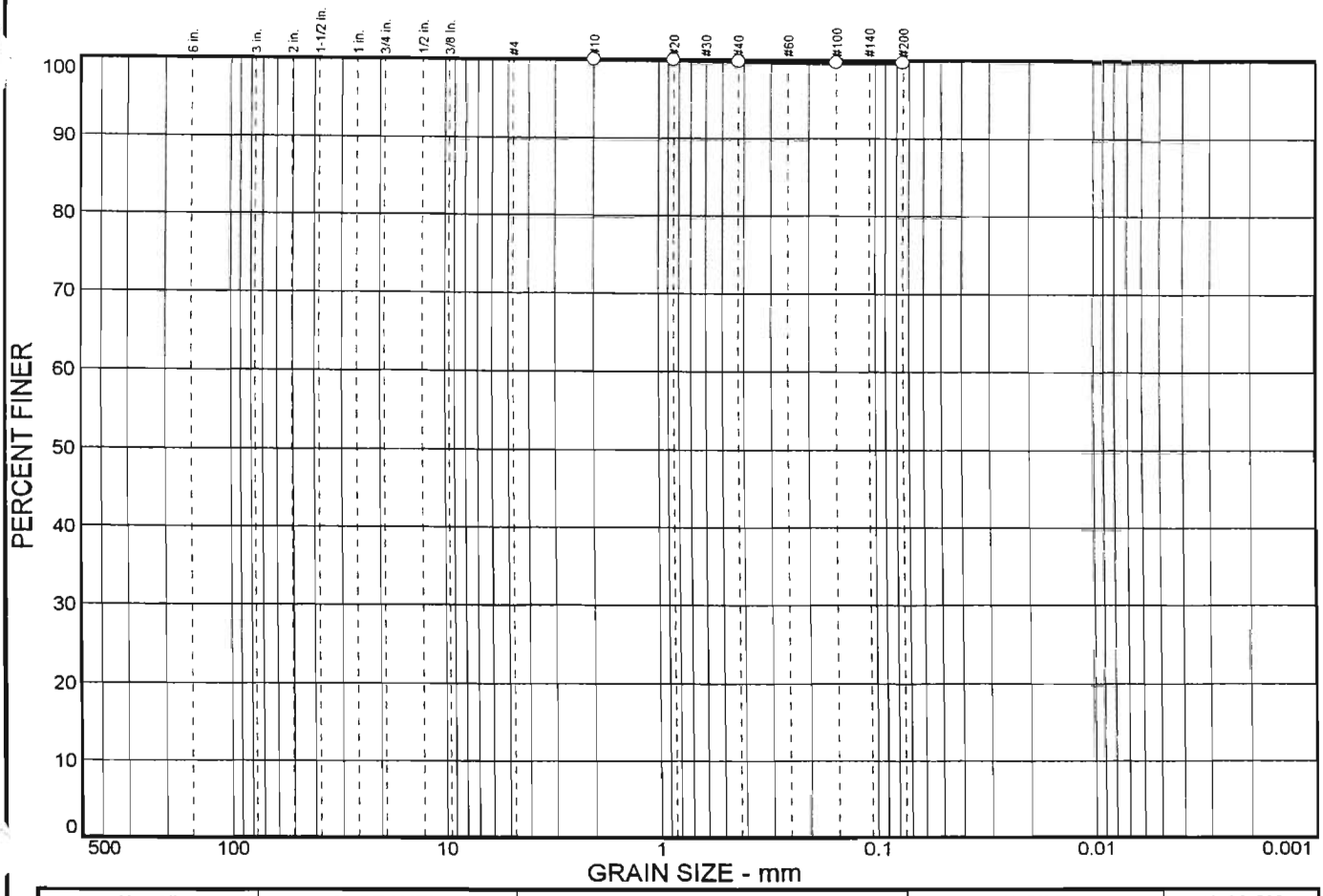
Remarks

Sample No.: 4-A **Source of Sample:** CB-CUL-13 **Date:** 7/8/98
Location: X=247092.2420 Y=210444.4960 **Elev./Depth:** 4.5' - 6.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	0.3	99.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	99.9		
#100	99.7		
#200	99.7		

* (no specification provided)

Soil Description

SILT, trace sand, dark gray.

Atterberg Limits

PL= 36.9 LL= 71.5 PI= 34.6

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= MH AASHTO=

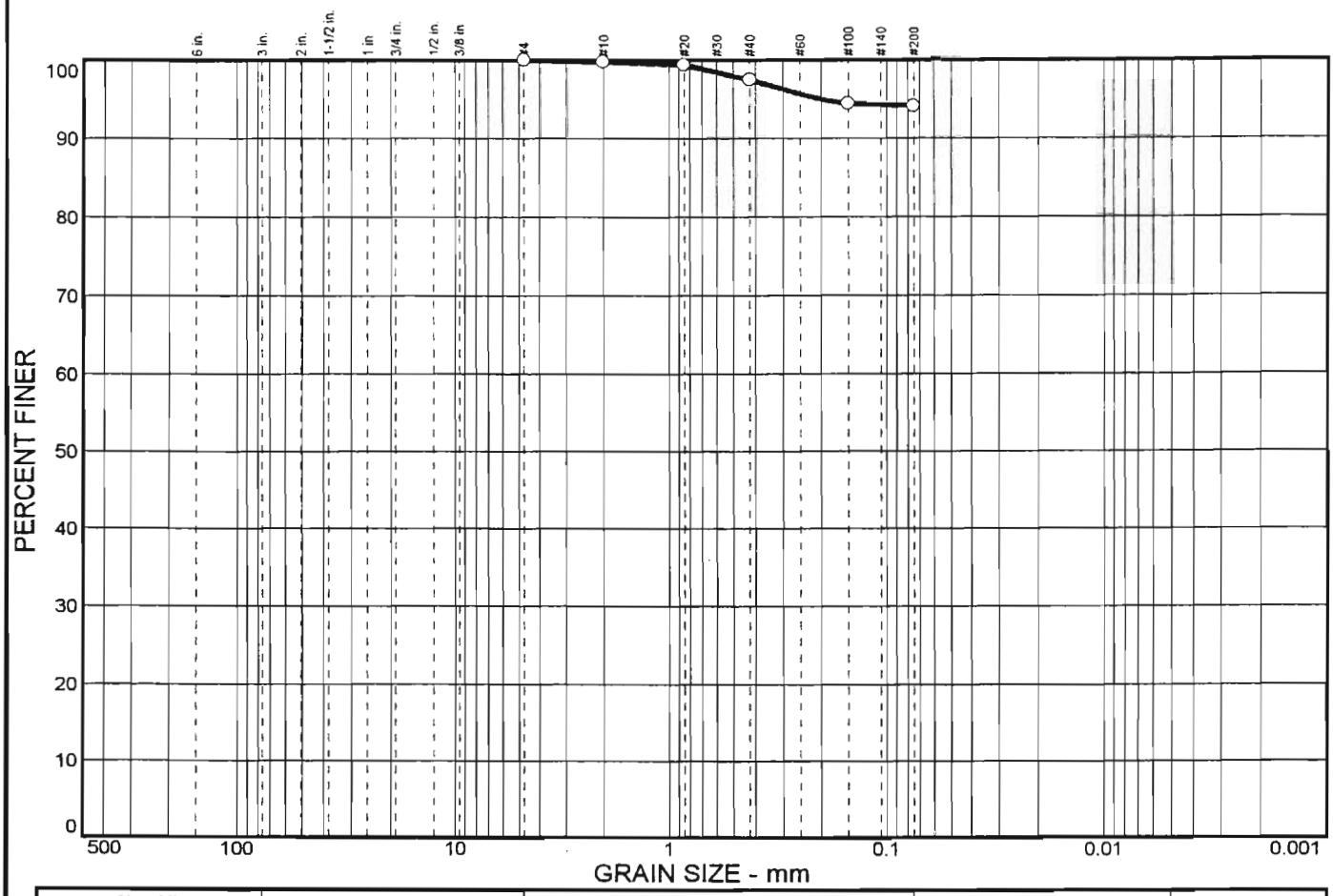
Remarks

Sample No.: 8-A **Source of Sample:** CB-CUL-13 **Date:** 7/8/98
Location: X=247092.2420 Y=210444.4960 **Elev./Depth:** 10.5' - 12.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	5.9	94.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.8		
#20	99.4		
#40	97.5		
#100	94.4		
#200	94.1		

* (no specification provided)

Soil Description

CLAY, trace sand, dark gray.

Atterberg Limits

PL= 42.3 LL= 114.5 PI= 72.21

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CH AASHTO=

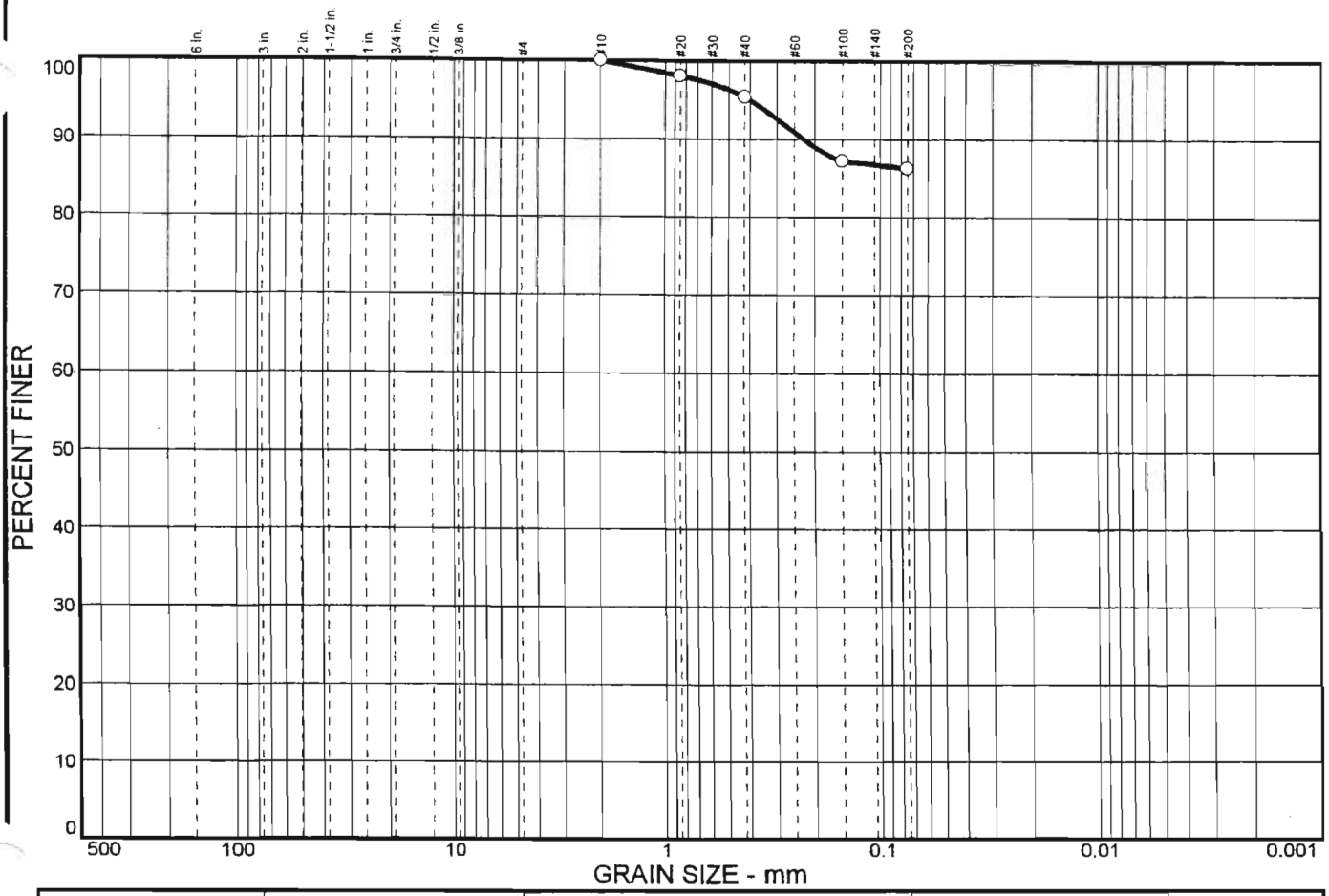
Remarks

Sample No.: 4-A **Source of Sample:** CB-CUL-14 **Date:** 7/8/98
Location: X=246987.9150 Y=211306.2170 **Elev./Depth:** 4.5' - 6.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	13.7	86.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	98.1		
#40	95.4		
#100	87.2		
#200	86.3		

* (no specification provided)

Soil Description

CLAY, little sand, dark gray.

Atterberg Limits

PL= 38.3 LL= 97.9 PI= 59.63

Coefficients

D_{85}= D_{60}= D_{50}=
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= CH AASHTO=

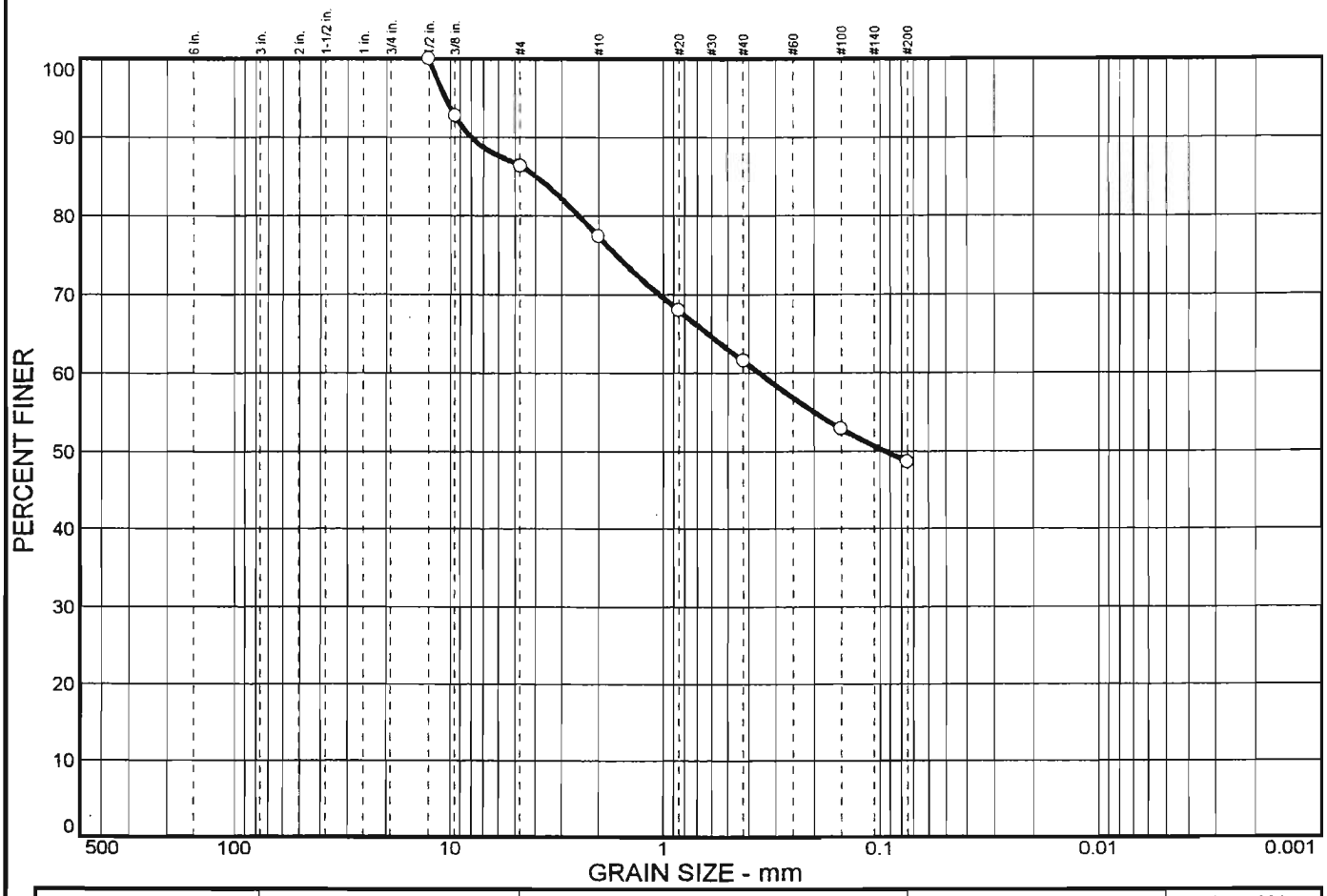
Remarks

Sample No.: 8-A **Source of Sample:** CB-CUL-14 **Date:** 7/8/98
Location: X=246987.9150 Y=211306.2170 **Elev./Depth:** 10.5' - 12.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	13.6	37.7	48.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.5 in.	100.0		
.375 in.	92.8		
#4	86.4		
#10	77.4		
#20	68.0		
#40	61.6		
#100	52.9		
#200	48.7		

* (no specification provided)

Soil Description

Sandy CLAY, little gravel, pale brown.

Atterberg Limits

PL= 12.2 LL= 15.5 PI= 3.3

Coefficients

D_{85}= 3.96 D_{60}= 0.356 D_{50}= 0.0944
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SC-SM AASHTO=

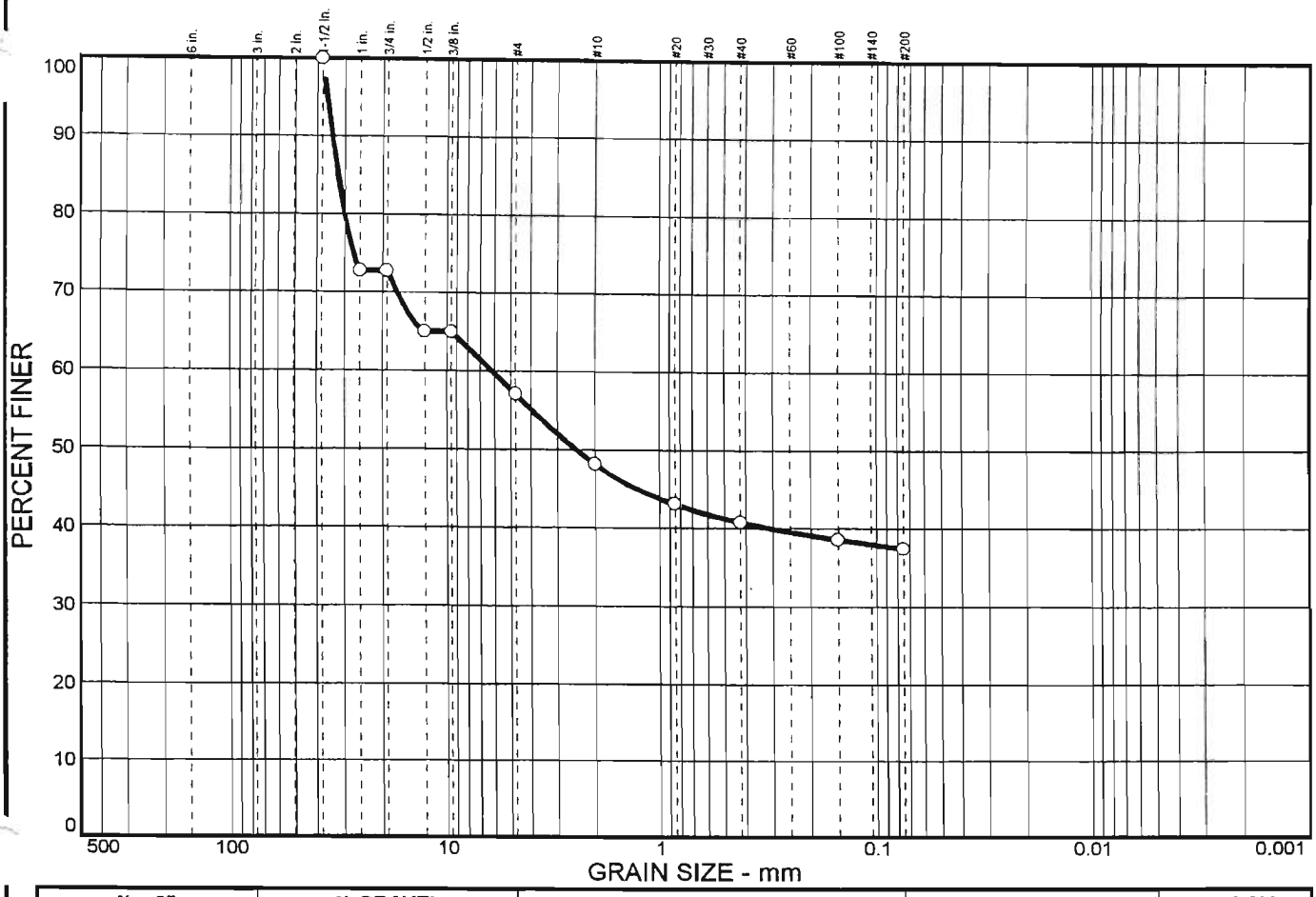
Remarks

Sample No.: 12-A **Source of Sample:** CB-CUL-15 **Date:** 7/16/98
Location: X=243604.9140 Y=204359.9440 **Elev./Depth:** 19.5' @ 21.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	42.9	19.7	37.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5 in.	100.0		
1 in.	72.7		
.75 in.	72.7		
.5 in.	65.0		
.375 in.	65.0		
#4	57.1		
#10	48.2		
#20	43.1		
#40	40.8		
#100	38.6		
#200	37.4		

* (no specification provided)

Soil Description

Clayey GRAVEL, little sand, brown.

Atterberg Limits

PL= 14.8 LL= 38.7 PI= 23.9

Coefficients

D_{85}= 32.0 D_{60}= 6.14 D_{50}= 2.45
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= GC AASHTO=

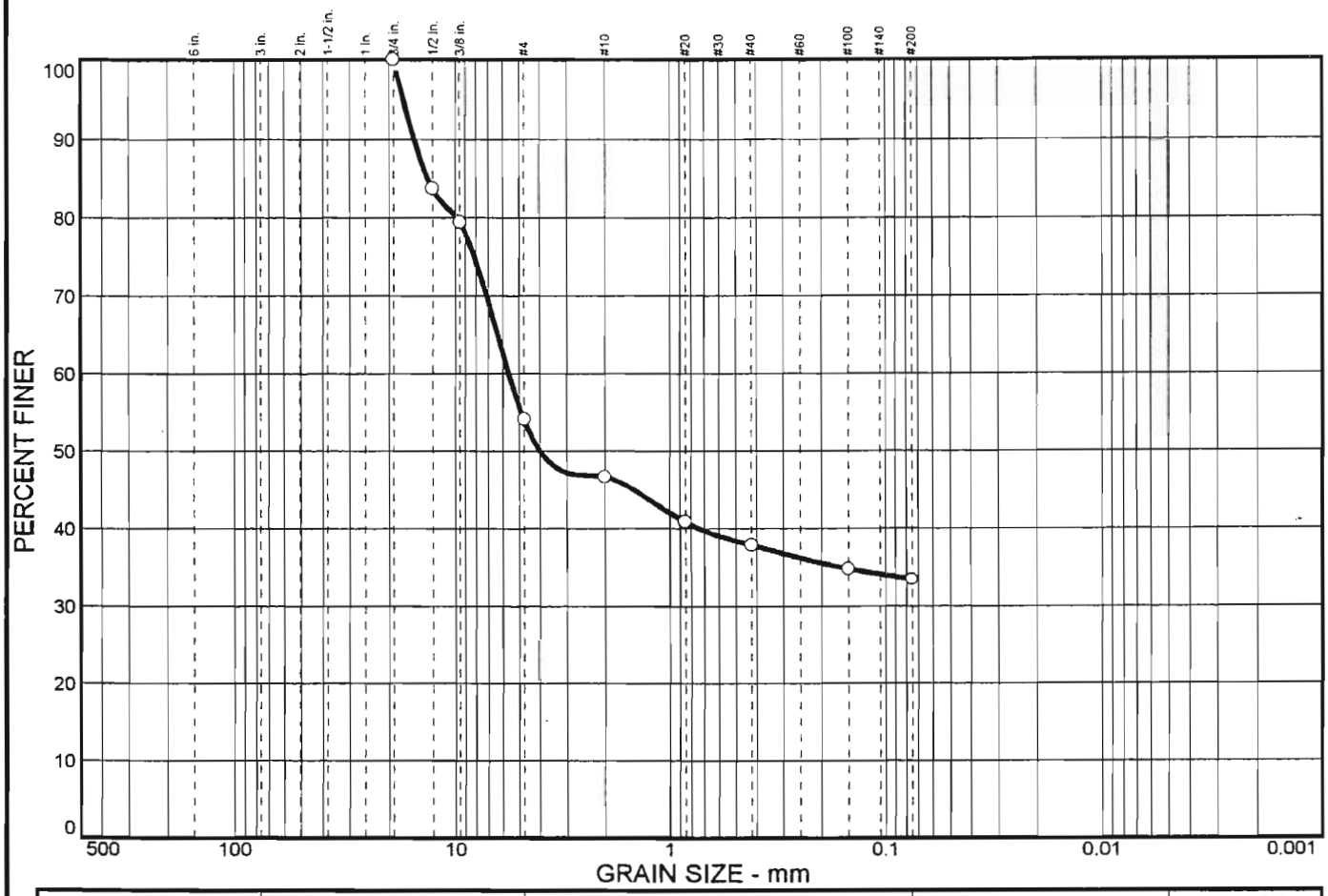
Remarks

Sample No.: 3-A **Source of Sample:** CB-CUL-15 **Date:** 7/16/98
Location: X=243604.9140 Y=204359.9440 **Elev./Depth:** 3.0' @ 4.5'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	45.9	20.7	33.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.5 in.	83.7		
.375 in.	79.4		
#4	54.1		
#10	46.7		
#20	40.9		
#40	37.9		
#100	34.8		
#200	33.4		

* (no specification provided)

Soil Description

Silty GRAVEL, some sand, pale brown.

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 13.4 D_{60}= 5.60 D_{50}= 3.98
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= GM AASHTO=

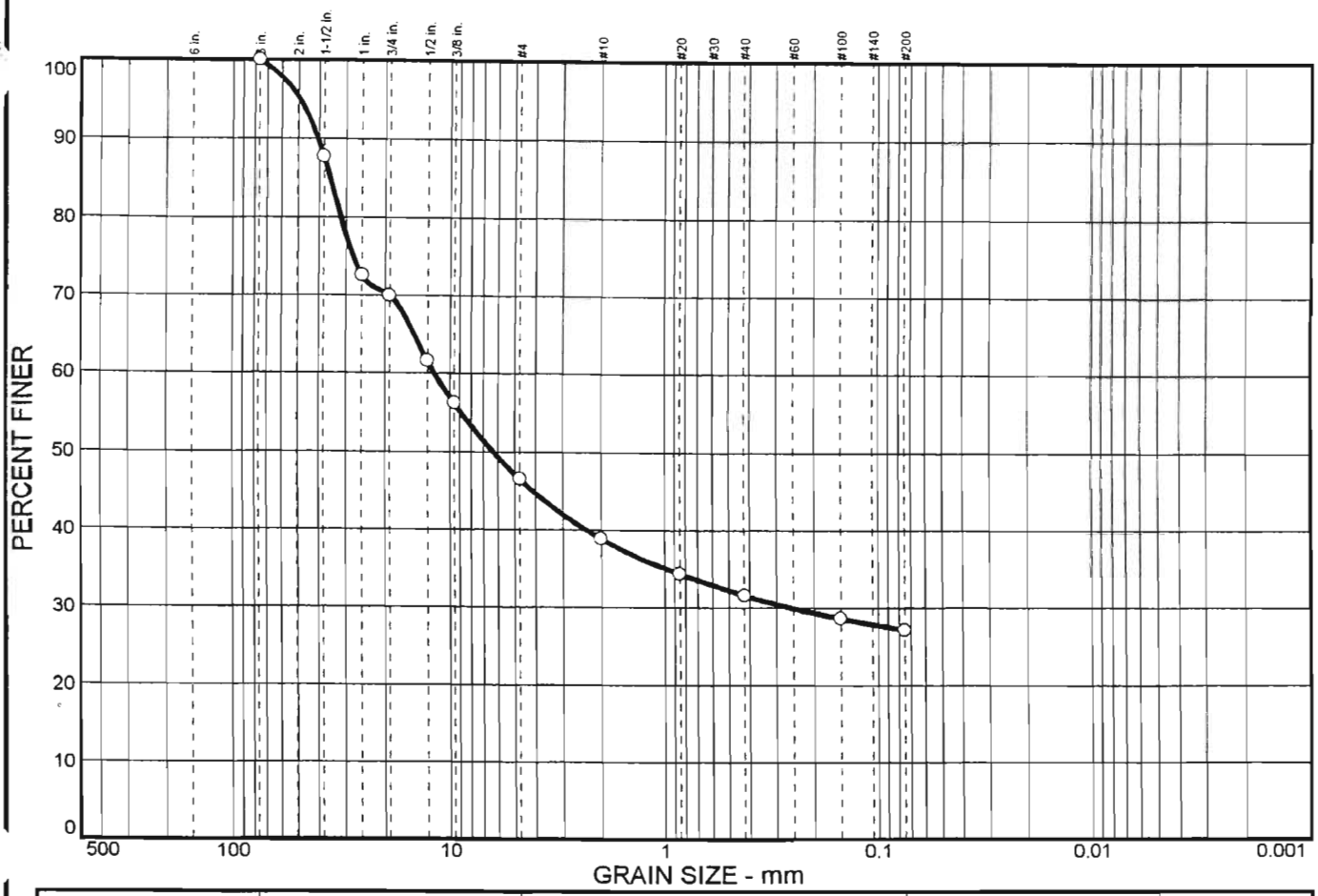
Remarks

Sample No.: 30-A **Source of Sample:** CB-CUL-15 **Date:** 7/16/98
Location: X=243604.9140 Y=204359.9440 **Elev./Depth:** 46.5' @ 48.0'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	53.4	19.5	27.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3 in.	100.0		
1.5 in.	87.8		
1 in.	72.6		
.75 in.	70.0		
.5 in.	61.6		
.375 in.	56.2		
#4	46.6		
#10	38.9		
#20	34.4		
#40	31.6		
#100	28.6		
#200	27.1		

* (no specification provided)

Soil Description

GRAVEL, some clay, little sand, brown.

Atterberg Limits

PL= 20.0 LL= 63.6 PI= 43.6

Coefficients

D_{85}= 35.5 D_{60}= 11.8 D_{50}= 6.26
D_{30}= 0.258 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= GC AASHTO=

Remarks

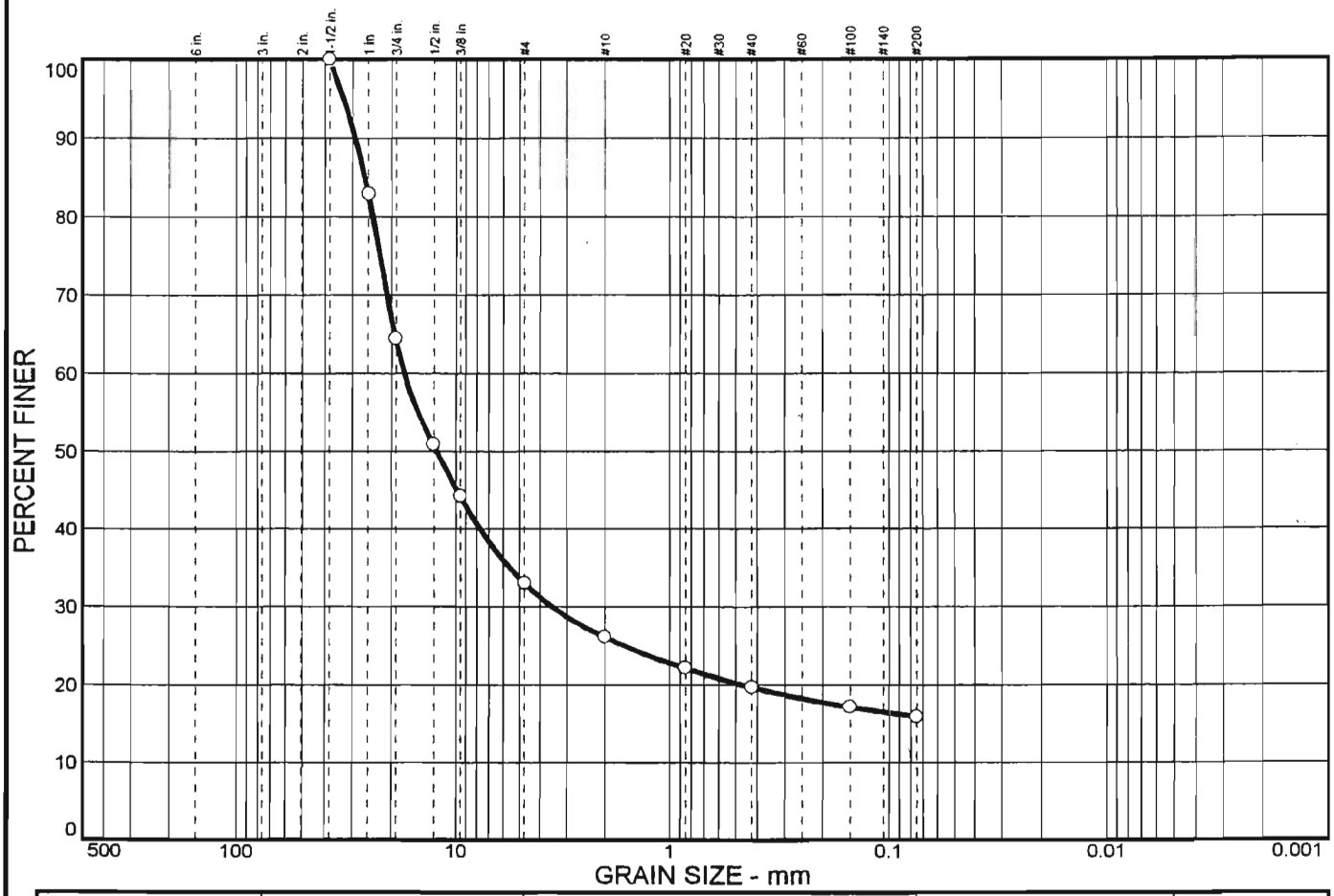
MAx Dry Dens 111.9 pcf @ 15.2% Opt Moisture

Sample No.: 1-A **Source of Sample:** TP-CUL-1 **Date:** 7/16/98
Location: X=243609.0380 Y=204369.8740 **Elev./Depth:** 0.0' @ 4.5'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	67.0	17.1	15.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5 in.	100.0		
1 in.	82.9		
.75 in.	64.4		
.5 in.	50.9		
.375 in.	44.3		
#4	33.0		
#10	26.1		
#20	22.1		
#40	19.7		
#100	17.1		
#200	15.9		

* (no specification provided)

Soil Description

GRAVEL, little sand and silt, pale brown.

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 26.3 D_{60}= 17.4 D_{50}= 12.2
D_{30}= 3.53 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= GM AASHTO=

Remarks

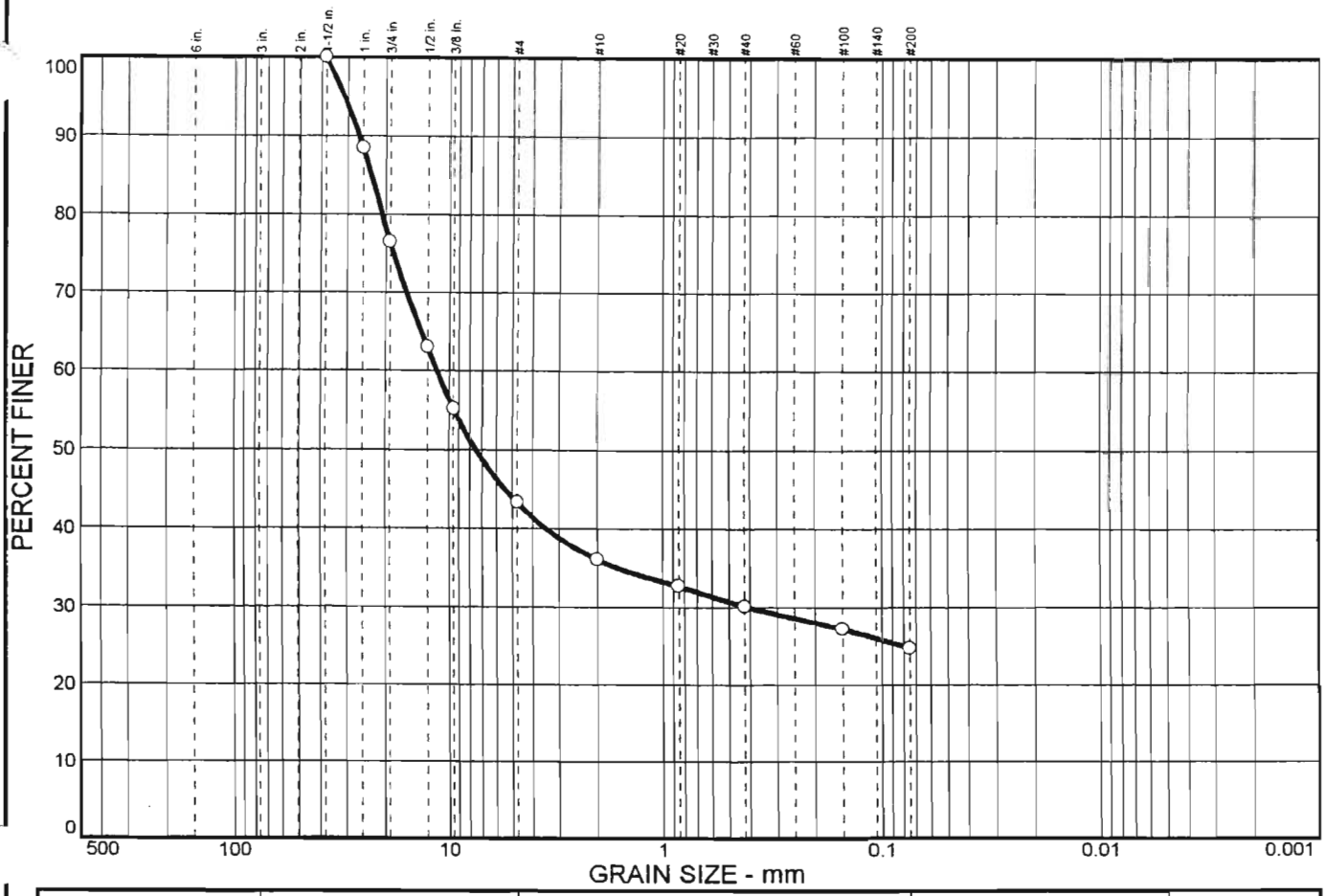
MAx Dry Dens 116.3 pcf @ 11.3% Opt Moisture

Sample No.: 1-A **Source of Sample:** TP-CUL-2 **Date:** 7/16/98
Location: X=243724.1080 Y=204022.1290 **Elev./Depth:** 0.0' @ 4.2'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	56.6	18.8	24.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5 in.	100.0		
1 in.	88.5		
.75 in.	76.5		
.5 in.	63.0		
.375 in.	55.2		
#4	43.4		
#10	36.1		
#20	32.7		
#40	30.1		
#100	27.1		
#200	24.6		

* (no specification provided)

Soil Description

GRAVEL, some clay, little sand, pale brown.

Atterberg Limits

PL= 14.1 LL= 34.0 PI= 19.9

Coefficients

D_{85}= 23.3 D_{60}= 11.4 D_{50}= 7.45
D_{30}= 0.413 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= GC AASHTO=

Remarks

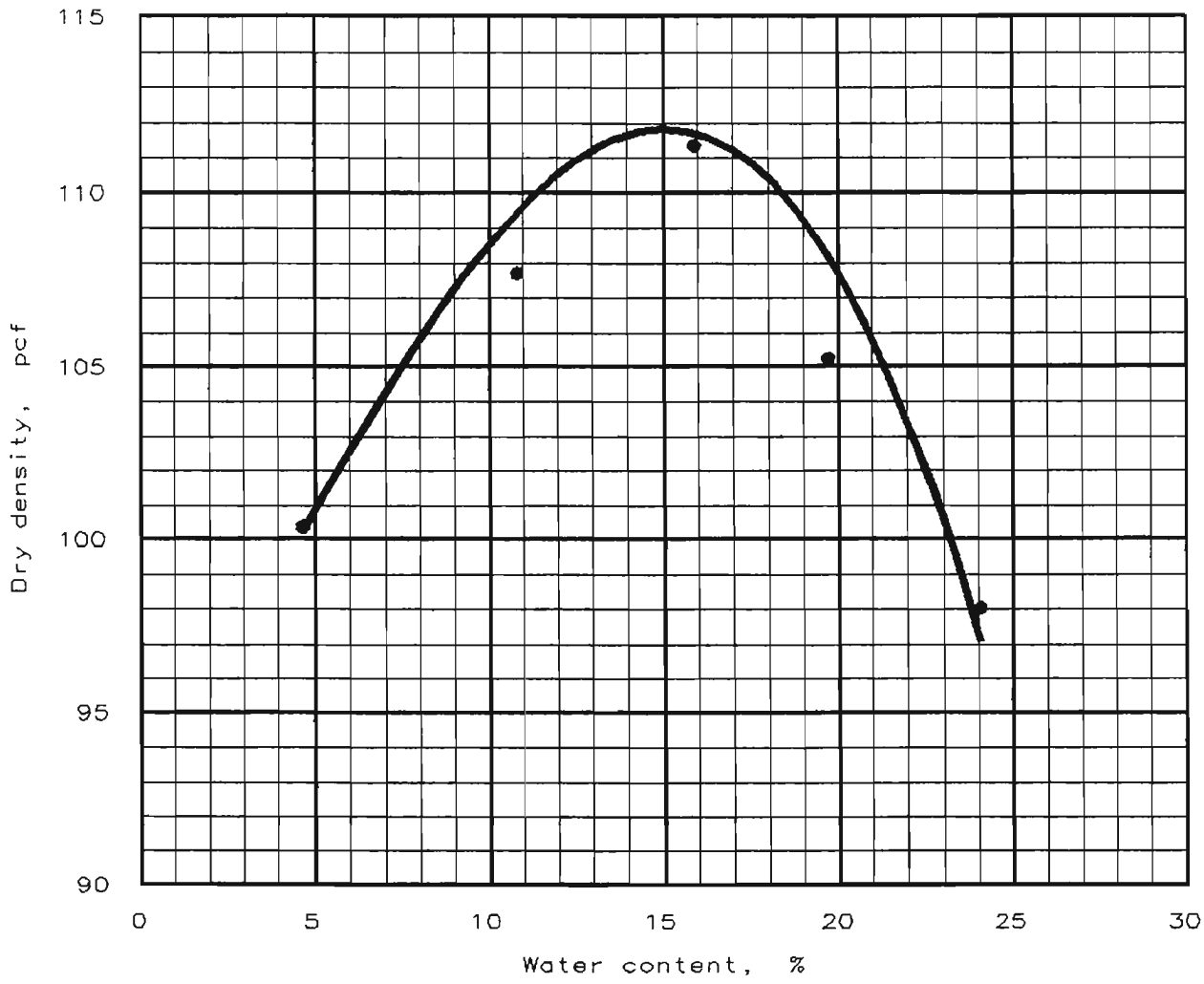
Max Dry Dens 111.7 pcf @ 12.3% Opt Moisture

Sample No.: 2-A **Source of Sample:** TP-CUL-2 **Date:** 7/16/98
Location: X=243724.1080 Y=204022.1290 **Elev./Depth:** 4.5' @ 9.5'

GEO CIM, INC.

Client: Corp of Engineers
Project: Rio Culebrinas Project
Aguadilla, P.R.
Project No: 2174-98 **R. Davila-GCI**

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure C, Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
N/A	GC		17.9 %	2.74	63.6	43.6	30.0 %	27.1 %

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 111.8 pcf Optimum moisture = 15.1 %	GRAVEL, some clay, little sand, brown.

Project No.: 2174-98
Project: Rio Culebrinas Project
Location: Aguadilla, P.R.

Date: July 16, 1998

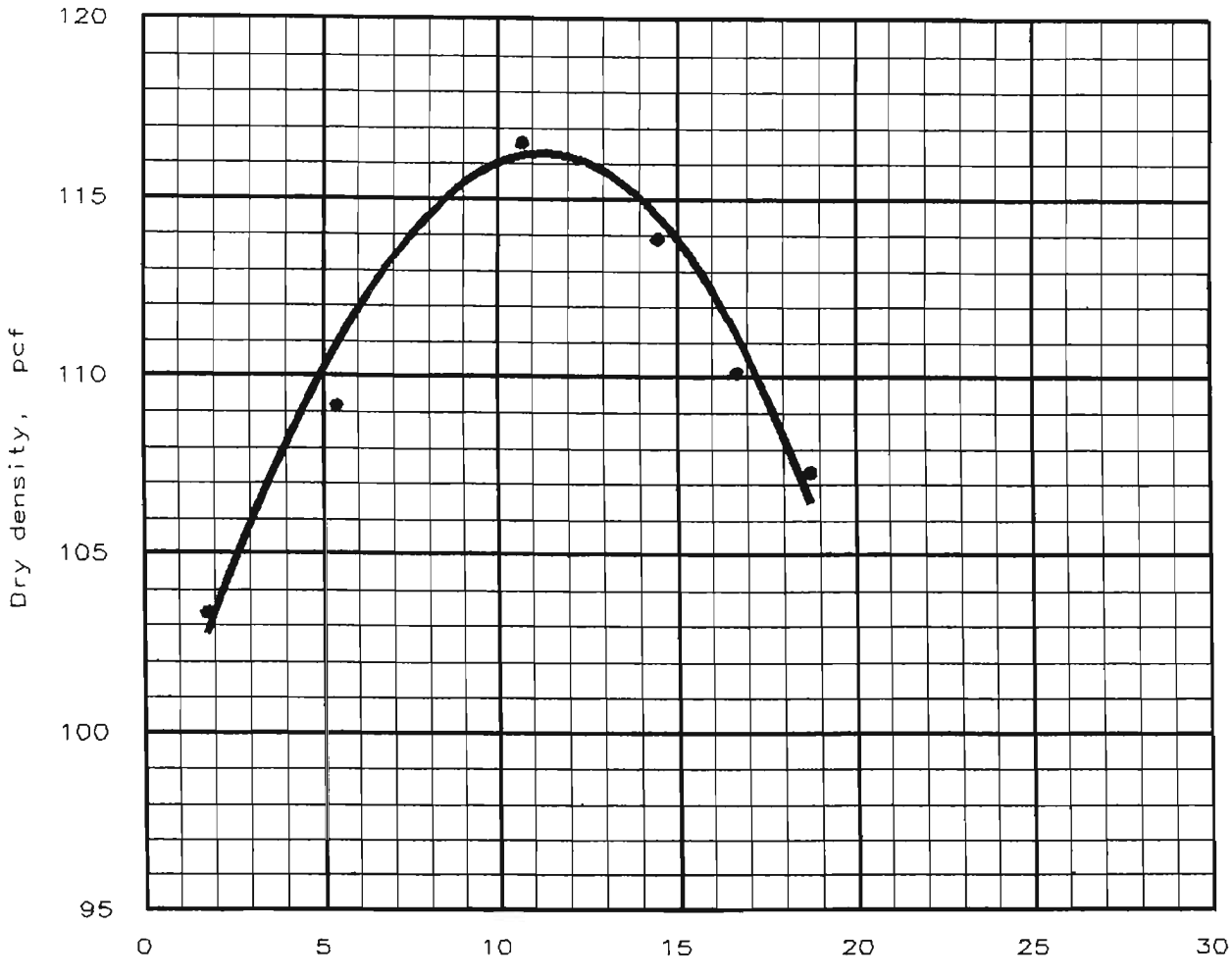
Remarks:
Corp of Engineers
TP-CUL-1 **SAMPLE NO. 1**
X=243609.03 Y=204369.87

MOISTURE-DENSITY RELATIONSHIP TEST

GEO CIM, INC.

Fig. No. 1

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-91 Procedure C, Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in	% < No.200
	USCS	AASHTO						
N/A	GM		4.0 %	2.75			35.6 %	15.9 %

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 116.3 pcf Optimum moisture = 11.3 %	GRAVEL, little sand and silt, pale brown to pink

Project No.: 2174-98
Project: Rio Culebrinas Project
Location: Aguadilla, P.R.

Date: July 16, 1998

Remarks:
Corp of Engineers
TP-CUL-2 **SAMPLE NO. 1**
X=243724.10 Y=204022.12

MOISTURE-DENSITY RELATIONSHIP TEST

GEO CIM, INC.

Fig. No. 1

United States Army Corps of Engineers
File Number 98-153
August 27, 1998

Table 1

DESCRIPTIONS OF SHELBY TUBE SOIL SAMPLES

Boring	Depth (feet)	Description	Length (inches)		Classification Tests							Measured w_c (%)	S_u (TV) (lb/ft^2)	Tube Average	
					-200 (%)	LL (%)	PL (%)	PI (%)	OC (%)	G_s	Group† Symbol			w_c (%)	γ_t (lb/ft^3)
CB-CUL-5	13.0 - 15.0	Brown clay	3.5	23.5	--	--	--	--	--	--	--	44.5	--	55.9	100.7
		Gray fat clay with sand and thin seams of fine sand	20.0		78 80 76 73	58	30	28	5.8	2.69	CH	57.6 57.5 54.8 61.7	360 390 360 --		
CB-CUL-13	8.0 - 10.0	Brown clay with organic material	3.0	18.5	--	--	--	--	--	--	--	64.5	--	73.2	96.7
		Gray fat clay with thin seams of fine sand	15.5		97 99 100	74	31	43	--	2.70	CH	73.6 76.5 77.2 72.4	240 260 260 260		
CB-CUL-14	8.0 - 10.0	Gray fat clay to sandy fat clay with thin seams and lenses of fine sand and fine shell fragments and lenses of organic material	15.5	26.5	89 60 81	91	29	62	9.6	2.65	CH	87.1 69.0 82.1 53.1	-- -- 400 --	72.8	100.5
		Gray medium to fine sand with shell framents and occasional lenses of gray clay	11.0		--	--	--	--	--	--	--	40.5	--	40.5	101.9

Where: w_c = Moisture content; γ_t = Total unit weight; -200 = Fines content (i.e., amount of material finer than the U.S. Standard No. 200 sieve); LL = Liquid limit; PL = Plastic limit; PI = Plasticity Index; OC = Organic content (loss on ignition); G_s = Specific gravity; and S_u (TV) = Undrained shear strength measured with a Torvane.

† Group symbols in accordance with ASTM Standard D 2487 "Classification of Soils for Engineering Purposes".

A:\98-153 RC.001.wpd

United States Army Corps of Engineers
File Number 98-153
August 27, 1998

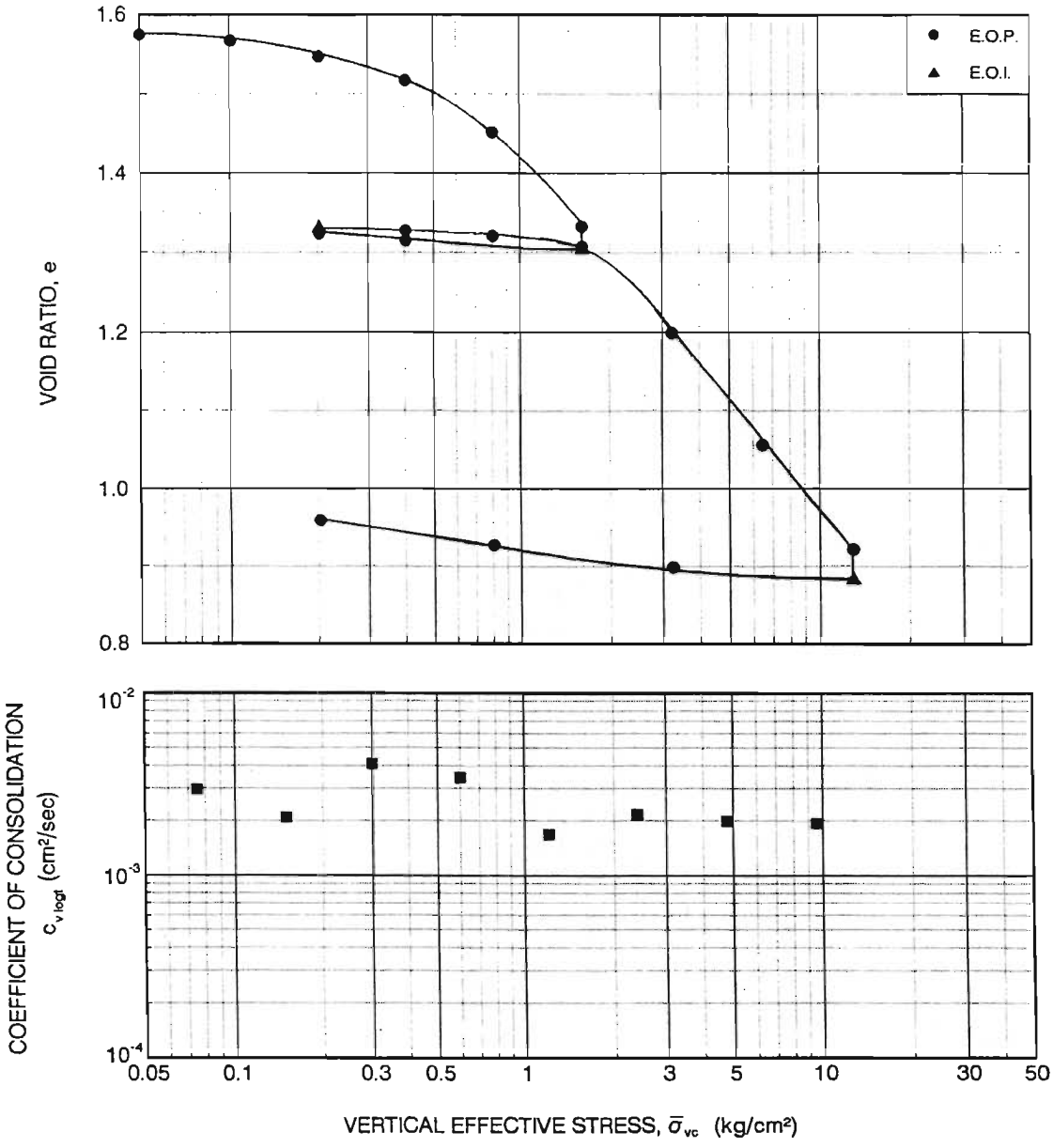
Table 2

UNCONSOLIDATED UNDRAINED (UU) TRIAXIAL COMPRESSION TEST RESULTS

Boring	Depth (feet)	Specimen Dimensions			w_c (%)	γ_d (lb/ft^3)	S (%)	-200 (%)	σ_c (kg/cm^2)	$\dot{\varepsilon}$ (cm/min)	at $(\sigma_1-\sigma_3)_{max}$			
		H (cm)	D (cm)	H/D							ε_a (%)	Compressive Strength (kg/cm^2)	σ_1 (kg/cm^2)	σ_3 (kg/cm^2)
CB-CUL-13	8.0 - 10.0	7.10	3.48	2.04	73.7	56.3	100	97	1.05	0.066	18.8	0.38	1.43	1.05
		7.08	3.47	2.04	73.6	56.4	100	100	2.10	0.066	18.5	0.33	2.43	2.10
CB-CUL-14	8.0 - 10.0	7.09	3.52	2.01	93.0	47.7	100	89	0.87	0.066	17.8	0.40	1.27	0.87
		7.09	3.52	2.01	75.5	55.1	100	60	1.76	0.066	17.8	0.38	2.14	1.76

Where: H = Specimen height; D = Specimen diameter; w_c = Moisture content; γ_d = Dry density; S = Calculated degree of saturation; -200 = Fines content (i.e., amount of material finer than the U.S. Standard No. 200 sieve); σ_c = Confining stress; $\dot{\varepsilon}$ = Vertical displacement rate; ε_a = Axial strain; σ_1 = Major principal stress; σ_3 = Minor principal stress.

A:\98-153 RC.001.wpd



SAMPLE DATA

BORING NUMBER:	CB-CUL-5
SAMPLE NUMBER:	--
DEPTH (FEET:	13.0-15.0
DESCRIPTION:	GRAY FAT CLAY WITH SAND AND THIN SEAMS OF FINE SAND

INDEX PROPERTIES

LIQUID LIMIT (%):	58
PLASTIC LIMIT (%):	30
PLASTICITY INDEX (%):	28
% PASSING NO. 200:	78
SPECIFIC GRAVITY:	2.69

SPECIMEN CONDITIONS

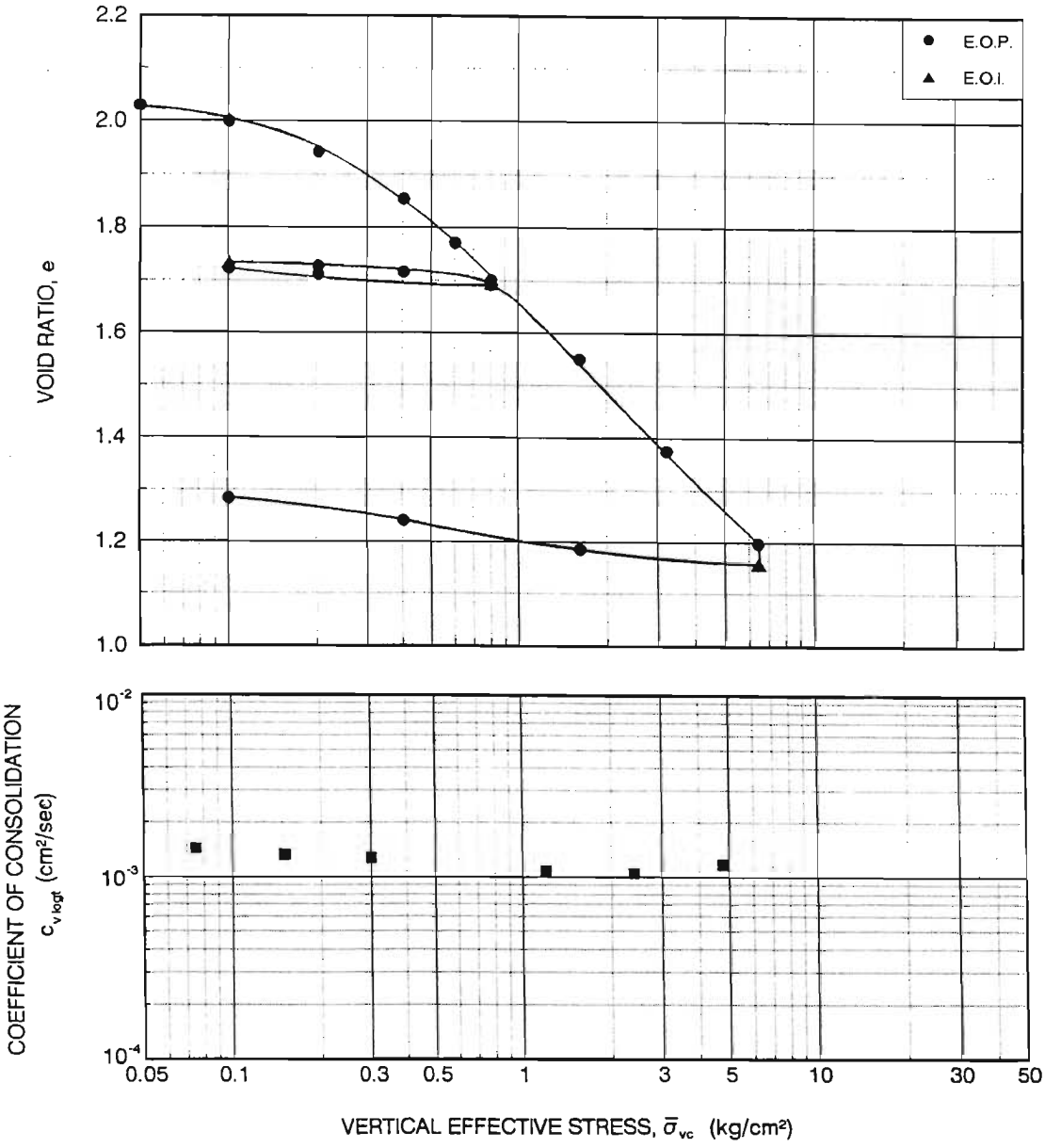
	INITIAL	FINAL
MOISTURE CONTENT (%):	57.4	37.1
DRY DENSITY (lb/ft³):	65.0	83.8
VOID RATIO:	1.58	1.00
SATURATION (%):	98	100

INCREMENTAL LOADING CONSOLIDATION TEST ON SAMPLE CB-CUL-5

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

LABORATORY TESTING
CONTRACT NO. DACW17-98-D-0003
RIO CULEBRINAS PROJECT

DRAWN BY: SA	CHECKED BY: SA	DATE: 08-19-98
FILE NO.: 98-153	APPROVED BY:	FIGURE: 12



SAMPLE DATA	
BORING NUMBER:	CB-CUL-13
SAMPLE NUMBER:	--
DEPTH (FEET:	8.0-10.0
DESCRIPTION:	GRAY FAT CLAY WITH THIN SEAMS OF FINE SAND

SPECIMEN CONDITIONS	INITIAL	FINAL
MOISTURE CONTENT (%):	76.3	49.3
DRY DENSITY (lb/ft³):	55.1	72.3
VOID RATIO:	2.06	1.33
SATURATION (%):	100	100

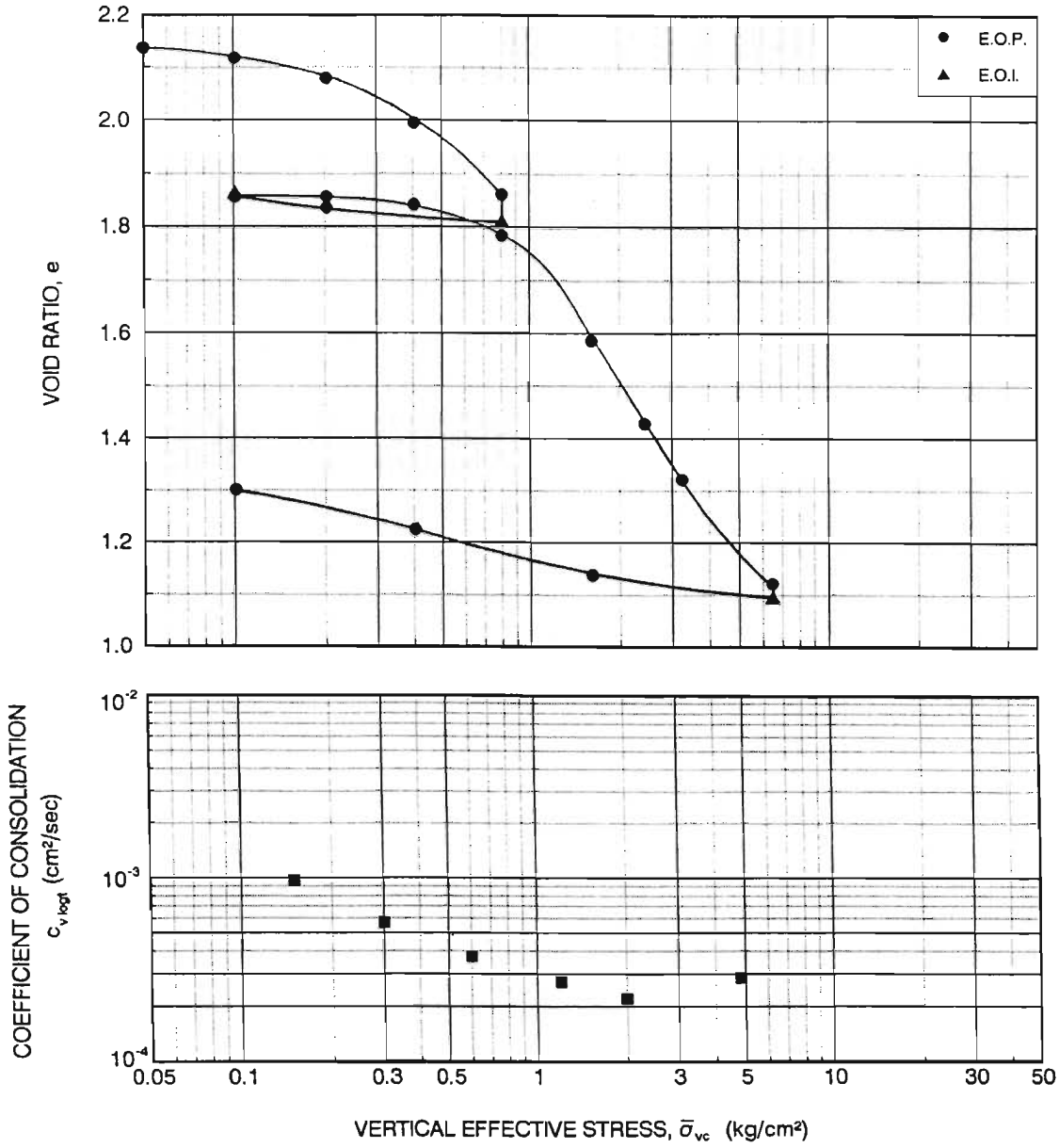
INDEX PROPERTIES	
LIQUID LIMIT (%):	74
PLASTIC LIMIT (%):	37
PLASTICITY INDEX (%):	43
% PASSING NO. 200:	99
SPECIFIC GRAVITY:	2.70

INCREMENTAL LOADING CONSOLIDATION TEST ON SAMPLE CB-CUL-13

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

LABORATORY TESTING
CONTRACT NO. DACW17-98-D-0003
RIO CULEBRINAS PROJECT

DRAWN BY: SA	CHECKED BY: SA	DATE: 08-19-98
FILE NO.: 98-153	APPROVED BY:	FIGURE: 13



SAMPLE DATA

BORING NUMBER:	CB-CUL-14
SAMPLE NUMBER:	--
DEPTH (FEET:	8.0-10.0
DESCRIPTION:	GRAY FAT CLAY WITH THIN SEAMS OF FINE SAND

SPECIMEN CONDITIONS

	INITIAL	FINAL
MOISTURE CONTENT (%):	80.9	51.8
DRY DENSITY (lb/ft³):	52.6	69.7
VOID RATIO:	2.14	1.37
SATURATION (%):	100	100

INDEX PROPERTIES

LIQUID LIMIT (%):	91
PLASTIC LIMIT (%):	29
PLASTICITY INDEX (%):	62
% PASSING NO. 200:	81
SPECIFIC GRAVITY:	2.65

INCREMENTAL LOADING CONSOLIDATION TEST ON SAMPLE CB-CUL-14

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

LABORATORY TESTING
CONTRACT NO. DACW17-98-D-0003
RIO CULEBRINAS PROJECT

DRAWN BY: SA	CHECKED BY: SA	DATE: 08-19-98
FILE NO.: 98-153	APPROVED BY:	FIGURE: 14

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
SECTION 205
FINAL DETAILED PROJECT REPORT
AND ENVIRONMENTAL ASSESSMENT

APPENDIX C
DESIGN AND COST ESTIMATES

RIO CULEBRINAS @ AGUADA/AGUADILLA, PUERTO RICO
DETAILED PROJECT REPORT

Appendix C
Design and Cost Estimates

Table of Contents

Table of Contents (continued)

LIST OF TABLES

LIST OF PLATES

Appendix C
Design and Cost Estimates

A. INTRODUCTION

1. General. This Appendix presents a discussion of applicable design considerations and construction methods utilized to establish a basis for the cost estimates. General requirements for real estate and operation and maintenance are also presented.

B. DESIGN AND CONSTRUCTION

2. Channels. A cutoff channel would be constructed in the flood plain to connect portions of the existing river system. The cutoff channel would bypass that portion of the existing channel that meanders outside of the proposed Aguadilla levee alinement.

3. Levees. Two levees would be constructed in the Rio Culebrinas floodplain to provide 100-year flood protection to the residences of the communities of Aguadilla and Espinar. Conventional earth handling equipment would be used to construct the levees. Construction material would be obtained from the designated borrow area. A geotechnical discussion of the suitability of materials is provided in Appendix B. The levees would be constructed to satisfy the hydraulic requirements presented in Appendix A and would have a minimum crest width of 3.0 meters with side slopes of 1 vertical on 2.5 horizontal (1V:2.5H). Also, both levees would be overbuilt 0.15 to 0.30 meters along certain reaches to compensate for long-term settlement.

Typical sections of the Aguadilla and Espinar levees are provided on Plates C-5 and C-6. The disposition of the materials removed from the project area (including debris), that are unsuitable for levee construction, would be in accordance with paragraph 7b. of this appendix.

4. Drainage Culvert Structures. Drainage culvert structures would be placed through the levees to provide for interior drainage. The Aguadilla levee would have three drainage structures and the Espinar levee would have one drainage structure. All culverts would have an invert elevation of -0.30 meters NVGD, and the corrugated metal pipe (CMP) coating and required thickness would be based on exposure to sea water and soil characteristics. A temporary diversion channel would be constructed at each structure site to divert water during construction.

a. Aguadilla Levee. The drainage structures in the Aguadilla levee would consist of AL-S-1 (3-60" CMP), AL-S-2 (6-60" CMP), and AL-S-3 (3-60" CMP). Flap gates and concrete headwalls with wingwalls would be provided on the floodside end of each structure. Refer to Plates C-2 and C-3 for site plan and typical section.

b. Espinar Levee. The drainage structure in the Espinar levee would consist of EL-S-1a. The structure would have 2-60" CMP with flap gates. A concrete headwall with wingwalls would be provided on the floodside end of the structure. Refer to Plates C-2 and C-3 for site plan and section.

5. Drainage Culverts. A 36-inch CMP culvert would be provided at each road ramp location (3) to maintain interior drainage along the protected side of the levee. Refer to Plate C-4 for a typical site plan and section.

6. Bank Protection. The levees would be grassed to provide general erosion protection. Riprap would be utilized as standard practice in protecting the intake and discharge areas for the proposed culvert drainage structures.

7. Borrow and Disposal Areas.

a. Borrow Area. A detailed geotechnical discussion of the materials within the borrow area is provided in Appendix B. The location of the borrow area is shown on Plate B-2 in Appendix B.

b. Disposal Area. A specific designated disposal area is not required. All debris and unsuitable material from construction of the project features would be placed in the flood plain adjacent to the levees or used as topsoil along the levee.

C. RELOCATIONS

8. General. This project has two local sponsors. The municipality of Aguada would be responsible for the Epinar levee and corresponding features, and the municipality of Aguadilla would be responsible for the Aguadilla levee and corresponding features. The project sponsors would be required to assume the costs for all relocations and alterations. These costs are based on the general alinements shown in the main report. Final alinements would be determined upon completion of detailed topographic surveys and would be adjusted as necessary to minimize impacts on existing structures and utilities. The recommended plan presented in this report would require some road relocations as discussed in the following

paragraphs. All relocation of utilities, electric transmission lines, or telephone lines would be the responsibility of the project sponsor.

9. Road Relocations. Three road ramps would be required where the proposed levee crosses Highway 418, Highway 115, and Highway 442. The road ramps would be constructed prior to construction of the levee, and a temporary road by-pass would be provided at each location. No other road relocations are anticipated. The locations of the proposed road ramps are shown on Plate C-1.

10. PR Hwy 418 Box Culvert. The existing box culvert (bridge) located in Cano Madre Vieja under the highway would be extended approximately 10 meters at each end to accommodate the proposed road ramp.

11. Utilities. Water lines, sewer lines, electric power lines, and telephone lines would require relocation. The location of the areas of anticipated impacts on existing utilities are provided on Plate C-1. The estimated costs for relocation of these utilities are included in the cost estimate.

D. OPERATIONS AND MAINTENANCE

12. General. The project sponsor would be responsible for operation and maintenance of the improvements and features proposed in this report upon completion of the construction project. The Contractor would be responsible for all maintenance during the construction contract.

13. Inspection. Joint field inspections with personnel from the U.S. Army Corps of Engineers and the local sponsor would be conducted on a regular basis to evaluate the performance and condition of the various project features. Additional field inspections would be conducted following a significant storm event.

14. Estimated Annual Costs. The estimated annual operation and maintenance cost for the project is $15,000. These costs are based on removing accumulated debris and sediment adjacent to the control structures and repairing the riprap protection on an annual basis or as required after a significant storm event. Levee maintenance would consist of periodic mowing and erosion repair.

15. O&M Manual. Operation and maintenance of the project facilities would be performed in accordance with instructions prepared and incorporated in the "Operation and Maintenance Manual" which would be furnished to the project sponsor. The O&M Manual would be prepared in accordance with ER 1110-2-401.

E. COST ESTIMATES

16. General. The estimates of first cost for construction of the recommended plan were prepared using M-CACES software and are presented in Table C-1. Also, the cost of the non-construction features of the project is included. The cost estimate includes a narrative, a summary cost, and a detailed cost showing quantity, unit cost, and the amount for contingencies for each cost item.

The cost estimates are prepared for an effective date of October 2003.

TABLE C-1

Rio Culebrinas-100 Yr.Flood Plan

Designed By: CESAJ-EN
Estimated By: Kirby R.Clifton

Prepared By: Kirby R. Clifton & Manuel Perez
Update: M.Perez 10-01-03

Preparation Date: 10/01/03
Effective Date of Pricing: 10/01/03

Sales Tax: 6.00%

M C A C E S G O L D E D I T I O N
Composer GOLD Software Copyright (c) 1985-1994
by Building Systems Design, Inc.
Release 5.30

This planning project cost estimate was updated to reflect cost growth from 10-01-01 to 10-01-03. Civil Works Construction Cost Index System (CWCCIS) was utilized to determine inflation indexes for each individual category, i.e. Relocations, Levees, Channels, etc.

The 100-yr. construction cost estimate presented here reflects the cost changes generated by the revised Espinar Levee alignment, which is now proposed to be placed out of the coastal barrier zone.

This is a planning level cost estimate based on information provided by Design Branch, H&H Branch, Planning Division and Real Estate Division.

The basis of cost include UPB cost data, generic construction cost models, developed cost, as well as previous estimates for this type of project.

Contractor markups of about 30% of construction cost was used.

No specific analysis of labor cost was made. A labor database for P.R. was used. Equipment rates were obtained from the Region 11 1997 EP 1110-1-8. No specific risk analysis was made and a contingency of 25% of the construction cost was used.

Planning, Engineering and Design was placed at 8% of construction cost and Construction Supervision was placed at 10% of construction cost.

** PROJECT OWNER SUMMARY - Feature (Rounded to 100's) **

	QUANTY UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
01 CONSTRUCTION COST					
01_02 Relocations		32,800	8,200	41,000	
01_08 08 Roads, Railroads and Bridges		218,800	54,700	273,500	
01_09 09 Channels and Canals		76,900	19,200	96,100	
01_11 11 Levees and Floodwalls		974,400	243,600	1,218,000	
01_15 15 Floodway Control-Divert. Strt		754,600	188,700	943,300	
TOTAL CONSTRUCTION COST		2,057,500	514,400	2,571,900	
02 NON-CONSTRUCTION COST					
02_01 LANDS AND DAMAGES		1,317,900	395,400	1,713,200	
02_30 PLANNING, ENGINEERING & DESIGN		165,800	41,400	207,200	
02_31 CONSTRUCTION MANAGEMENT		207,200	51,800	259,100	
TOTAL NON-CONSTRUCTION COST		1,690,900	488,600	2,179,500	
TOTAL Rio Culebrinas-100 Yr.Flood Plan		3,748,400	1,003,000	4,751,400	

** PROJECT OWNER SUMMARY - Element (Rounded to 100's) **

		QUANTY	UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
01	CONSTRUCTION COST						
01_02	Relocations						
01_02_03	Cemetery, Utilities, & Structure						
01_02_03_18	Utilities			32,800	8,200	41,000	
	TOTAL Cemetery, Utilities, & Structure			32,800	8,200	41,000	
	TOTAL Relocations			32,800	8,200	41,000	
01_08	08 Roads, Railroads and Bridges						
01_08_01	Roads						
01_08_01_ 1	Mob, Demob & Preparatory Work			10,900	2,700	13,700	
01_08_01_ 2	Excavate and Haul Ramp #1 Fill	6156.00	LCY	15,300	3,800	19,100	3.11
01_08_01_ 4	Construct Ramp #1	5232.00	CCY	18,700	4,700	23,400	4.47
01_08_01_ 5	Paving Ramp #1			35,300	8,800	44,100	
01_08_01_ 6	Excavate and Haul Ramp #2 Fill	6156.00	LCY	15,300	3,800	19,100	3.
01_08_01_ 7	Construct Ramp #2	5232.00	CCY	18,700	4,700	23,400	4.47
01_08_01_ 8	Paving Ramp #2			35,300	8,800	44,100	
01_08_01_ 9	Excavate and Haul Ramp #3 Fill	6156.00	LCY	15,300	3,800	19,100	3.11
01_08_01_10	Construct Ramp #3	5232.00	CCY	18,700	4,700	23,400	4.47
01_08_01_11	Paving Ramp #3			35,300	8,800	44,100	
	TOTAL Roads			218,800	54,700	273,500	
	TOTAL 08 Roads, Railroads and Bridges			218,800	54,700	273,500	
01_09	09 Channels and Canals						
01_09_01	Cutoff Canal						
01_09_01_02	Canal Excavation	10400	CY	25,200	6,300	31,400	3.02
01_09_01_07	Clearing and Grubbing - no haul	1.00	ACR	400	100	500	515.62
	TOTAL Cutoff Canal	225.00	LM	25,600	6,400	32,000	142.04
01_09_02	Interior Drainage Channels						
01_09_02_01	Channel Excavation	21700	LCY	48,500	12,100	60,600	2.79
01_09_02_02	Clearing and Grubbing	7.00	ACR	2,900	700	3,600	515.
	TOTAL Interior Drainage Channels	3456.00	LM	51,300	12,800	64,200	18.57

** PROJECT OWNER SUMMARY - Element (Rounded to 100's) **

	QUANTY UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
TOTAL 09 Channels and Canals		76,900	19,200	96,100	
01_11 11 Levees and Floodwalls					
01_11_01 Aguadilla Levee					
01_11_01_ 1 Mob, Demob & Preparatory Work		23,400	5,900	29,300	
01_11_01_ 2 Excavate and Haul Levee Fill	51746 CCM	261,900	65,500	327,400	6.33
01_11_01_ 4 Construct Levee	51746 CCM	225,200	56,300	281,500	5.44
TOTAL Aguadilla Levee	51746 CCM	510,500	127,600	638,100	12.33
01_11_02 Espinar Levee					
01_11_02_ 1 Mob, Demob & Preparatory Work		19,300	4,800	24,100	
01_11_02_ 2 Excavate and Haul Levee Fill	46800 CCM	239,000	59,800	298,800	6.38
01_11_02_ 4 Construct Levee	46800 CCM	205,500	51,400	256,900	5.49
TOTAL Espinar Levee	46800 CCM	463,900	116,000	579,800	12.39
TOTAL 11 Levees and Floodwalls		974,400	243,600	1,218,000	
01_15 15 Floodway Control-Divert. Strt					
01_15_02 CMP @ Ramps & Internal Channel					
01_15_02_01 3' CMP @ Ramp & Internal Channel	3.00 EA	74,400	18,600	93,000	30999
TOTAL CMP @ Ramps & Internal Channel		74,400	18,600	93,000	
01_15_04 Culvert AL-S-1					
01_15_04_01 3 - 60" CMP w/Flapgate	1.00 EA	124,200	31,000	155,200	155245
TOTAL Culvert AL-S-1		124,200	31,000	155,200	
01_15_09 Culvert AL-S-2					
01_15_09_01 6 - 60" CMP w/Flapgate	1.00 EA	290,800	72,700	363,500	363512
TOTAL Culvert AL-S-2		290,800	72,700	363,500	
01_15_10 Culvert AL-S-3					

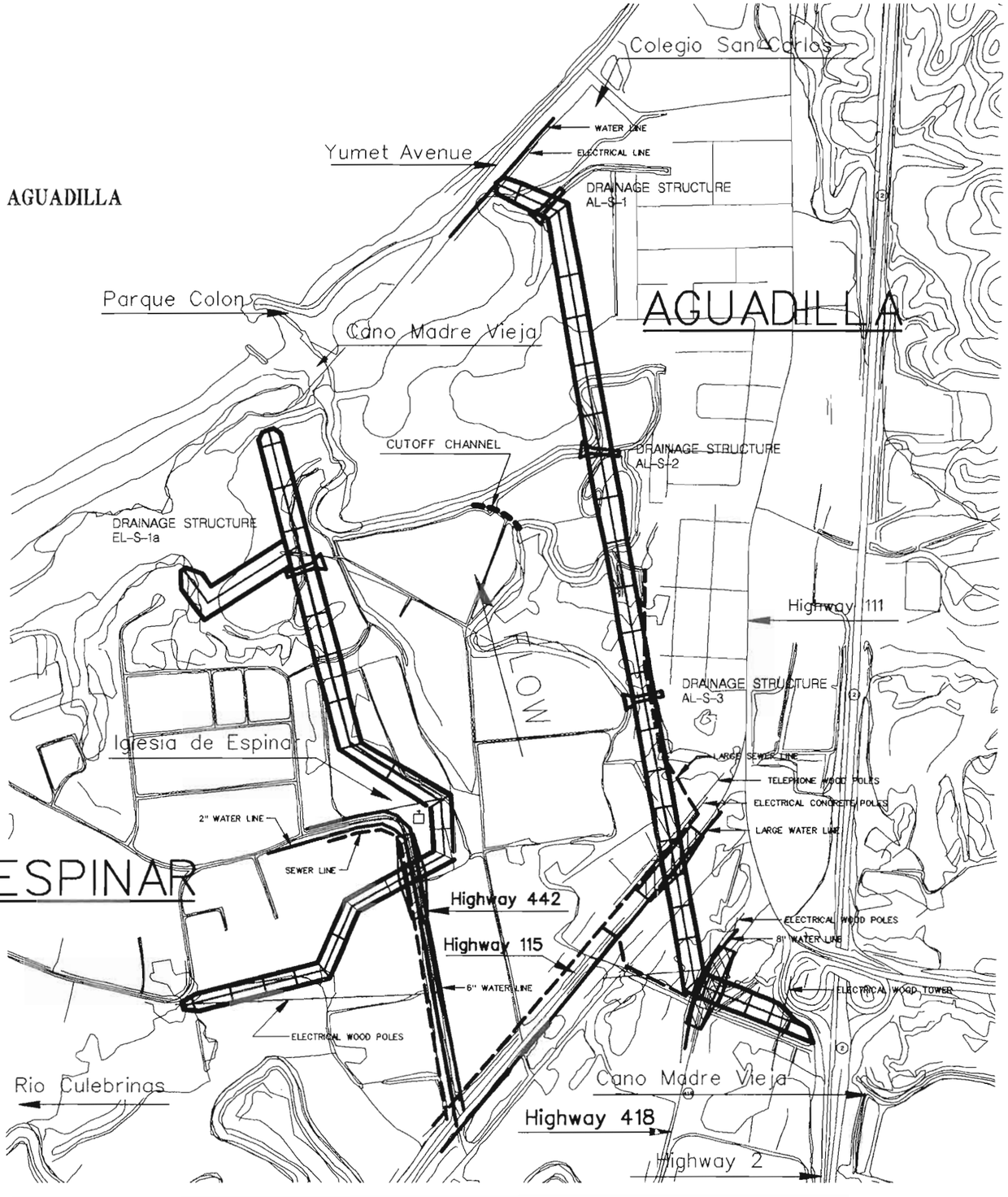
** PROJECT OWNER SUMMARY - Element (Rounded to 100's) **

		QUANTY	UOM	CONTRACT	CONTINGN	TOTAL COST	UN.
01_15_10_01	3 - 60" CMP w/Flapgate	1.00	EA	130,700	32,700	163,400	163351
	TOTAL Culvert AL-S-3			130,700	32,700	163,400	
01_15_11	Culvert EL S-1A						
01_15_11_01	2-60" CMP w/gates	1.00	EA	102,200	25,500	127,700	127719
	TOTAL Culvert EL S-1A			102,200	25,500	127,700	
01_15_12	Extend Concrete Box Culvert						
01_15_12_01	Headwall Foundations	9.00	CY	1,600	400	2,000	218.23
01_15_12_02	Bottom Slab	28.00	CY	4,900	1,200	6,100	218.99
01_15_12_03	Cut-off Walls	7.00	CY	3,400	800	4,200	604.52
01_15_12_04	Headwalls or Wingwalls	8.00	CY	3,000	800	3,800	473.57
01_15_12_05	Box Walls	39.00	CY	9,900	2,500	12,400	318.78
01_15_12_06	Top Slab	28.00	CY	9,500	2,400	11,900	425.83
	TOTAL Extend Concrete Box Culvert	123.00	CY	32,400	8,100	40,500	329.0
	TOTAL 15 Floodway Control-Divert. Strt			754,600	188,700	943,300	
	TOTAL CONSTRUCTION COST			2,057,500	514,400	2,571,900	
02	NON-CONSTRUCTION COST						
02_01	LANDS AND DAMAGES						
02_01_01	Lands and Damages			1,317,900	395,400	1,713,200	
	TOTAL LANDS AND DAMAGES			1,317,900	395,400	1,713,200	
02_30	PLANNING, ENGINEERING & DESIGN						
02_30_30	Planning, Engineering & Design			165,800	41,400	207,200	
	TOTAL PLANNING, ENGINEERING & DESIGN			165,800	41,400	207,200	
02_31	CONSTRUCTION MANAGEMENT						
02_31_31	Construction Management			207,200	51,800	259,100	
	TOTAL CONSTRUCTION MANAGEMENT			207,200	51,800	259,100	

** PROJECT OWNER SUMMARY - Element (Rounded to 100's) **

	QUANTY	UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
TOTAL NON-CONSTRUCTION COST			1,690,900	488,600	2,179,500	
TOTAL Rio Culebrinas-100 Yr.Flood Plan			3,748,400	1,003,000	4,751,400	

BAHIA DE AGUADILLA



N

CMP DRAINAGE STRUCTURES

ROAD RAMP ACROSS LEVEE

C:\des\culbrnas\utility.dgn

DESIGN ENG.:	
REH	
DWN. BY:	CHD. BY:
REH	

RIO CULEBRINAS @ AGUADA /AGUADILLA, PUERTO RICO
DETAILED PROJECT REPORT

PROJECT PLAN

ROAD RAMPS / UTILITIES RELOCATIONS

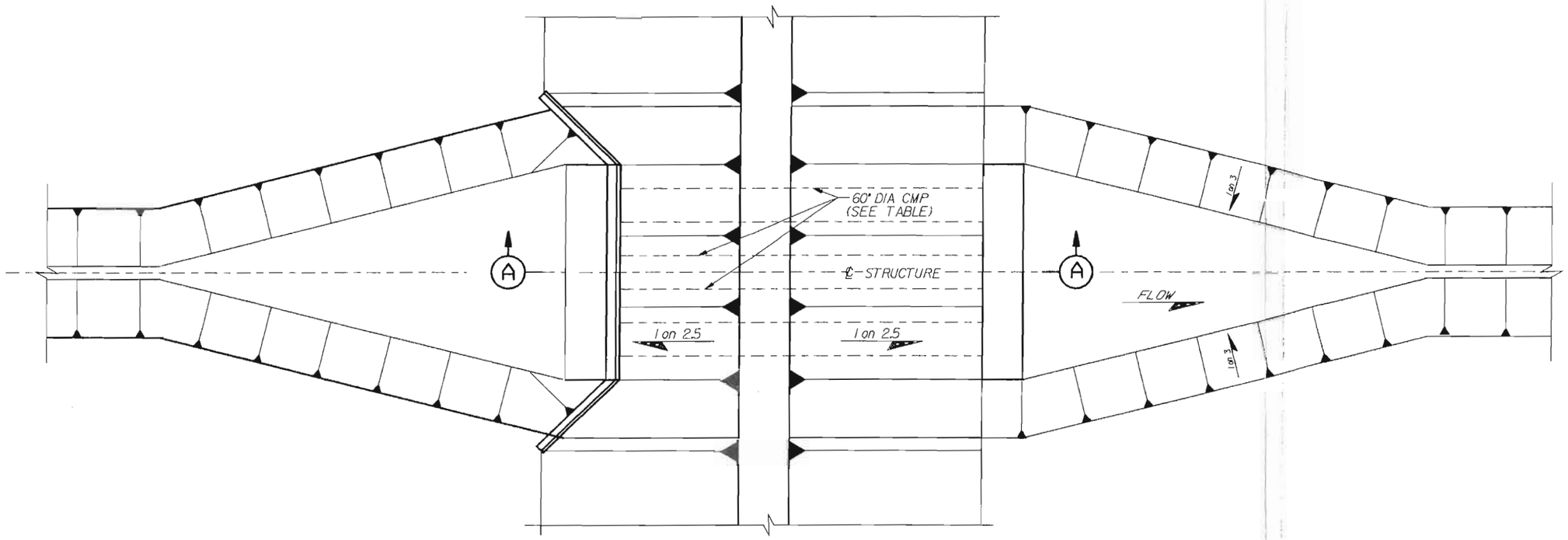
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

NOT TO SCALE

DATE: NOVEMBER 1999

(REVISED: MARCH 2001)

PLATE C-1



SITE PLAN

RIO CULEBRINAS @ AGUADA /AGUADILLA, PUERTO RICO
DETAILED PROJECT REPORT

AQUADILLIA / ESPINAR CONTROL STRUCTURES

SITE PLAN

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

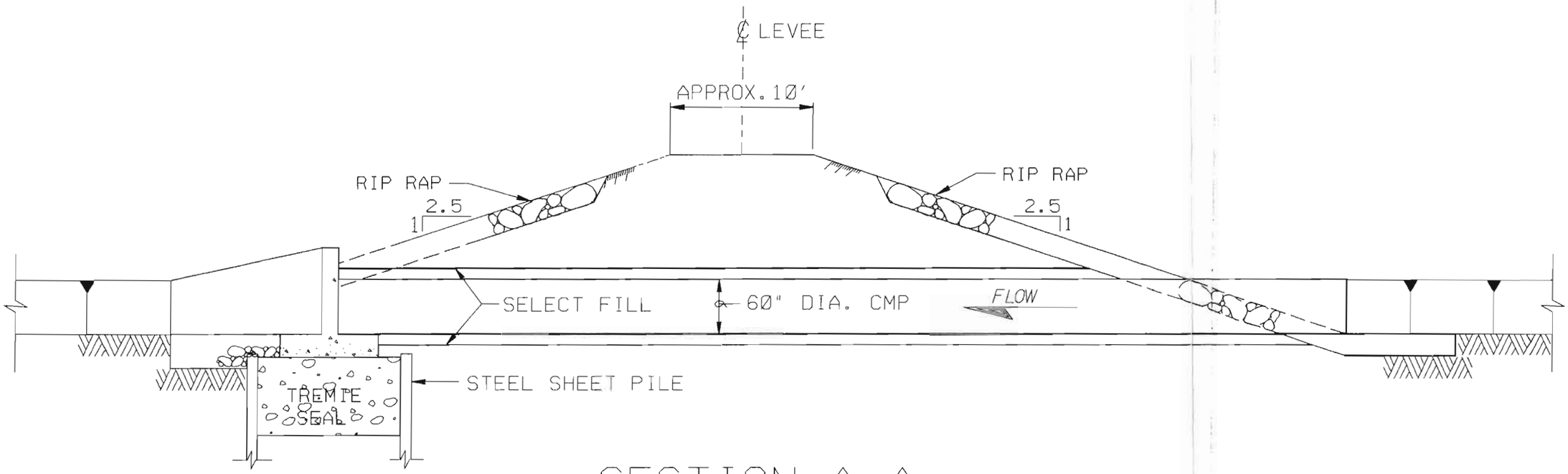
DESIGN ENG.:	
J.D.H.	
DWN BY:	CKD BY:
D.W.P.	

NOT TO SCALE

NOVEMBER 1999

(REVISED: MARCH 2001)

PLATE C-2



SECTION A-A

STRUCTURE	LEVEE STATION	NO CMP	CMP SIZE (INCHES)	GATE TYPE	INVERT EL. (FEET)	CHANNEL INVERT (FEET)	TOP OF LEVEE (FEET)	TOTAL LEGNTH OF PIPE (FEET)
AL-S-1	1+39.5	3	60	FLAP	-1.0	-1.0	12.04	215
AL-S-2	6+05.5	6	60	FLAP	-1.0	-1.0	14.34	946.1
AL-S-3	10+52.9	3	60	FLAP	-1.0	-1.0	15.35	275
EL-S-1A	2+50.0	2	60	FLAP	-1.0	-1.0	14.44	315

NOTE:

HEADWALL DISTANCE DOES NOT INCLUDE WINGWALL DISTANCE.

DESIGN ENG.: J.D.H.	
DWN BY: J.D.H	CKD BY:

RIO CULEBRINAS @ AGUADA /AGUADILLA, PUERTO RICO
DETAILED PROJECT REPORT

AGUADILLA / ESPINAR CONTROL STRUCTURE

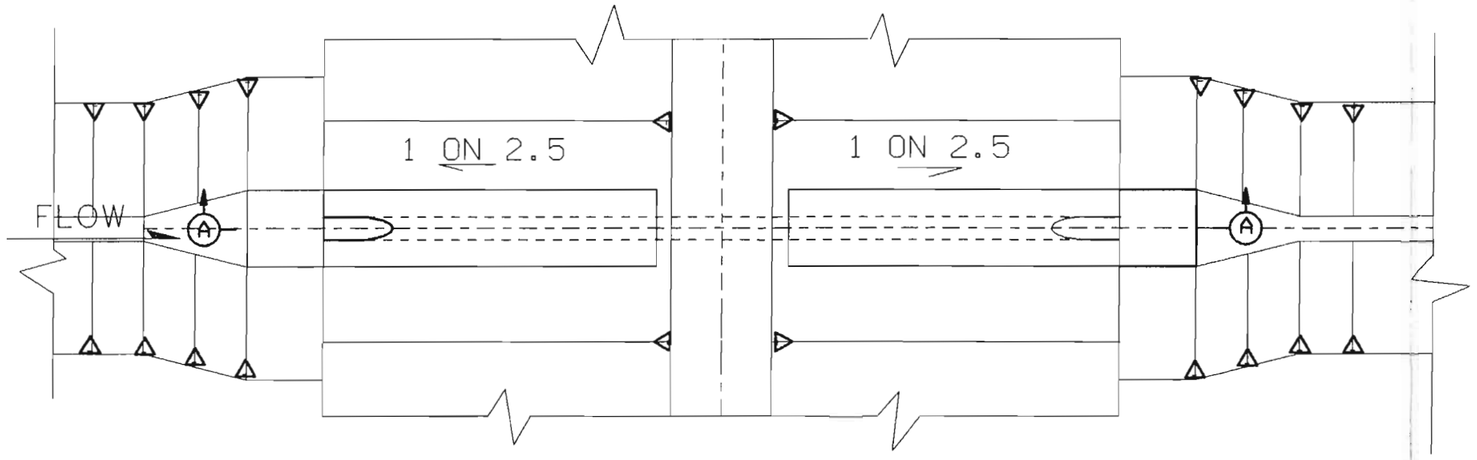
TYPICAL SECTION

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

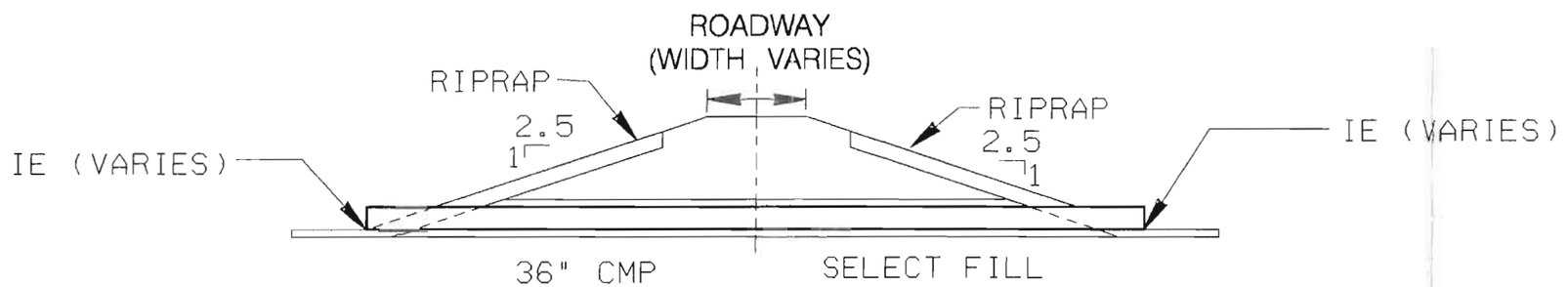
NOVEMBER 1999

(REVISED: MARCH 2001)

PLATE C-3



TYPICAL 36" CMP CULVERT PLAN



SECTION

RIO CULEBRINAS @ AGUADA /AGUADILLA, PUERTO RICO
DETAILED PROJECT REPORT

TYPICAL 36" CMP CULVERT STRUCTURE
SITE PLAN AND SECTION

DESIGN ENG.: J.D.H.
DWN BY: | CKD BY:

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

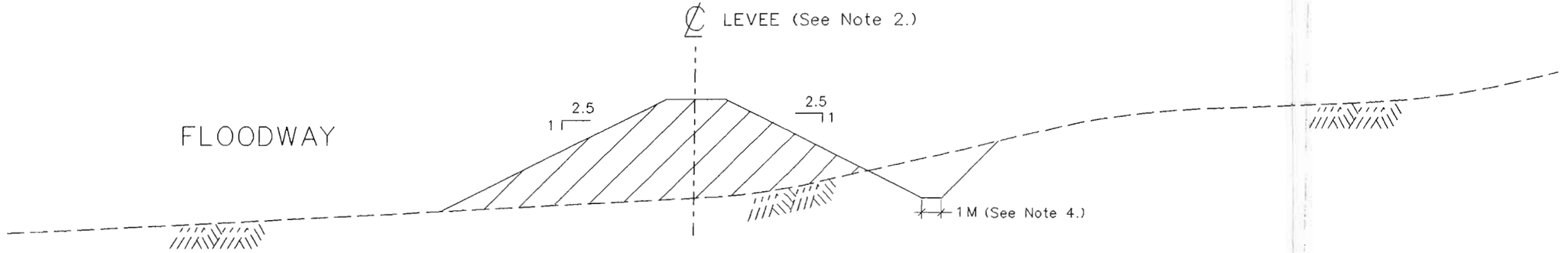
NOT TO SCALE NOVEMBER 1999

(REVISED: MARCH 2001)

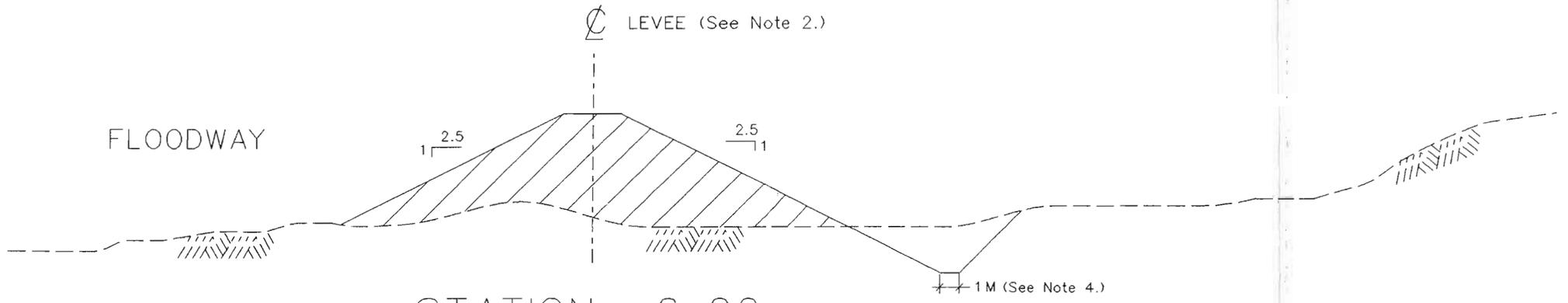
PLATE C-4

WEST

EAST



STATION 12+00



STATION 6+00

NOTES:

1. DRAINAGE STRUCTURES WOULD BE PROVIDED THROUGH THE LEVEES AT APPROXIMATELY AS FOLLOWS:
AL-S-1 AT STATION 1+39.5 (3-60" CMP W/ FLAPGATES)
AL-S-2 AT STATION 6+05.5 (6-CMP" CMP W/ FLAPGATES)
AL-S-3 AT STATION 10+52.9 (3-60"CMP W/ FLAPGATES)

2. LEVEE CROWN WIDTH IS 3 METERS. ELEVATIONS AT STATION POINTS ALONG THE LEVEE ARE PROVIDED IN APPENDIX A.

3. ROAD RAMPS WOULD BE CONSTRUCTED AT PR HIGHWAYS 115 AND 418, AND LOW-FLOW DRAINAGE CULVERTS WOULD BE INSTALLED ON THE PROECTED SIDE OF THE LEVEE.

4. INVERT ELEVATION VARIES. REFER TO TABLE A-9 IN APPENDIX A.

C:\des\culbrnas\typsec.dgn

DESIGN ENG.:	
REH	
DWN. BY:	CKD. BY:
REH	

RIO CULEBRINAS @ AGUADA /AGUADILLA, PUERTO RICO
DETAILED PROJECT REPORT

TYPICAL SECTIONS

AGUADILLA LEVEE

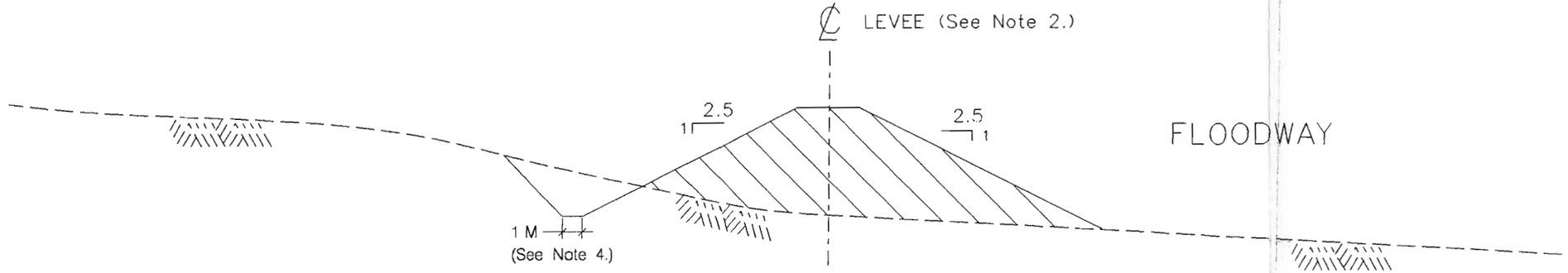
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

NOT TO SCALE NOVEMBER 1999

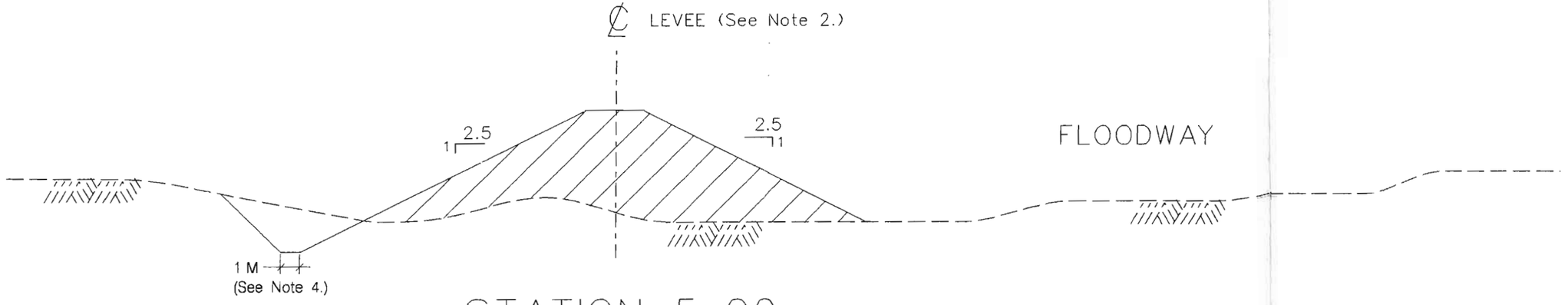
(REVISED: MARCH 2001) PLATE C-5

WEST

EAST



STATION 10+00



STATION 5+00

NOTES:

1. A DRAINAGE STRUCTURE EL-S-1a WOULD BE PLACED THROUGH THE LEVEE AT APPROXIMATELY STATION 2+50. STRUCTURE WOULD CONSIST OF 2-60" CMP WITH FLAPGATES.

2. LEVEE CROWN WIDTH IS 3 METERS. ELEVATIONS AT STATION POINTS ALONG THE LEVEE ARE PROVIDED IN APPENDIX A.

3. A ROAD RAMP WOULD BE CONSTRUCTED AT PR HIGHWAY 442, AND A LOW-FLOW DRAINAGE CULVERT WOULD BE INSTALLED ON THE PROTECTED SIDE ON THE LEVEE.

4. INVERT ELEVATION VARIES. REFER TO TABLE A-9 IN APPENDIX A.

DESIGN ENG.:	
REH	
DWN. BY:	CKD. BY:
REH	

RIO CULEBRINAS @ AGUADA /AGUADILLA, PUERTO RICO
DETAILED PROJECT REPORT

TYPICAL SECTIONS

ESPINAR LEVEE

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

NOT TO SCALE NOVEMBER 1999

(REVISED: MARCH 2001) PLATE C-6

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
SECTION 205
FINAL DETAILED PROJECT REPORT
AND ENVIRONMENTAL ASSESSMENT

APPENDIX D
REAL ESTATE PLAN

TABLE OF CONTENTS

Plate D-1

2/00 bam
Revised 9/00,12/00,7/01,10/03 bam

1. STATEMENT OF PURPOSE

a. This Real Estate Plan is tentative in nature for planning purposes only and both the final real property acquisition lines and the real estate cost estimates provided are subject to change even after approval of this Detailed Project Report (DPR).

b. A reconnaissance report for this project was completed on March 1992, which showed that a levee alternative to solve the flooding problem at the study area appeared to be feasible and that further detailed studies were warranted. The Municipalities of Aguadilla and Aguada are the local sponsors for the project.

2. AUTHORIZATION

This study was authorized by Section 205 of the Flood Control Act of 1948 as amended, which states:

The Secretary of the Army is hereby authorized to allot from any appropriations heretofore or hereafter made for flood control, not to exceed $40,000,000 for any one fiscal year, for the construction of small projects for flood control and related purposes not specifically authorized by Congress, which comes within the provisions of Section 1 of the Flood Control Act of June 22, 1936, when in the opinion of the Chief of Engineers such work is advisable. The amount allotted under this Section for a project shall be sufficient to complete Federal participation in the project. Not more than $7,000,000 shall be allotted for a project at any single locality. The provisions of local cooperation specified in Section 3 of the Flood Control Act of June 22, 1936, as amended, shall apply. The work shall be complete in itself and not commit the United States to any additional improvements to insure its successful operation, except as may result from the normal procedure applying to projects authorized after submission of preliminary examination and survey reports.

3. PROJECT DESCRIPTION

The Rio Culebrinas Basin is located in the northwestern coast of Puerto Rico within the Municipalities of Lares, San Sebastian, Moca, Aguada, and Aguadilla, approximately 115 kilometers west of San Juan. Flooding is a major frequent

problem along the southwestern edge of the town of Aguadilla and the community of Espinar.

Rio Culebrinas originates in the western part of the central mountain range of Puerto Rico at an elevation of about 450 meters (1,500 feet) above mean sea level. Its major tributaries are Rio Guatemala, Rio Caño, Rio Sonador, and Quebrada Grande. The river flows in a westerly direction through the towns of San Sebasián, Moca, Aguadilla, and Aguada to discharge into the Aguadilla Bay in the Mona Passage. The Caño Madre Vieja, a 2.1 kilometer (1.3 miles) distributary of Rio Culebrinas, is an old river outlet that flows across the study area and discharges into the Aguadilla Bay. This small intermittent stream is the political boundary dividing the Municipalities of Aguadilla and Aguada.

The land in the project and vicinity of the project is predominately agricultural/grazing land within the floodway, further defined as Flood Zone 1. The floodway is defined as:

> *The water course of the channel, river, creek, brook, or natural drainage channel and that portion of adjacent lands to permit the discharge of the base flood without cumulatively increasing the water surface elevation by more than one foot in undeveloped areas, or six inches in developed areas.*

Flood Zone 2 is defined as the area situated between the floodway limits and the limits of the 100-year floodplain. Flood Zone 2 regulations permit new buildings in this zone when these are defined and constructed in such a way that will cause the least possible obstruction to the flow of water, will provide safety conditions, will resist the effects of hydrodynamic and hydrostatic pressures of floodwater or coastal surges, and comply with any other applicable provision of law or regulation.

These definitions are the Government of Puerto Rico Planning Board's Regulation for Floodable Zones, Regulation 13, Second Revision dated March 6, 1987.

The agricultural/grazing land located in the floodway (Flood Zone 1) would still be subject to flooding after the project is implemented, though at considerably less stages than pre-project flooding. Flood Zone 1 restricts land uses to exclude new construction, structures, landfills, substantial improvements or other developments. The Puerto Rico Planning Board will maintain these lands under flood

plain regulations to prohibit development as will be specified in the proposed Project Cooperation Agreement (PCA).

The recommended plan consists of the construction of two levees, interior drainage facilities, 3 road ramps, and a pilot channel that requires approximately 40 acres of land and protects the southwestern section of the town of Aguadilla and the community of Espinar, in Aguada, against the 100-year flood from Rio Culebrinas.

The Aguadilla levee would require approximately 24.20 acres of land and would begin at high ground near Highway 2 and extend towards the north for about 1.8 kilometers to end at high ground near Yumet Avenue. There will be three drainage structures and two road ramps for this levee segment. An interior drainage channel would be required along the protected side of the levee. A culvert will be provided where the road ramps intersects the interior drainage channel. An existing concrete box culvert over Cano Madre Vieja would be impacted by one of the road ramps. This box culvert should be extended to accommodate the road ramp.

The alignment of the proposed Espinar levee has been modified to start outside of the coastal barrier zone thus avoiding any impacts to it. It is about 120 meters or 1.26 acres shorter than what was presented in the first draft report and requires approximately 16.24 acres of land. To protect the lower lying eastern side of the community, a levee spur with an interior drainage channel that is about 266 meters long ties between the coastal barrier zone and the residential area perpendicular to the original levee at the northeast corner of the Espinar community. It covers about 1.23 acres of floodable wetlands and .5 acre of residential area. See Plate D-1. A drainage structure would be constructed for the Espinar levee spur at Espinar levee station 2+50. There would also be a road ramp intersecting the levee at Highway 442.

In order to continue the flow in Cano Madre Vieja to the coastline, a cutoff channel would be required. The cutoff channel would require approximately 1.3 acres of land.

No disposal area would be required. Unsuitable materials and debris from clearing and grubbing operation would be deposited at the municipal landfill. Material from pilot and drainage channels would be used for levee construction and the rest would come from a commercial

borrow site at Tablonal Quarry which is not part of the real estate valuation.

Construction access will be through local public streets and highways. Final access will be determined during the plans and specifications.

The three required road ramps are where the levee crosses Highways 418, 115, and 442. These are further addressed under 15a, Road Relocations. As to Highway 4439, it will be blocked since the Municipality has no interest in keeping it open.

No residential or commercial improvements are known to be affected by this project.

4. FEDERAL OWNED LANDS

There are no federally owned lands within the project limits.

5. SPONSOR OWNED LANDS

The non-Federal sponsors will be responsible for providing all lands, easements and rights-of-way required for the project. No lands required for the project have been identified as sponsor-owned lands. However, all ownerships will be verified and delineated during the preparation of the parcel maps to be performed during plans and specifications.

6. ESTATES

a. Standard Estates

The following standard estates will be required.

FLOOD PROTECTION LEVEE EASEMENT

A perpetual and assignable right and easement in (the land described in Schedule A) (Tracts Nos. _____, _____, & _____) to construct, maintain, repair, operate, patrol and replace a flood protection levee, including all appurtenances thereto; reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

CHANNEL IMPROVEMENT EASEMENT

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (the land described in Schedule A) (Tracts Nos. ___ and ___) for the purposes as authorized by the Act of Congress approved _____, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions therefrom; to excavate, dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT OR OTHER NON-STANDARD ESTATE

A temporary and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. ___ & ___), for a period not to exceed three (3) years, beginning with date possession of the land is granted to the Project Sponsor, for use by the Project Sponsor and the U.S. Army Corps of Engineers, their representatives, agents, assigns and contractors as a work area, including the right to move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of Rio Culebrinas Flood Control Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

b. Non-Standard Estates

Due to the lengthy process required to segregate public lands and record legal documents to secure easements, lands to be transferred between governmental agencies is usually accomplished by first executing a Right-of-Entry with Intent to Acquire or a letter permit whereby each entity agrees on the conditions of the transfer, estates and acreage to be transferred and timeframe for completion of transfer. These documents vary in format but are always perpetual, irrevocable, and assignable. In Puerto Rico, they are considered legal, binding documents.

7. NAVIGATION SERVITUDE

Navigational servitude is available to the Federal Government if lands required for this project are within the navigable waters of the United States.

8. PROJECT MAP

A planning map of the project features is included in Plate D-1 along with a map showing the location of the utilities.

9. INDUCED FLOODING

A Takings Analysis prepared August 7, 2003, concluded that "the modeled results for the 10, 25, 50, and 100-year flood on the Rio Culebrinas and Caño Madre Vieja show that there is a very slight increase, 1 to 2 hours at most, in the duration of the flooding in the pooling area. However, the estimated depth of the flooding would decrease in each event modeled at both the highest and lowest elevations in the subject area. Further, the frequencies of the projected events are not substantial. Therefore, in light of current available modeling data and relevant case law, there is no taking in the pooling area behind the northeast portion of the Aguadilla levee." The area will still be subject to flooding with project implementation, though at considerably less stages than pre-project flooding.

10. REAL ESTATE BASELINE COST ESTIMATE

Lands and Damages (Approx. 45 acres):

Flood Protection Levee Easements:	
Espinar Levee (16.24 acres)	$ 516,000
Aguadilla Levee (24.20 acres)	$ 557,000

Espinar Levee Spur (1.73 acres)	$ 59,000
Channel Improvement Easement (1.30 acres)	$ 5,000
Sub-Total	$1,137,000
Total Lands and Damages	$1,137,000

Acquisition/Administrative Costs

Federal:	
Project Planning	$ 21,000
Review of PCA	$ 2,000
Review of Acquisitions	$ 11,000
Review of Appraisals	$ 6,000
Review of Condemnation	$ 13,000
Review of PL 91-646	$ 0
Total Federal Acquisition/ Admin Costs	$ 53,000
Non-Federal:	
Acquisitions	$ 32,000
Appraisals	$ 16,000
Condemnations	$ 80,000
PL 91-646	$ 0
Total Non-Federal Acquisition/ Admin Costs	$ 128,000
Public Law 91-646 Payments	$ 0
Contingency (30%) (RD)	$ 395,200
Total Estimated Real Estate Costs (RD)	$ 1,713,200

*A contingency of 30% is estimated to cover uncertainties associated with such elements as valuation variance, negotiation latitude, condemnation awards and interest, and refinement of boundary lines during ownership verification.

11. RELOCATION ASSISTANCE BENEFITS

We do not anticipate any benefits under Public Law 91-646.

12. MINERALS

No known minerals exist in the project area.

13. NON-FEDERAL SPONSOR'S AUTHORITY TO PARTICIPATE

This project has two local sponsors. The Municipality of Aguada would be responsible for the Espinar levee and corresponding features, and the Municipality of Aguadilla would be responsible for the Aguadilla levee and corresponding features. Municipalities within Puerto Rico are empowered by Section 821 of Title 29 of the Statutes of Puerto Rico to construct public works projects in conjunction with agencies of the United States through contracts. This section also provides authority to bond and expend monies therefore. Municipalities are also an autonomous local government whose operations are subject to the Constitution of the Commonwealth of Puerto Rico, and to the Puerto Rico Law for Municipalities, Act 81 of August 30, 1991. Municipalities also have legislative and administrative powers under Section 1107 of Title 21 for municipal purposes to construct public works including the power to acquire lands and equipment necessary and convenient thereto.

14. REAL ESTATE MILESTONES

Acquisition will be initiated after execution of the Project Cooperation Agreement. All lands needed for the project must be acquired and certified to the Federal Government prior to the advertising of project construction contracts. It is estimated to take approximately two years to acquire project lands.

15. RELOCATION OF ROADS, BRIDGES, UTILITIES, TOWNS, AND CEMETERIES

The project sponsors would be required to assume the cost for all relocations and alterations involved with this project. Although this real estate appendix describes the relocations and alterations, it does not include any costs associated with the relocated structures. An Attorney's Opinion of Compensability will have to be requested for the road ramps and the relocation of the utilities to determine if there is a compensable interest in these relocations.

a. Roads

Three road ramps would be required where the proposed levee crosses Highway 418, Highway 115, and Highway 442. These are relocations in place that are located within the levee right-of-way. Since no temporary construction work areas have been delineated for the road ramps, a higher than usual contingency of 30% has been applied to the real estate cost estimate. Any required temporary construction areas will be addressed during plans and specifications.

A detour road will be required for Highway 442 ramp and will be identified during plans and specifications and upon coordination with the Puerto Rico Highway and Transportation Authority. Highway 418 could be used as a detour while working on Highway 115 and vice versa. The locations of the proposed road ramps are shown on Plate C-1.

b. Bridges

There are no bridges affected by this project, except for an existing box culvert located in Cano Madre Vieja under Highway 418 that would have to be extended approximately 10 meters at each end to accommodate the proposed road ramp.

c. Utilities

There are water lines, sewer lines, electric power lines, and telephone lines that would require relocation. The location of the existing utilities and costs associated with these utilities are provided in the attached map.

d. Towns

There are no reestablishment of towns for this project.

e. Cemeteries

There are no identified cemeteries located on lands to be acquired for the project.

16. PRESENCE OF CONTAMINANTS (HAZARDOUS, TOXIC AND RADIOACTIVE WASTES)

There are no known hazardous, toxic, and radiological waste (HTRW) sites within the project area. An initial HTRW assessment was conducted in May 1995 and updated in May 1999. The assessment included an investigation of the water

quality and air quality potential impacts in the project area, review of available literature and documents, and site reconnaissance. The predominant land use is agricultural and poses little or no HTRW threat. No signs of potential HTRW problems were identified and no sites with potential for contamination with HTRW were found.

17. ATTITUDE OF LANDOWNERS

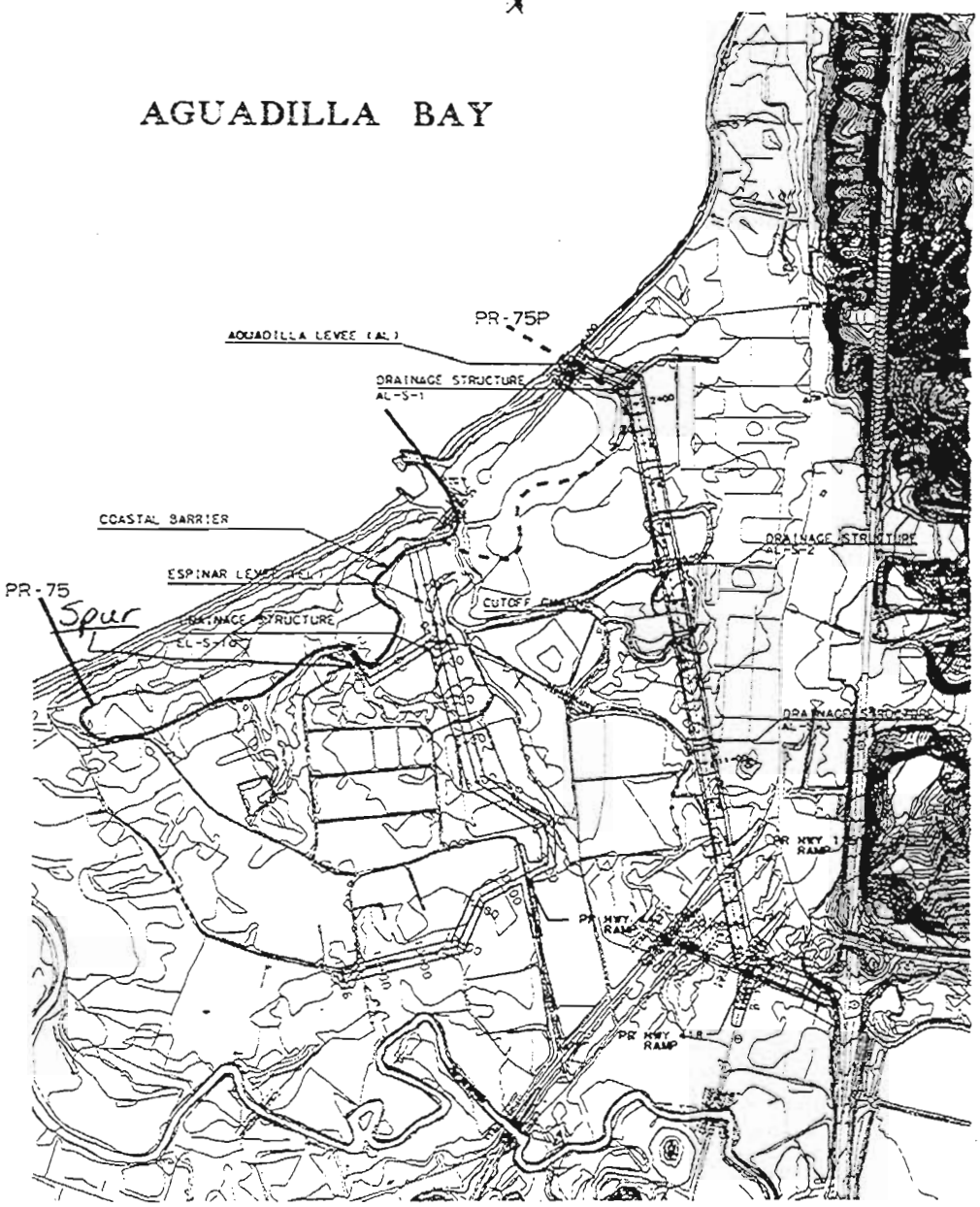
Various interested groups and residents of the floodplain are in support of this project. They have been involved in the coordination effort early on.

18. MCACES

PROJECT: RIO CULEBRINAS FLOOD CONTROL PROJECT, PR
DETAILED PROJECT REPORT
DATE: 2/00; Rev. 9/00, 7/01

01	LANDS AND DAMAGES		
01AA	PROJECT PLANNING	$21,000	
01B--	ACQUISITIONS		
01B20	BY LOCAL SPONSOR (LS)	$32,000	
01B40	REVIEW OF LS	$11,000	
01C-	CONDEMNATIONS		
01C20	BY LS	$80,000	
01C40	REVIEW OF LS	$13,000	
01E--	APPRAISALS		
01E30	BY LS	$16,000	
01E50	REVIEW OF LS	$ 6,000	
01F--	PL 91-646 ASSISTANCE		
01F20	BY LS	$ 0	
01F40	REVIEW OF LS	$ 0	
01G--	TEMPORARY PERMITS/LICENSES RIGHTS-OF-ENTRY		
01G20	BY LS	$ 0	
01G40	REVIEW OF LS	$ 0	
01G60	DAMAGE CLAIMS		
01M00	PROJECTED RELATED ADMINISTRATION		
	REAL ESTATE REVIEW OF PCA	$ 2,000	
01R--	REAL ESTATE PAYMENTS		
01R1	LAND PAYMENTS		
01R1B	BY LS	$1,137,000	
01R2	PL 91-646 ASSISTANCE PAYMENTS		
01R2B	BY LS	$ 0	

TOTAL REAL ESTATE COST EXCLUDING CONTINGENCY	**$1,318,000**
REAL ESTATE CONTINGENCY (30%) (RD)	**$ 395,200**
TOTAL PROJECT REAL ESTATE COST (RD)	**$1,713,200**



DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

US Army Corps of Engineers
Jacksonville District

RIO CULEBRINAS AT AGUADA/AGUADILLA
PUERTO RICO

DETAILED PROJECT REPORT
RECOMMENDED PLAN

File name:
Reference files:
Designed by:
Drawn by:
Checked by:
Scale:
Plot date: JULY 1999
D.O. FILE NO.

PLATE
D-1

...\Rio Culebrinas\plate2.dgn 03/15/01 01:36:24 PM

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
SECTION 205
FINAL DETAILED PROJECT REPORT
AND ENVIRONMENTAL ASSESSMENT

APPENDIX E
ECONOMIC ANALYSIS

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

APPENDIX E
ECONOMIC ANALYSIS

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

TABLE OF CONTENTS (Cont.)

LIST OF FIGURES

TABLE OF CONTENTS (Cont.)

LIST OF PLATES
(Plates follow text)

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

APPENDIX E
ECONOMIC ANALYSIS

I. INTRODUCTION

A. General

The Río Culebrinas Detailed Project Report is being conducted under Section 205 of the Flood Control Act of 1948, as amended.

The study area is located southwest of the town of Aguadilla and at Espinar Ward, northeast of Aguada. This appendix describes the social and economic conditions pertaining to the detailed Río Culebrinas floodplain. A description of the estimated flood damage induced by the river for existing and future conditions, as well as the benefits to be derived from the implementation of alternative flood control plans for the area, are discussed.

B. Social and Economic Profile

The municipalities of Aguadilla and Aguada are included in the western region of Puerto Rico, as established by the Puerto Rico Planning Board. This region located in the most western part of Puerto Rico, includes the municipalities of Aguada, Aguadilla, Añasco, Cabo Rojo, Guánica, Hormigueros, Isabela, Lajas, Mayagüez, Moca, Rincón, Sabana Grande, and San Germán. Aguadilla is one of the three development centers of the region. It has a territorial extension of 94.8 square kilometers and a population density of 626 persons per square kilometer. Aguada, located south west of Aguadilla has a territorial area of 80.1 square kilometers and a population density of 448.3 persons per square kilometer. They are located about 130 kilometers from the San Juan Metropolitan Area.

The city of Aguadilla is one of the largest urbanized areas on this part of the island. The economic base of the municipality revolves around major manufacturing activities, trade, educational, and health services. The second most important airport in Puerto Rico is located at Aguadilla's former Ramey Air Force Base.

1. Population. The total population for the Municipalities of Aguadilla and Aguada grew from 86,173 inhabitants in 1980 to 95,246 in 1990 for an increase of 10.5 percent. According to US Census Bureau estimates for July 1998, the municipality of Aguadilla showed an increase of 12 percent for a total population of 66,404. Aguada also showed a change of 9.6 percent for a total population of 39,347. The Community

of Espinar, which is part of Aguada, had a total population of 1,382 in 1990 and estimated 1,600 inhabitants in 1998. The population of the two municipalities, according to the Puerto Rico Planning Board, is expected to grow to 106,200 in 2005. See Figure E-1.

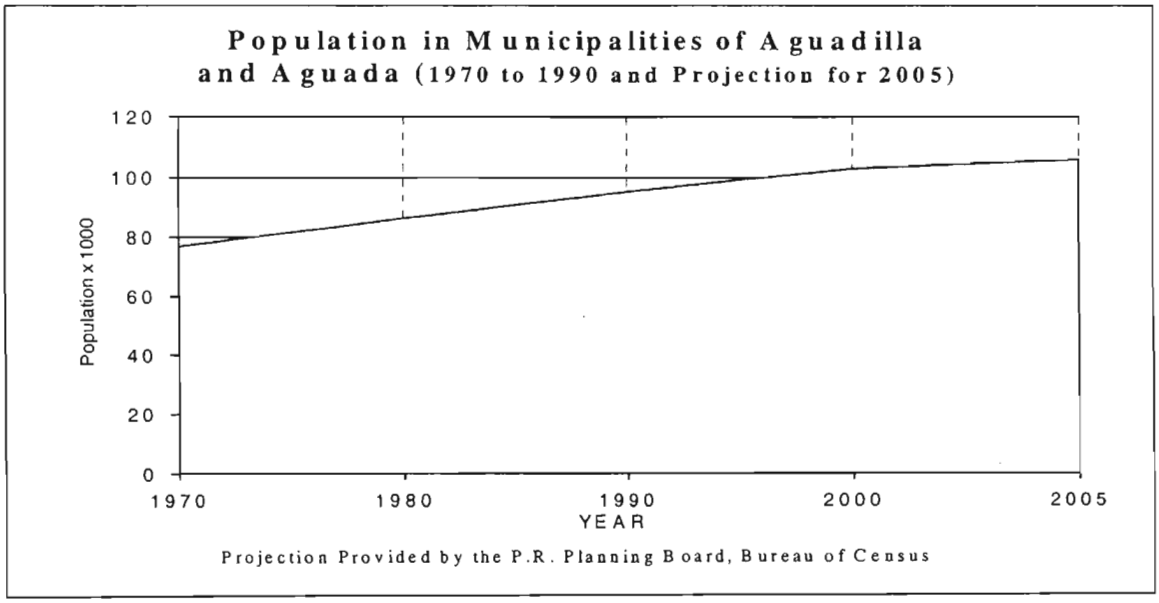


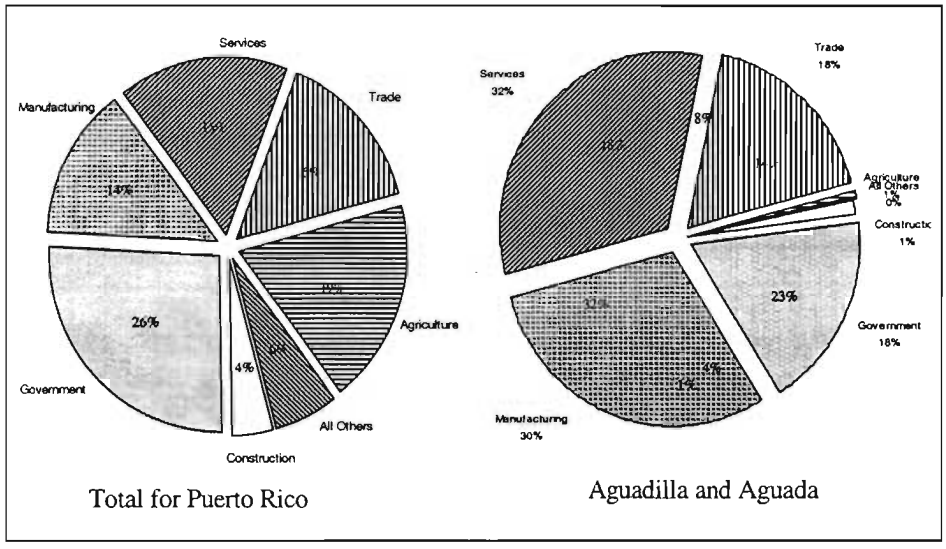
Figure E-1

2. Employment. Local economy was traditionally centered around agricultural pursuits mainly sugar cane in the coastal plain, and coffee, cash crops and cattle at higher ground. The sugar industry, as in the rest of the island has significantly declined. However, it is still cultivated throughout the study areas. The Central Coloso, the only sugar mill still operating in Puerto Rico, is located in the study area.

Today manufacturing, services and government sectors are the principal providers of employment. As of May 1999, the total labor force in Aguadilla and Aguada was about 24,360[1] persons. Of these, 85.3 percent or 20,779 were employed. The unemployment rate was estimated at 14.7 percent. Refer to Figure E-2 and Table E-1.

Employment by Sector

Percentage Distribution



Source: P.R. Department of Labor and Human Resources

Figure E-2

[1] This figure represents the total employment covered by the Employment Security Law. This law covers about 97 percent of the Puerto Rico labor force.

TABLE E-1

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

Distribution of Employed People by Major Economic Sector
(Aguadilla and Aguada)
As of May 1999

Total Labor Force	24,360
Employed	20,779
Unemployed	3,581
Unemployed Rate	14.7
Distribution:	
Manufacturing	6,096
Non-Manufacturing	14,548
Construction	450
Transportation, Communications, etc.	1,218
Trade	3,620
Finance	485
Services	4,989
Government	3,756
Others	30
Agriculture and Related	135

3. Infrastructure. Public utilities for power and domestic sanitary and water supply provide the necessary services to the area. These include a wastewater treatment plant with 8-MGD capacity that serves the towns of Aguadilla and Aguada. An electric power transmission center located at Victoria Ward (Reach 3, Zone 5) has 112 MVA capacity with 2 incoming 115 KV transmission lines and five 38 KV subtransmission lines. Eight substations connected to the 38KV system distribute power to the 13.2 and 4.16 KV network.

A network of state roads and highways connect the town of Aguadilla and Aguada with the rest of the island. These recently improved transportation routes, adjoining the study area, contribute to support continuous economic development of the municipalities in the northwestern and western region of Puerto Rico.

The second most important airport of Puerto Rico is located at Aguadilla. The airport is rapidly becoming a major air cargo movement center. According to Ports Authority statistics air cargo between 1997 and 1998 increased from 36,770,100 to 55,800,600 pounds. This represents a 52 percent increase.

4. Tourism. Aguadilla is well known for its surfing beaches favored by local tourism and international wave riders. The most popular sites are Crashboat, Gas Chambers and Wilderness. This sector of the base economy is characterized by its

growth and development over the past years with sustained investments in the hotel rooms inventory. This expansion offers new and/or renovated accommodations, which in FY98 showed an increase of over 10 percent registration for the area.

C. Detailed Study Area

The detailed study area includes the southern portion of the town of Aguadilla including Higuey and Victoria wards, and Espinar Ward in the town of Aguada. The area is divided into three damage reaches for purpose of economic analysis, plan formulation, and evaluation. The total area encompasses approximately 942 structures and facilities of all land uses, major transportation routes, and parks. Most of the houses in the floodable area are medium-sized concrete structures. Families in this area belong to middle to low income groups. Elderly persons represent about 11 percent of the population residing in the study area. See Plate 1 at the end of this Economic Appendix for delineation of reaches.

II. FLOOD DAMAGE ANALYSIS

A. General

This section provides a description of damage reaches and zones, property subject to flooding, values of property, and depth-damage relationships used to calculate flood damage estimates. Potential flood damage without project and damage estimates for the alternative flood control plans under consideration are also included.

The inventory of property subject to flooding was conducted through field visits using flood profile maps for existing conditions developed as part of this study.

B. Damage Reaches and Zones

Reach 1, is located south of Caño Madre Vieja and from extends the coastline to the intersection of PR Highway 115 and PR Highway 447. This reach includes the community known as Espinar Ward of the municipality of Aguada.

Reaches 2 and 3 comprise the southern part of the town of Aguadilla and contain most of the commercial, public, and utilities affected by flooding. Refer to Table E-2 and Plate 1 for further details.

TABLE E-2

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

Reaches and Zones for Economic Analysis

REACH	ZONES	DESCRIPTION OF SECTORS
1	1 to 7	South of Caño Madre Vieja, Espinar Ward of Aguada, mostly residential low-income community.
2	1	Residential Public Housing Community in Aguadilla.
3	1 to 5	Southern portion of the town of Aguadilla. Residential, Commercial, Public and Utilities land use.

Damage reach 1 was further subdivided into seven topographically similar zones to facilitate economic analysis. Reach 3 was subdivided into five zones for the same purpose.

C. Inventory of Property Subject to Flooding

For purposes of this analysis, property subject to flooding was grouped in six land use categories. These are: residential, commercial, public, nonprofit organization facilities, utilities, and highways and streets. The following paragraphs describe the property subject to flooding and land use categories.

1. Residential. Approximately 90 percent of all residential structures in the study area are subject to flooding by the 100-year flood. Table E-3 shows their distribution by nodes and flood frequency.

Most of the residential structures affected consist of reinforced concrete, one-family housing units. Average size of structures is about 80 square meters.

TABLE E-3

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

Estimated Residential Structures affected by flooding
By Reach/Node and Flood Frequency

	Reach/Node													
Frequency	**1/1**	**1/2**	**1/3**	**1/4**	**1/5**	**1/6**	**1/7**	**2/1**	**3/1**	**3/2**	**3/3**	**3/4**	**3/5**	**TOTAL**
2	0	48	0	0	0	0	0	6	3	0	0	0	10	**67**
5	0	48	8	0	0	0	0	31	11	144	0	0	10	**252**
10	0	48	15	0	0	0	0	31	25	160	0	23	10	**312**
25	0	48	23	6	5	1	0	31	33	160	0	74	10	**391**
50	36	48	91	6	8	2	14	31	55	160	70	93	10	**624**
100	36	48	152	6	11	3	20	31	55	160	78	93	10	**703**
SPF	36	48	152	6	18	6	95	31	55	160	87	93	10	**797**

2. Commercial. A total of 95 commercial establishments within the study area are affected by the 100-year flood event. The historical depth-damage relationships developed at the Jacksonville District, Antilles Office consider eight different categories of commercial activity. Businesses were grouped on the basis of the type of transaction performed, the merchandise or services offered, and the similarities in the display of contents. Seven of these categories are present in the Río Culebrinas study area. These are described as follows:

a. Commercial category 1. Professional services offices, general merchandise outlets, miscellaneous retail stores, auto parts stores, sporting goods stores, drug stores, electrical equipment stores, food stores, auto services outlets, and apparel and accessories stores.

b. Commercial category 2. Personal, professional and commercial services outlets.

c. Commercial category 3. Eating and drinking places, repair services outlets, and small building materials outlets.

d. Commercial category 4. Auto Dealers.

e. Commercial category 5. Hardware stores and building materials outlets.

f. Commercial category 6. Finance institutions and real estate offices.

g. Commercial category 7. Warehouses.

Table E-4 shows the estimated number of commercial establishments grouped by commercial category.

TABLE E-4

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

Commercial Facilities affected by flooding
by category and flood frequency

Type of Business	Frequency (Years)						
	2	**5**	**10**	**25**	**50**	**100**	**SPF**
Commercial Category 1	4	6	10	14	34	38	38
Commercial Category 2					6	6	6
Commercial Category 3	3	4	9	15	34	34	34
Commercial Category 4				5	7	7	7
Commercial Category 5					9	9	9
Commercial Category 6							1
Commercial Category 7					1	1	1
TOTAL ALL CATEGORIES	**7**	**10**	**19**	**34**	**91**	**95**	**96**

3. Public. The public land use category comprises all facilities operated by the Commonwealth and municipal governments within the study area.

4. Nonprofit organizations. This category includes religious institution facilities and private educational facilities.

The number of public and nonprofit facilities affected by flooding is shown in Table E-5.

TABLE E-5

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

Property Subject to Flooding
Public and Nonprofit Facilities

Category	Frequency (Years)						
	2	**5**	**10**	**25**	**50**	**100**	**SPF**
Public	1	1	2	13	22	22	24
Nonprofit	0	0	0	0	2	4	7
TOTAL	1	1	2	13	24	26	31

5. Utilities. This category includes 18 electric power substations and related utility facilities as well as electric power lines, improvements to the land including the water, telephone, sewage and, and utility meters within the detailed study area.

6. Streets. This category includes all sidewalks, roads, and streets. Measurements of these facilities were made utilizing flooded area maps developed for this study. Table E-6 shows the results of such measurements by node and flood frequency. The 100-year flood affects approximately 11.7 kilometers of roads and streets.

TABLE E-6

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

Property Subject to Flooding
Kilometers of Streets and Highways

Reaches	Frequency (Years)					
	5	10	25	50	100	SPF
1	0.32	0.88	1.87	3.78	4.69	5.64
2	1.40	1.93	3.03	5.67	7.00	9.32
Total	1.72	2.81	4.90	9.45	11.69	14.96

D. Assessment of Property Values

1. General. Structure and content values were developed for each facility/structure under each land use category within the floodable area of the detailed study area. The structures values were based on construction cost estimates and comparable appraisal and sales data. Sources of information include construction cost estimates in the Ponce and Mayagüez area, the PR Appraisers Comparable Sales Data System Report, Municipal Property Registry Sales Data Bank and the PR Regulations and Administration Construction Cost Data System data. The physical condition of each structure was observed and values determined following accepted appraisers procedures. These values were adjusted downward to account for depreciation of structures resulting from obvious physical, functional or external obsolescent. Value of land was not included in the structure value assessment. Content values in the case of residential structures were established on the basis of data collected for similar developments for recently completed flood control studies while in the case of commercial facilities they were mostly established on the basis of interviews with businessmen.

2. Residential. For structure value, each house in the study area was visited and measured; its physical condition, including date of construction and first floor elevation determined. Then, a replacement value adjusted for depreciation was determined using construction cost data from sources mentioned above. The residential content values were assessed by comparative analysis with recently completed flood control feasibility studies in Puerto Rico and recent field investigations developed for the Economics Reevaluation of other projects. Comparative analysis was based on similar socio-economics conditions at each site. Experience in other studies performed has shown that content value do not vary significantly through Puerto Rico for similar type of developments and socioeconomic conditions. Table E-7 shows average structure and content values for residential developments by reach.

TABLE E-7

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

Average Values of Property Subject to Flooding
Residential Land Use

Reach	Sector	Number of structures	Average values ($ 2003)	
			Structure	Contents
1	Espinar Ward	325	34,800	11,300
2	Aponte Public Housing	31	125,000	23,000
3	Aguadilla urban Area	441	46,200	17,100
	TOTAL DETAILED STUDY AREA	797	44,616	14,694

3. Commercial and other land uses. Structure values for commercial uses were established following same procedure as with the residential structures. Their content however were based on specific inspections and interviews with owners and managers of the facilities as well as on previous data developed for other projects.

Values for public, non-profit, and utilities facilities were determined utilizing comparable data from recent studies. Utility values were provided by the PR Aqueduct and Sewer Authority, PR Electric and Power Authority and the PR Telephone Company. Table E-8 shows structure and content value for commercial land uses, while Table E-9 shows corresponding values for other land uses.

TABLE E-8

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

Estimated Value of Structures and Contents
Commercial Facilities

Land Use Category	Number of Structures	Total Values ($2003)	
		Structure	Contents
Commercial Category 1	38	2,282,388	2,403,796
Commercial Category 2	6	438,675	519,100
Commercial Category 3	34	1,054,755	567,721
Commercial Category 4	7	638,300	15,371,368
Commercial Category 5	9	1,316,000	7,477,000
Commercial Category 6	1	70,000	250,000
Commercial Category 7	1	39,375	50,000
Total Commercial Use	96	5,839,493	26,638,985

Table E-9

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

Value of Structures and Contents
Public, Nonprofit and Utilities

	Number of Structures	**Total Values ($2003)**	
		Structure	**Contents**
Public	24	1,952,995	4,429,921
Nonprofit	7	498,750	67,302
Utilities	18	1,836,538	350,000
Total Public, Nonprofit and Utilities	**49**	**4,288,283**	**4,847,223**

4. Other property (external to main structure). This property refers to lawns, yards, parking areas, fences, automobiles, and other facilities outside the main structures. Values for these were obtained through field visits and were integrated with their corresponding land use.

E. Depth-Damage Relationships

Depth-damage relationships for the residential, commercial, and public land uses developed for the Río Puerto Nuevo Survey Report (Jacksonville District, 1984) were utilized to estimate flood damages for existing development. These damage curves were developed using historical data on flood damages throughout the island.

The depth-damage curves are developed on a percentage basis were generated for the residential, commercial, public schools and nonprofit organizations land uses. Available historical damage data for comparable areas throughout the island allowed the establishment of relationships between depth of water and percentage damage potential to structure and contents for the facilities mentioned. Such data were not available for some land uses and the depth-damage relationships were established on an absolute basis from information provided by representatives of these land uses. Below a description of the procedure followed in the development of the depth damage curves.

1. Residential. To determine the damage susceptibility of residential structures, the actual damages to 250 comparable structures throughout Puerto Rico during the floods of Eloise (1975) and other most recent hurricanes were analyzed. The data was obtained from the Damage Survey Reports (DSR) of the Federal Emergency Management Agency (FEMA). Restoration of damages was executed under the Minimum Repair Program of that agency. For each residential structure the cost of replacing or repairing the structural damages was divided by the total estimated value of the structure. A minimum-least-squares curve of the percentages of structural damages related to the depth of water was fitted to the data. The curve was used to determine structural damages to all residential structures within the flood plain. Most of the structural damages are to the following categories: electric system, plumbing system, windows, doors, air conditioning units, water heaters, kitchen cabinets, built-in stoves and ovens, bathroom fixtures, wall-to-wall carpeting, paint, and other furnishings. The foundations and the structures do not suffer significant damages because they are primarily built of reinforced concrete. These are affected mostly in areas near the riverbanks where velocities are significant. Due to lack of data, relationships between velocities and damage potential could not be developed and were not considered. To determine residential content damage susceptibility, actual damages to content in 30 residential structures in the Puerto Nuevo area during the 1977 flood were analyzed. These data were obtained from the Small Business Administration records on disaster loans to residents in the area and from records of flood insurance policy claims from the National Flood Insurance Program (NFIP). The value of contents damaged was divided by estimates of the total value of contents, and a minimum-least-square regression of percentage of content damages to depths of water was fitted to the data. This curve

was then used to determine damages from different flood stages to the contents of residences throughout the flood plain. Figure E-3 shows the curves. The historical depth of water was obtained from the U.S. Geological Survey records and residents of the area. These curves were updated in 1987 using actual flood damages to 98 housing structures from the 1985 floods along the Río Cibuco, Vega Baja, Puerto Rico.

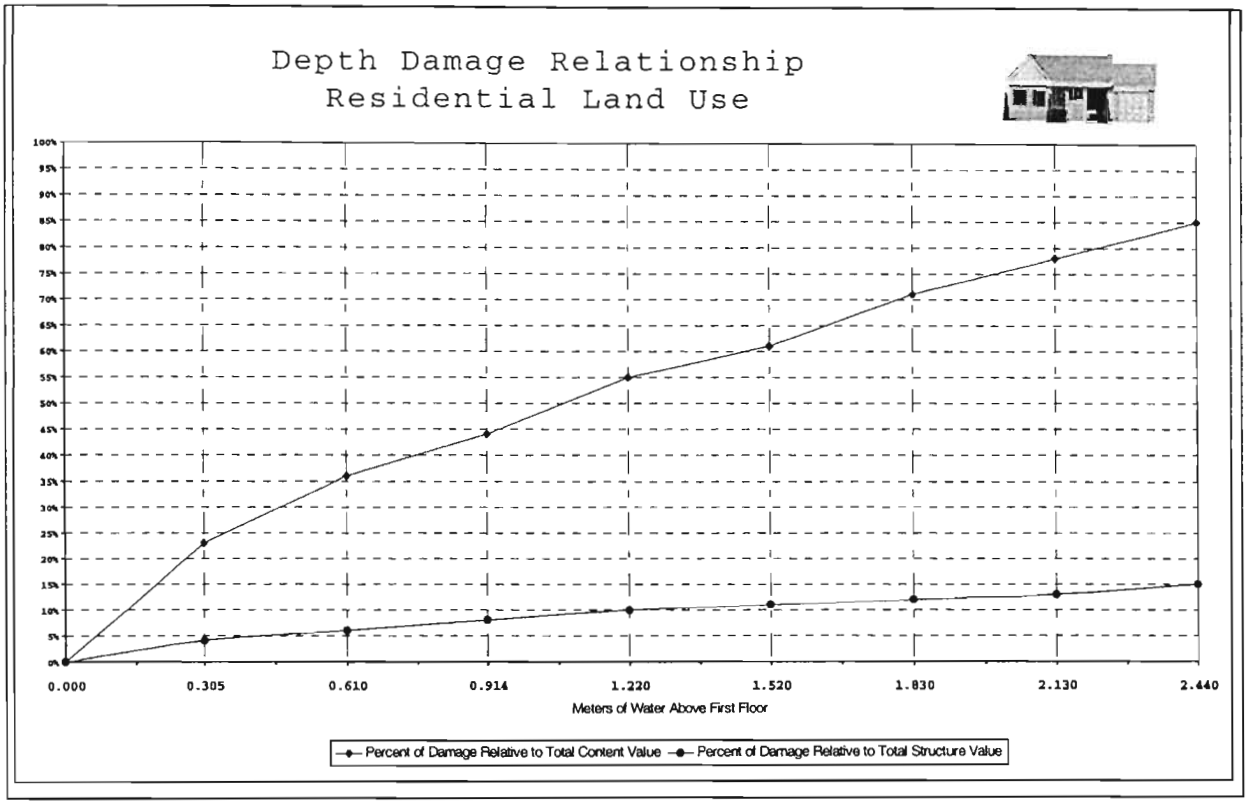


Figure E-3

2. Commercial establishments. Curves derived for the various categories of commercial establishments for the Río Puerto Nuevo area were developed during 1990 by a professional appraiser with considerable experience in investigating claims under the National Flood Insurance Program (NFIP).

Average damages in terms of a percentage were determined by the analysis of claims under the NFIP. Empirical data were used to develop damages for floodwaters of less than 1.22-meter depth. Percentage figures for damages occurring at depths over 1.22 meters were estimated by the appraiser on the basis of professional judgment. Although similar in nature, different types of businesses show different contents damage percentages since the merchandise is displayed differently. For commercial facilities, major structural damages consist of the electrical system, plumbing facilities, door, windows, air conditioning units, and other furnishings.

In some instances, a total loss at 1.22, 2.1, or 2.44 meters depth has been considered. In other cases, total loss occurs at a higher water elevation. The

average floor-to-ceiling height in an average commercial building is between 2.44 and 3 meters, while other types of businesses have higher ceilings and some property is stored or placed above 2.44 meters.

Figures E-4 to E-10 present the depth-damage percentage relationships for he various commercial categories found in the study area. As indicated previously, these are categories 1, 2, 3, 4, 5, 6, and 7.

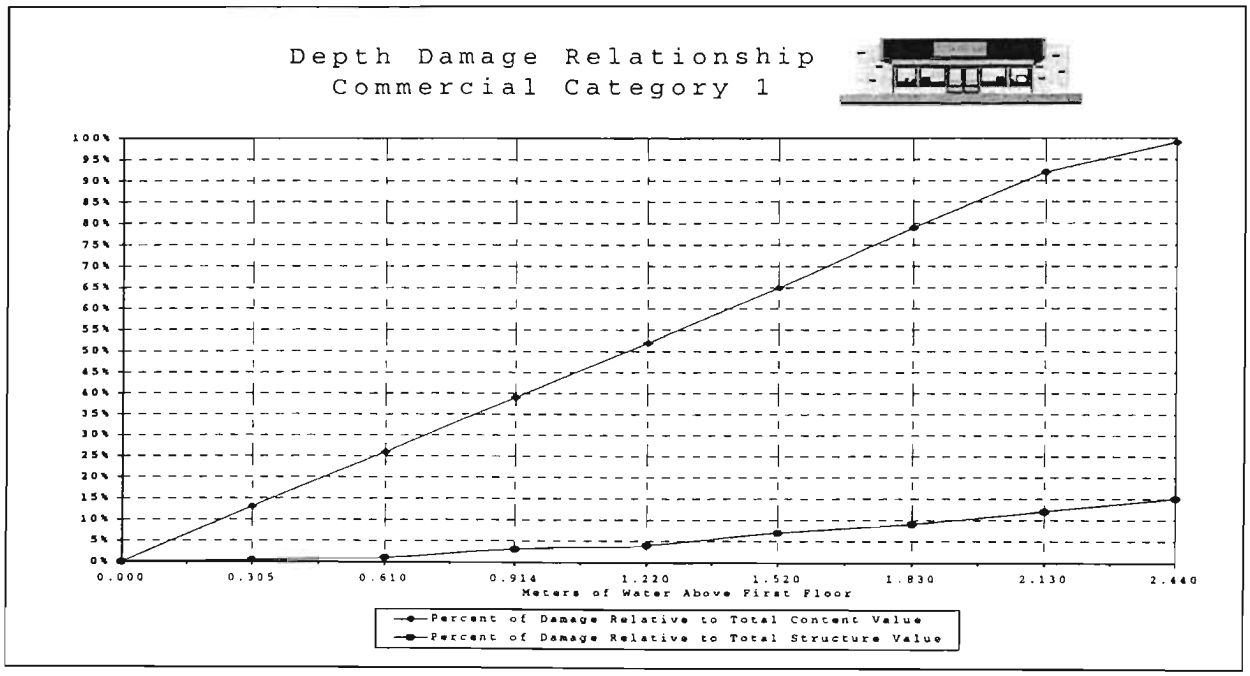


Figure E-4

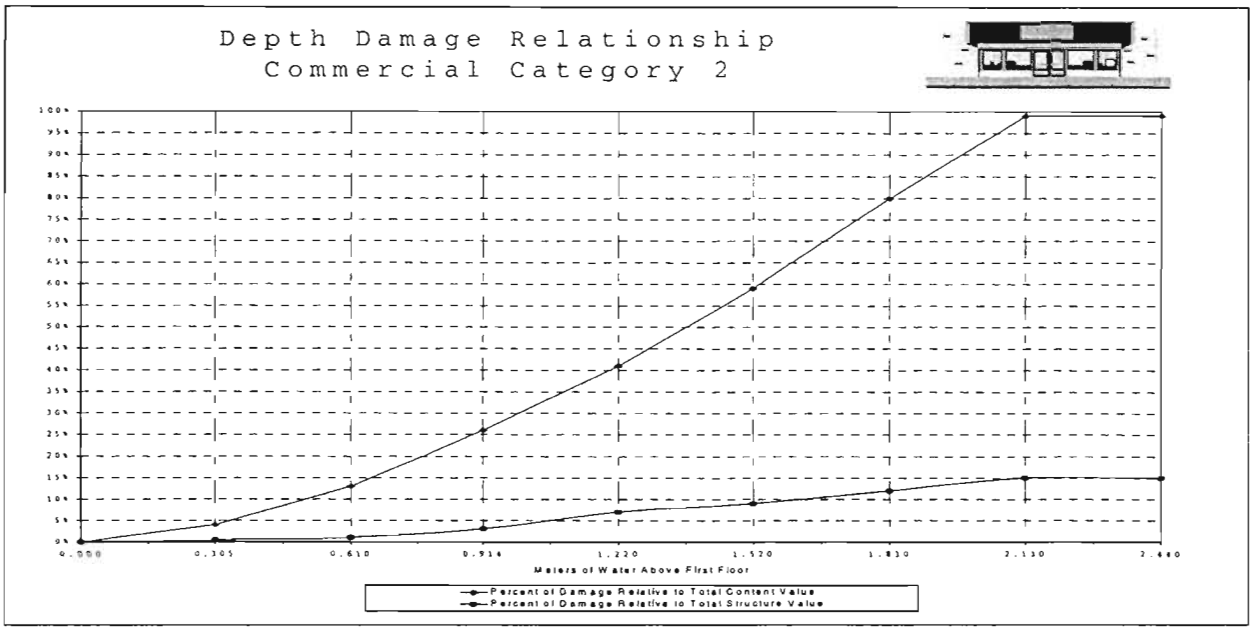

Depth Damage Relationship
Commercial Category 2
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
0.000
0.305
0.610
0.914
1.220
1.520
1.830
2.130
2.440
Meters of Water Above First Floor
Percent of Damage Relative to Total Content Value
Percent of Damage Relative to Total Structure Value

Figure E-5

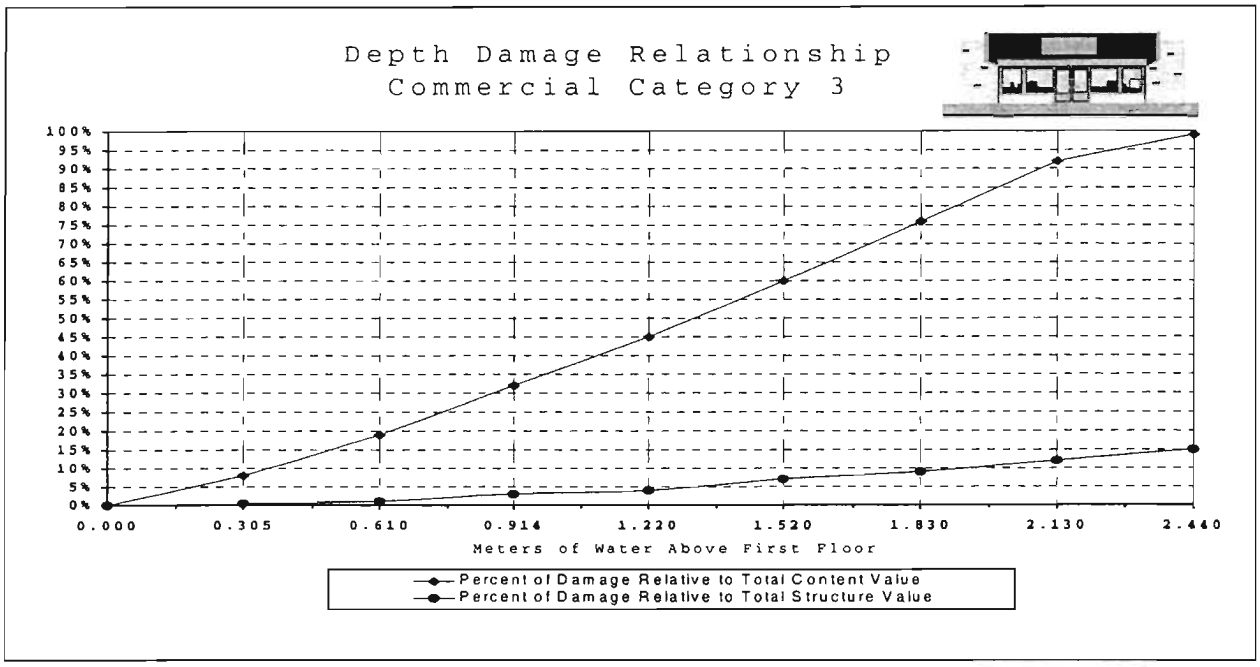


Figure E-6

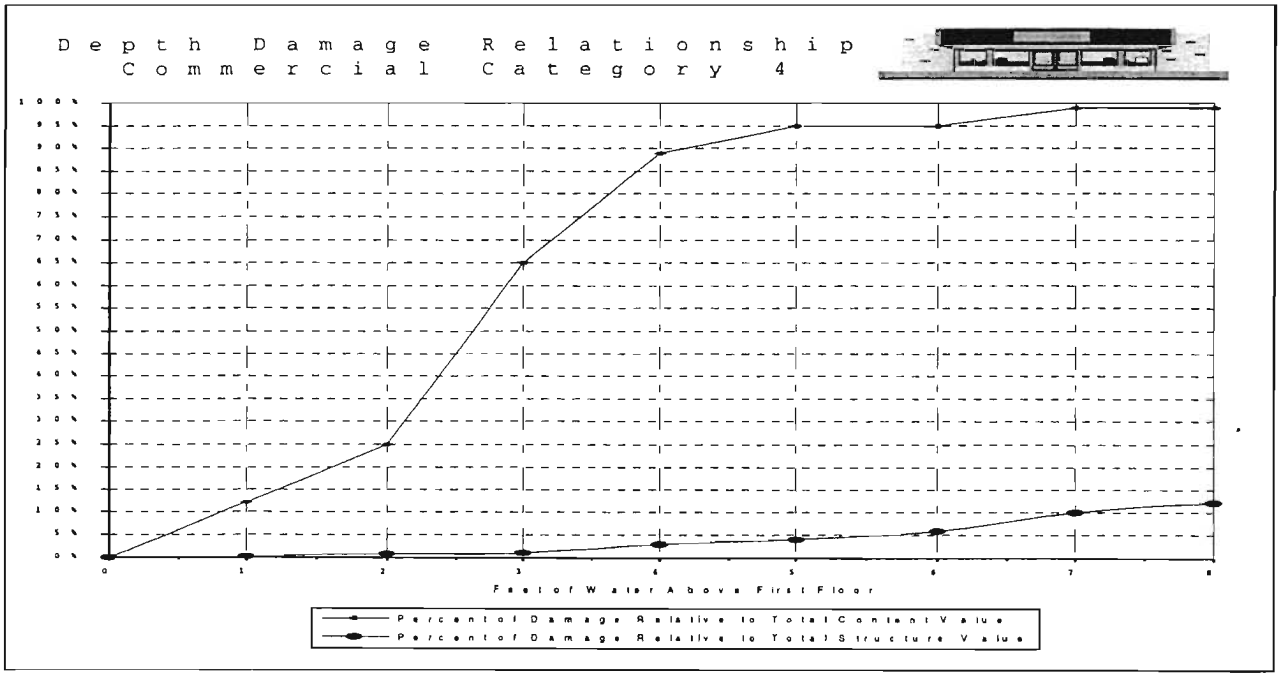


Figure E-7

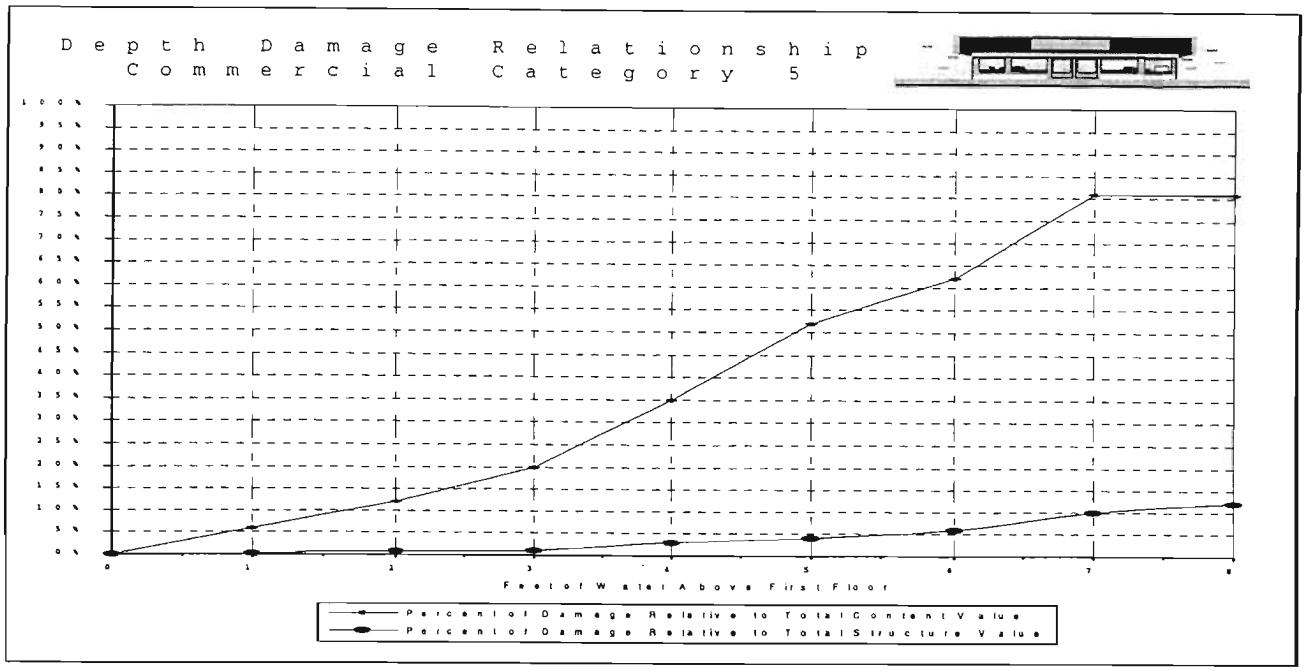


Figure E-8

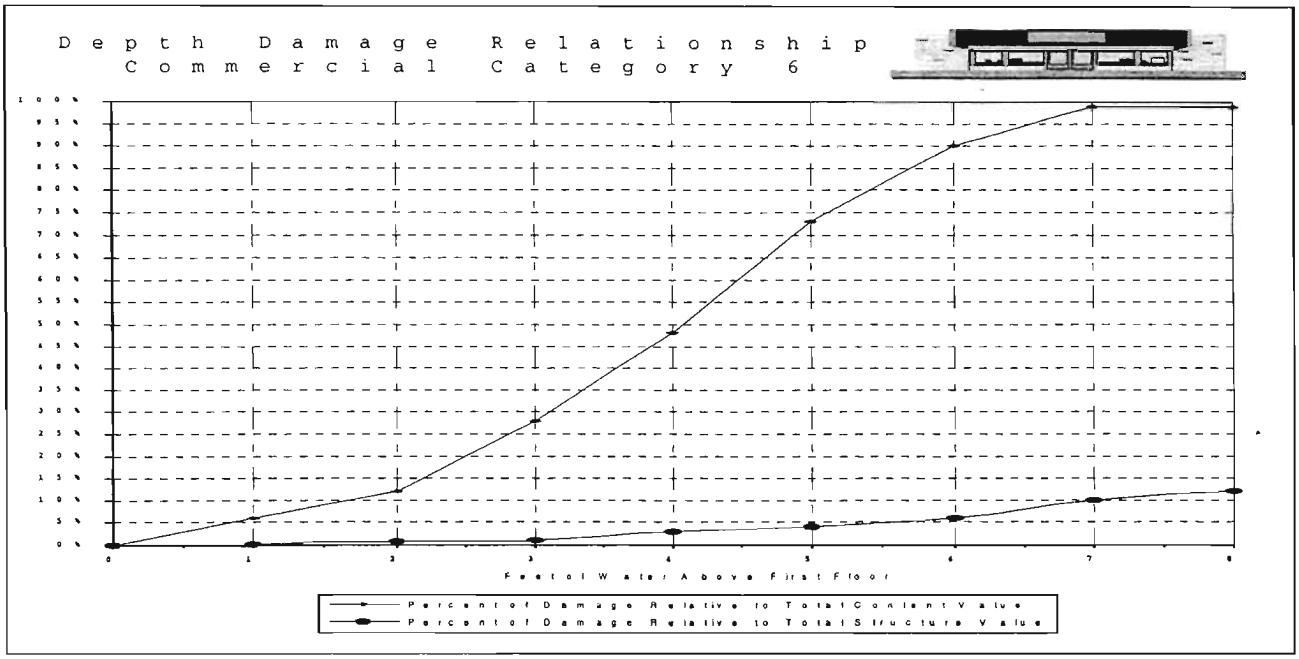


Figure E-9

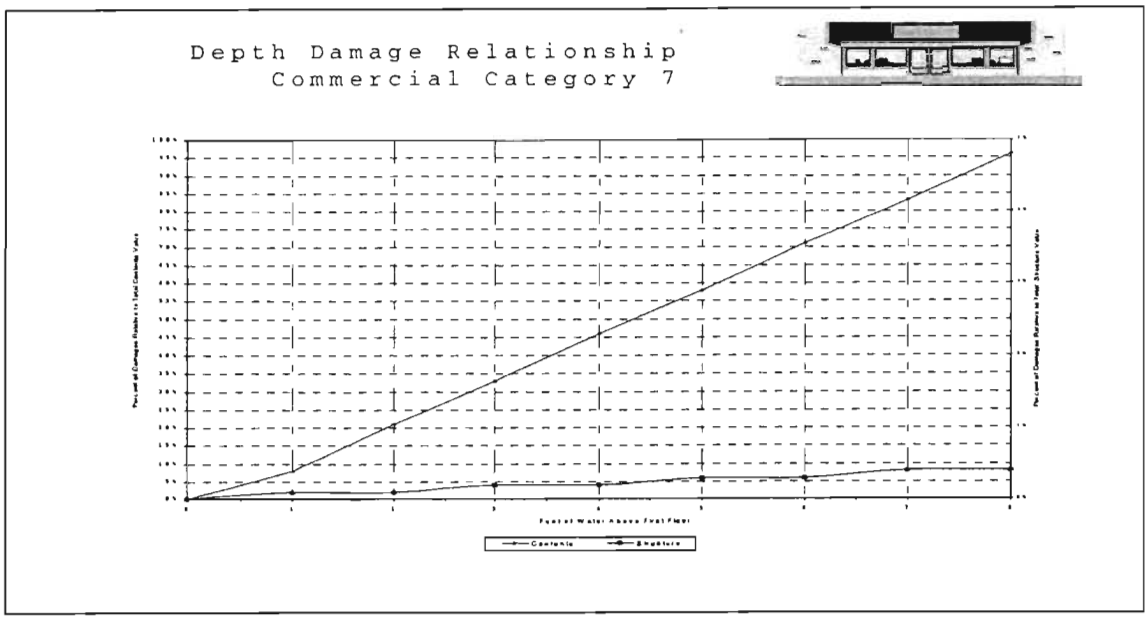


Figure E-10

3. Public buildings and offices. Damage estimates to structure and contents of public buildings and offices were established using the depth-damage relationship developed for elementary schools. For school buildings, data provided by the Superintendent of Schools, the school directors, the Public Buildings Authority, and the General Services Administration were used to develop basic depth-damage relationships. Figures E-11 and E-12 show damage curves for school facilities.

4. Utilities. Cleanup and cost of repair for water, sewage, electric, gas and telephone lines, meters, and cable TV external facilities were estimated at $2,000 per 4,000 square meters of developed land in the detailed study area. These figures are based on field observations and discussions with representatives from public agencies and private enterprises that administer the various utilities. The damage potential of specialized equipment at electric substations was assessed through discussions with electric utility engineers.

5. Roads and streets. Damage to roads and streets were estimated applying a percentage of the cost of repair per kilometer to the number of kilometers flooded for each flood frequency analyzed. Damage per kilometer was developed through discussions with officials of the San Juan Regional Office of the Department of Transportation and Public Works (DTPW). Analysis of current road construction and repair costs was obtained from variety of source. In accordance with DTPW, the total cost of repairing a badly damaged two-lane highway is $79,600 per kilometer. Damages to roads and streets during the flood events analyzed were estimated as a function of the water elevation above the surface of the pavement. A ceiling of 80 percent of the estimated maximum potential restoration cost was established in the evaluation of damages for the worst condition in this category of land use. Damages to

streets were estimated at 75 percent of the road damage per kilometer following the same procedure as indicated above.

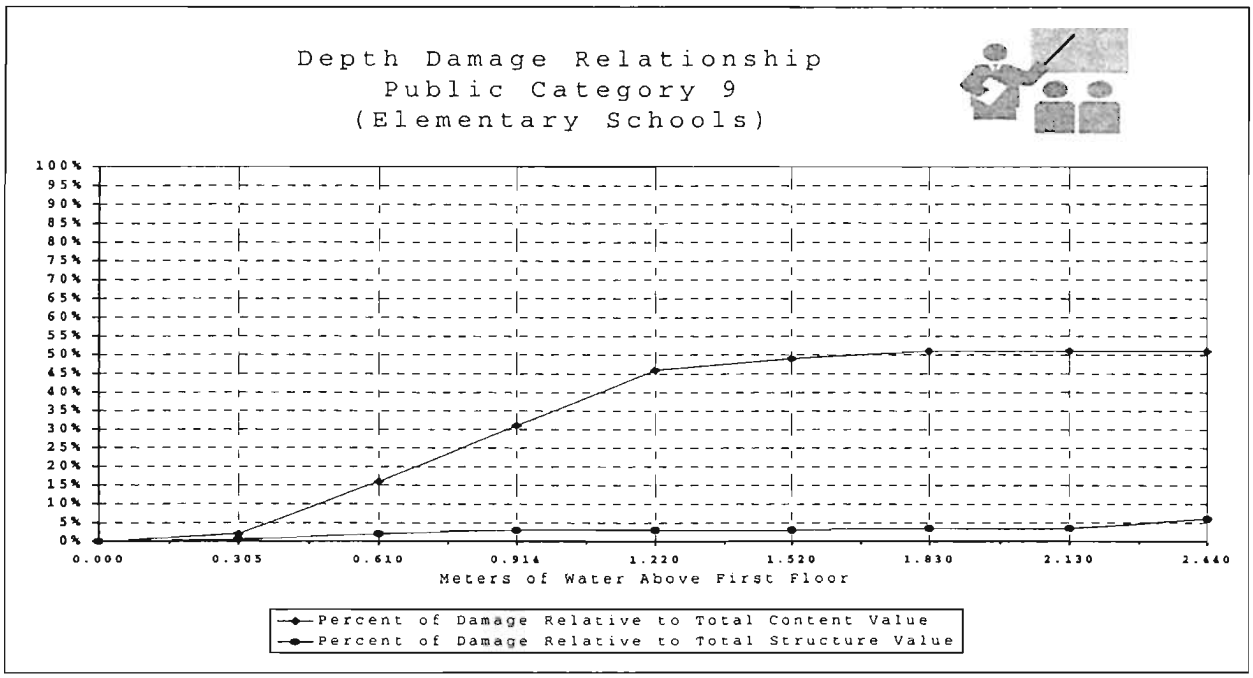


Figure E-11

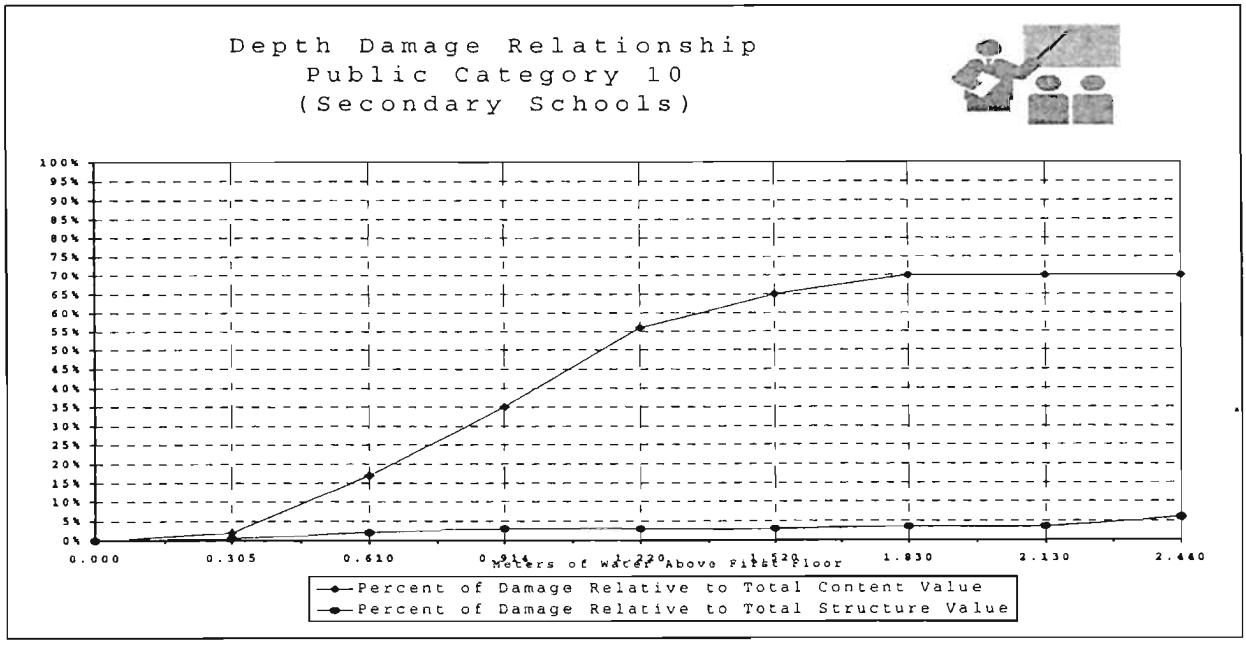


Figure E-12

6. Nonprofit organizations. Damage potential to the structures and contents of these facilities were developed using the depth-damage relationship for elementary schools. This is shown in Figure E-13.

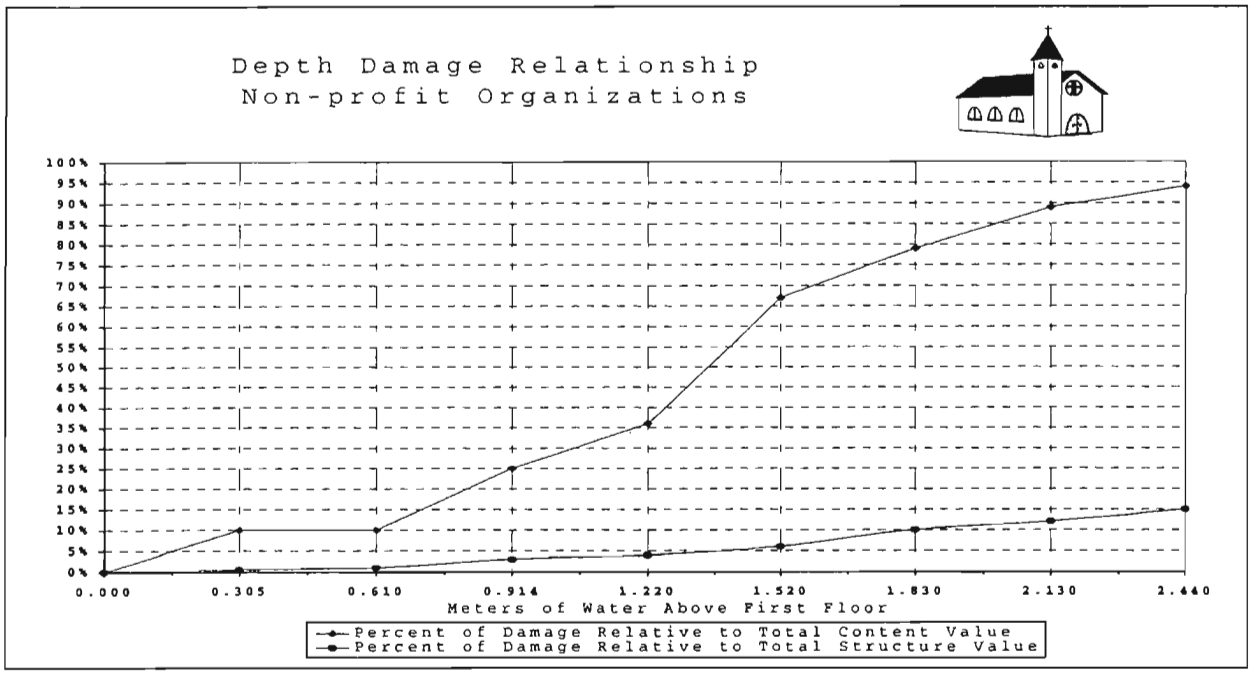


Figure E-13

F. Flood Damage

1. Historical floods. There is considerable descriptive information about the events that occurred in October 1985, April and May 1986, January 1992, September 1998 and most recent events, which took place during 1996-1998 (refer to Section V11.A.2 of Main Report). However, quantitative data on damage is very limited.

2. Potential damage. Flood damage according to flood frequency for residential, commercial, public, and nonprofit land uses were estimated utilizing a computer program developed at the Antilles Office. The program relates the depth-damage relationships previously considered to the value of structure and contents of different land uses subject to flooding given the first floor elevation of each structure. This provides information of potential damage for each flood frequency event.

To compare alternative plans average annual and cost and average annual equivalent damage are computed. This equivalent value represents a uniform distribution of annual values and is computed by discounting and amortizing each year's expected annual damage figure over the period of analysis, taking into account the time value of money associated with damage estimates. Expected annual damage and equivalent annual damage were computed utilizing the Expected Annual Flood Damage Computation Model developed by the Hydrologic Engineering Center, U.S.

Army Corps of Engineers. Potential damage were estimated at the beginning of the study using the 1999 price levels for structure and content values and were discounted at 6-7/8, the prevailing interest rate for the time of analysis for the first 50 years of the project life. During a recent field visit, it was noted that the original damage conditions for the entire study area have not experienced any significant change. Final analysis for the estimated damage assessment considers the FY 2003 price levels discounted at the 5 7/8 percent interest rate for the first 50 years of the project life.

a. Existing conditions. Table E-10 shows flood damage estimates for single events and land use categories under existing conditions. Total expected damages for the study area range from $531,000 for the 2-year event to over $12,000,000 for the 100-year flood.

TABLE E-10

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

Flood Damages for Single Flood Events
Without Project Conditions
($1,000 of 2003)

Damage Category	Frequency (Years)						
	2	5	10	25	50	100	SPF
Residential	177	508	1,206	2,235	4,529	5,180	11,109
Commercial	94	105	238	349	4,294	4,318	15,759
Public	54	54	129	207	371	371	1,521
Nonprofit	0	0	0	0	3	12	43
Utilities	206	382	627	843	1,297	2,007	2,282
Streets and Highways	0	7	22	50	153	222	546
TOTAL PER LAND USE	**531**	**1,056**	**2,222**	**3,684**	**10,647**	**12,110**	**31,260**

3. Expected annual flood damage. Expected annual damage for existing conditions (2003) are shown on Table E-11. These expected damage, which total $1,157,600, were derived through a damage-frequency analysis. The damage frequency integration technique was used to transform flood event damage for each of the land use categories analyzed into expected average annual damage.

TABLE E-11

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

Expected Annual Flood Damages Existing Conditions
(In $1,000 of 2003)

DAMAGES CATEGORY	ESPINAR	AGUADILLA	TOTAL
Residential	191.0	322.6	513.6
Commercial	2.0	274.3	276.3
Public	1.5	67.9	69.4
Non-profit	0.2	0.2	0.4
Utilities	20.9	265.5	286.4
Streets and Highways	3.5	8.0	11.5
TOTAL EXPECTED ANNUAL DAMAGES	**219.1**	**938.5**	**1,157.6**

Source: U.S. Army Corps of Engineers. Estimates developed applying Expected Annual Damages Model program Hydrologic Engineers Center. October 2003. Current discount rate: 5-7/8%

III. NATIONAL ECONOMIC DEVELOPMENT BENEFITS

A. General

This section describes the procedures utilized to estimate the various categories of national economic benefits analyzed for assessing flood control plans for the detailed study area. It also presents aggregate cost data of the plans considered. [2] Costs are discussed in detail in Appendix C, Design and Cost Estimates, while the flood control plans are described in detail in the Main Report.

B. Categories of Benefits Considered

1. Inundation reduction. Reduction of physical damages to property, experienced by occupants of the floodplain, is considered a contribution to income at the national level. The difference between expected physical annual damages expressed in monetary terms under with and without projects condition for each plan was taken as the contribution (the benefits) of that plan. Appropriate multiple frequency computations of hydrologic and hydraulic conditions and stage-damage relationships were used to estimate physical flood damages in the area.

Utilizing the depth/damage relationships previously discussed and flood stage data developed as discussed in Appendix A, Hydrology and Hydraulics, residual

[2] The total first cost for the recommended plan was updated to reflect cost growth from October 2001 to October 2003. Refers to Table C-1, Appendix C, MCACES report, October 2003.

damage estimates were developed for each land use category and level of protection. The plans are discussed in detail in the Main Report. Inundation reduction benefits for each of the candidate flood control plans are presented on Table E-12. Residual damages are also presented on Table E-12.

TABLE E-12

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

Inundation Damages Reduction Benefits
by Plan and Land Use
($1,000 of 2003)

Land Use	SPF Levee		100 Year Levee		50 Year Levee	
	Damage Reduced	Residual Damage	Damage Reduced	Residual Damaged	Damage Reduced	Residual Damaged
Residential	513.6	0.0	461.6	52.0	408.3	105.3
Commercial	276.3	0.0	202.5	73.8	158.6	117.7
Public	69.4	0.0	62.3	7.1	58.5	10.9
Non-profit	0.4	0.0	0.2	0.2	0.04	0.3
Utilities	286.4	0.0	275.7	10.7	255.0	31.4
Streets & Highways	11.5	0.0	8.9	2.6	6.7	4.8
TOTALS	**1,157.6**	**0.0**	**1,011.2**	**146.4**	**887.1**	**270.5**

Source: U.S. Army Corps of Engineers. Estimates develop applying Expected Annual Damages Model program Hydrologic Engineers Center. October 2003. Current Discount rate: 5-7/8%

2. Employment benefits. The basis for considering this benefit is contained in ER 1105-2-100, which is quoted in part. "Benefits from use of otherwise unemployed or underemployed labor resources may be recognized as a project benefit if the area has substantial and persistent unemployment at the time the plan is submitted for authorization and for appropriations to begin construction. Substantial and persistent unemployment exists in an area when: The current rate of unemployment, as determined by the appropriate annual statistics for the most recent 12 consecutive months, is 6 percent or more and has averaged at least 6 percent for the qualifying time periods. The annual average rate of unemployment has been at least: (a) 50 percent above the national average for three of the preceding four calendar years, or (b) 75 percent above the national average for two of the preceding three calendar years, or (c) 100 percent above the national average for one of the preceding two calendar years." Consequently, this benefit was considered for the study area.

The NED benefit considered for employment benefits is limited to payments to unemployed and underemployed labor resources directly utilized in the construction and installation of the project and labor used for operations and maintenance.

The unemployment rate in Puerto Rico has been very high as compared to the national average. The average annual rate of unemployment for Puerto Rico was estimate in 12.3 percent for the year 2002. United States National unemployment rate (annual average) for the same period was estimate in 5.8 percent. The unemployment remains as one of the major socioeconomics problems in Puerto Rico.

For determining the portion of construction labor cost allocated to the unemployed, it was assumed that 20 percent of the total construction cost of the project would be used for the wages and salaries of the construction workers. This figure was arrived at on the basis of information provided by representatives of the local private construction industry contacted through telephone calls, data obtained from the Unemployment Insurance Bureau of the Puerto Rico Department of Labor and Human Resources and from the Rio Puerto Nuevo Flood Control Project currently being built under the supervision of the Corps of Engineers in the San Juan Metropolitan Area.

To determine the relative amount and classification of labor, an analysis of the construction schedule at the river stream was made. The percentage distribution for the various categories is as follows:

Skilled	-	77%
Unskilled	-	20%
Others	-	3%

These percentages were determined from actual data from the Río Antón Ruiz project in Humacao, Puerto Rico. This project consists of levees and channel diversion. It was assumed that labor would remain constant during the construction phase due to the nature of the project and the location of the project in the eastern region of the island.

Wages and salaries used to employ workers pull out from the unemployed pool for each category of workers were determined on the basis of an analysis of empirical data from the Río Antón Ruiz. Percentages determined are as follows:

Skilled	-	60%
Unskilled	-	37%
Others	-	3%

These benefits are included as part of the recommended plan and were amortized at FY 2003 interest rate of 5 7/8 percent. The annual benefits over the 50-year life span of the project results in annual equivalent employment benefits of $19,525.

3. Reduction in Flood Insurance Overhead. With a flood control project in place, occupants of the previously floodable land are not required to flood insurance protection for projects providing 100 year or higher level of protection. It is appropriate to claim as a benefit the expense of servicing these policies and a pro-rata share of FIA's administrative costs. The computation process for the flood insurance costs saved, which are claimed as a benefit of the project, consist in applying to the number of the residential structure subject to flooding FEMA existing island wide percentage (24.6%) of flood insurance policies.

Then, multiplying the resultant figure by the current administrative cost of flood insurance policy. The annual administration cost for flood insurance policies for fiscal year 2003 are estimated in $133 per policy according to the Economic Guidance Memorandum 03-03, of the National Flood Insurance Program Operating Cost. This results in cost saved adding to $27,810 annually for the entire project.

C. Benefits and Costs Analysis.

The total first costs, interest during construction, total investment costs, and annual cost estimates for the alternative plans that were under consideration during FY 1999 are indicated on Table E-13. The evaluation of final plans was performed following ER-1105-2-100 (Principles and Guidelines) procedures. These plans were evaluated at 6 7/8 percent, the prevailing interest rate at the time of analysis during FY 1999. Alternative structural plans for the SPF Plan, the 100-year Plan and the 50-year Plan were considered in the economics for each alternative plan. The 100-year plan had the highest net benefits of $424,000 and was selected as the NED plan with a Benefit to Cost ratio of 2.4 to 1.0. Refer to Table 4, page 33, of the Main Report.

TABLE E-13

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

Economic Costs of Alternative Plans
($1,000 of 1999)

Cost Item	Structural Alternatives		
	SPF	100 Year	50 Year
PROJECT COST			
Total Construction Cost	$4,476	$2,781	$2,711
Pre-Construction Eng. and Design	403	250	244
Construction Management	448	278	271
Lands and Damages	720	646	646
Total First Cost	**6,047**	**3,955**	**3,872**
Interest During Construction	205	127	124
Total Investment Cost	**6,252**	**4,082**	**3,996**
Annual Investment Cost	431	282	276
Annual O&M Cost	25	20	20
TOTAL ANNUAL COST	**$456**	**$302**	**$296**

Source: U.S. Army Corps of Engineers. Note: These plan were evaluated at 6 7/8 percent, the prevailing interest rate at the time of analysis during FY 1999.

Table E-14 presents the revised economic analysis for the final assessment of the 100-year plan. The 100-year plan remains as the NED plan recommended. The NED plan was further analyzed and revision of all inundation reduction benefits and other benefits were taken into account following the guidance of ER-1105-2-100. All benefits were evaluated at 5 7/8 percent, the prevailing interest rate for FY 2003. This assessment provides current data for the flood damages reduction benefits considered with the implementation of current construction of the project.

The economics of the recommended plan is shown in Table E-14 for the entire project. The total first cost of the plan [3] is $4,751,400, net benefits are $740,400 and its Benefit to Cost Ratio is 3.3 to 1.0.

[3] The cultural resources preservation was not included as part of the total first cost of the recommended plan for the economic analysis purpose only. ER 1105-2-100 (22 April 2000).

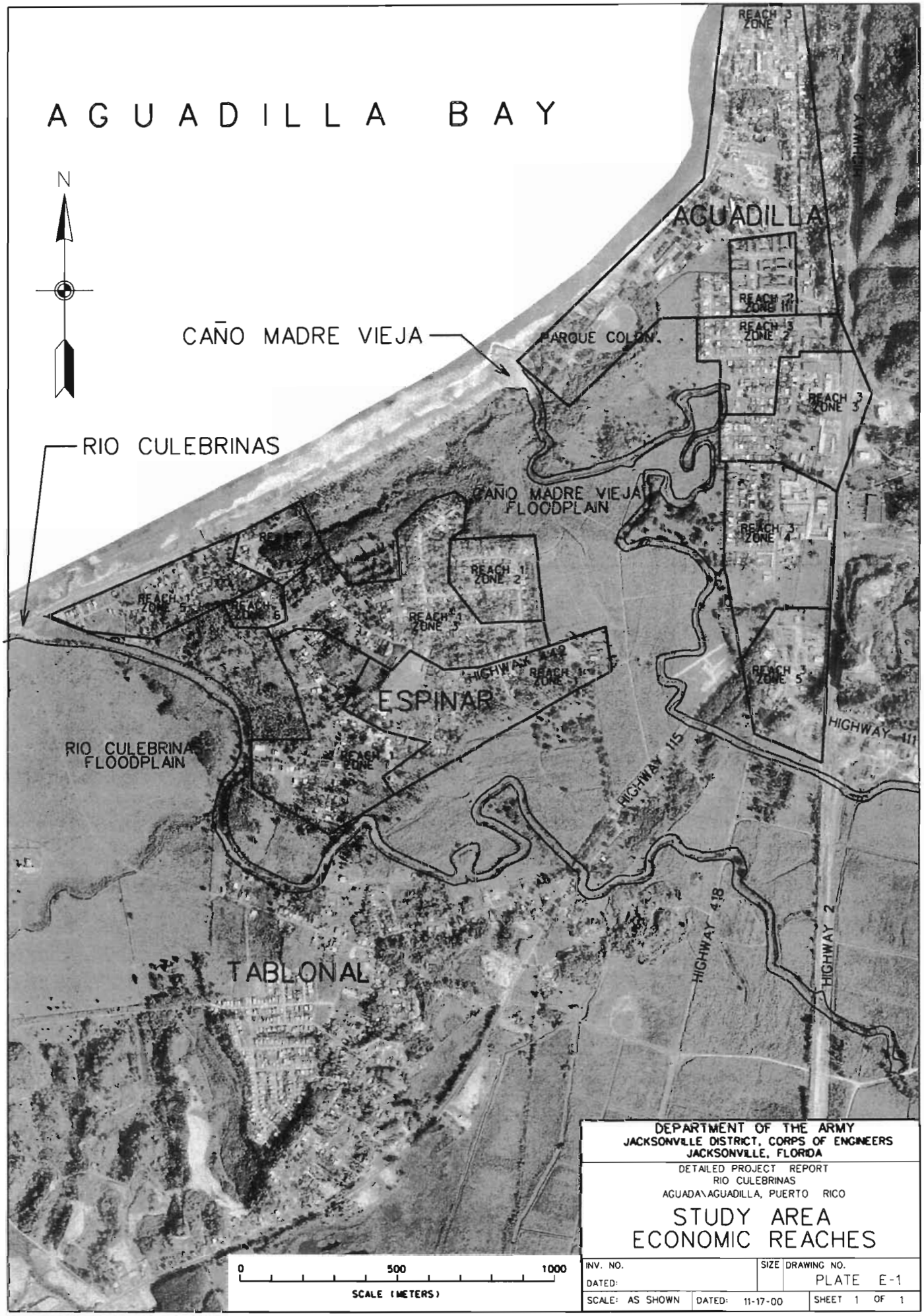
TABLE E-14

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

Economics of the Recommended Plan
(In $1,000 of October 2003)

	ESPINAR LEVEE	AGUADILLA LEVEE	ENTIRE PROJECTS
PROJECT COST			
Total First Cost *	1,839.2	2,912.2	4,751.4
Interest During Construction	35.6	75.5	111.1
Total Investment Cost	1,874.8	2,987.7	4,862.5
Annualized Investment Cost	116.9	186.2	303.1
Operation and Maintenance	5.0	10.0	15.0
Total Annual Cost	**121.9**	**196.2**	**318.1**
ANNUALIZED BENEFITS			
Inundation Reduction	193.7	817.5	1,011.2
Employment Benefits	6.2	13.3	19.5
Flood Insurance Cost Savings	11.8	16.0	27.8
TOTAL ANNUAL BENEFITS	**211.7**	**846.8**	**1,058.5**
NET NED BENEFITS	**89.8**	**650.6**	**740.4**
BENEFITS TO COST RATIO	**1.7**	**4.3**	**3.3**

Source: U.S. Army Corps of Engineers. Expected Annual Damages Estimates program. October 2003. Current Discount rate: 5 7/8%.
* Cultural Resources Preservation not included.



DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DETAILED PROJECT REPORT
RIO CULEBRINAS
AGUADA\AGUADILLA, PUERTO RICO

STUDY AREA ECONOMIC REACHES

INV. NO.		SIZE	DRAWING NO.
DATED:			PLATE E-1
SCALE: AS SHOWN	DATED: 11-17-00		SHEET 1 OF 1

SECTION 205
FLOOD CONTROL

MARCH 2002

RIO CULEBRINAS
AGUADILLA-AGUADA, PUERTO RICO

DRAFT
DETAILED PROJECT REPORT
AND
ENVIRONMENTAL ASSESSMENT

US Army Corps of Engineers
Jacksonville District

Municipio de Aguada

Municipio de Aguadilla

DRNA

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
SECTION 205
DETAILED PROJECT REPORT AND
ENVIRONMENTAL ASSESSMENT

A STUDY TO DETERMINE THE FEASIBILITY OF PROVIDING A FLOOD CONTROL PROJECT FOR THE RIO CULEBRINAS IN THE VICINITY OF AGUADILLA AND AGUADA, PUERTO RICO

JACKSONVILLE DISTRICT
U. S. ARMY CORPS OF ENGINEERS

MARCH 2002

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

SYLLABUS

This report describes the problems resulting from the overflow of Río Culebrinas at the southwest portions of the town of Aguadilla and the community of Espinar at Aguada, formulates several alternatives to reduce flooding damage, and recommends a plan of action. The report was prepared under the authority provided in Section 205 of the Flood Control Act of 1948 as amended. The study was conducted at the request of the Municipalities of Aguadilla and Aguada.

The study area lies in the alluvial flood plain of Río Culebrinas between the municipalities of Aguadilla and Aguada. This area is located in the northwestern coast of Puerto Rico. The Río Culebrinas has a drainage area of approximately 267 square kilometers. Río Culebrinas main channel has a relatively low hydraulic capacity at the alluvial valley. The excess discharge flows over the banks of the river into the Caño Madre Vieja alluvial valley producing damage in the adjacent communities. The 100-year flood for existing conditions will affect approximately 703 residential structures. Total damage range from approximately $2.2 million for the 10-year flood to $19.2 million for the Standard Project Flood (SPF) with average annual equivalent damage being approximately $1,157,600. Residences, commerce, and public facilities are, in that order, the most affected land uses.

The recommended plan consists of two segments of levees with a total length of approximately 3,300 meters, a 60 meters pilot channel, and interior drainage facilities. The plan protects the southwest portion of Aguadilla and the community of Espinar in Aguada. The plan is design to protect against the 100-Year flood and would reduce 87 percent of the total annual flood damage. This plan maximizes the net national economic development benefits. The total first cost of the recommended plan is approximately $4,548,000 with total annual cost estimated at $311,500. Since total annual benefit is $1,198,000, the implementation of the project would result in a benefit to cost ratio of 3.8/1.0. Under the current cost-sharing policy the Federal Government cost would be $2,410,600 while the non-Federal share would amount to $2,137,400.

LIST OF APPENDICES

CONVERSION FACTOR TABLE

LENGTH

1 kilometer = 0.6214 mile
1 meter = 3.2808 feet
1 centimeter = 0.3937 inch
1 millimeter = 0.03937 inch

AREA

1 square kilometer = 0.3861 square mile
1 square kilometer = 247.1054 acres
1 hectare = 2.4711 acres
1 square meter = 1.1960 square yards
1 square meter = 10.76 square feet
1 "cuerda" = 3,930.39 square meters
= 0.9712 acres

VOLUME

1 cubic meter = 1.3080 cubic yards
1 cubic meter = 35.3147 cubic feet

VELOCITY

1 meter per second = 3.2808 feet per second

FLOWRATE

1 cubic meter per second = 35.3147 cubic feet per second
1 cubic meter per second = 22.8241 million gallons per day (mgd)
1 liter per second = 0.1353 cubic feet per second

WEIGHT

1 metric ton = 2204.622 lbs.
1 metric ton = 1.1023 short tons

ABBREVIATIONS AND ACRONYMS

CBIA	Coastal Barrier Improvement Act
CBRA	Coastal Barrier Resources Act
CBRS	Coastal Barrier Resources System
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
EA	Environmental Assessment
DNER	Department of Natural and Environmental Resources
DPR	Detailed Project Report
EFIP	Emergency Flood Insurance Program
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIA	Federal Insurance Administration
HAER	Historic American Engineering Record
HQUSACE	Head Quarters United States Army Corps of Engineers
HTW	Hazardous and Toxic Wastes
LERRD	Lands, Easements, Rights-of-Ways, Relocations, and Disposal areas
MCACES	Micro Computer Aided Cost Engineering System
NED	National Economic Development
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NOAA	National Oceanic Atmospheric Administration
PCA	Project Cooperation Agreement
PRPB	Puerto Rico Planning Board
SAD	South Atlantic Division
SHPO	State Historic Preservation Officer
SPF	Standard Project Flood
USC	United States Code
USFWS	United States Fish and Wildlife Service

MAIN REPORT
AND
ENVIRONMENTAL ASSESSMENT

RIO CULEBRINAS AT AGUADILLA AND AGUADA, PUERTO RICO
DETAILED PROJECT REPORT

MAIN REPORT

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF FIGURES

LIST OF ENCLOSURES

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

MAIN REPORT

I. INTRODUCTION

This report presents the results of investigations into flooding and related problems resulting from the overflow of Río Culebrinas into Caño Madre Vieja at the southwest portions of the town of Aguadilla and at the community of Espinar at Aguada, Puerto Rico. The report was prepared in response to a request, from the Municipality of Aguadilla, for assistance in reducing flooding from Río Culebrinas and Caño Madre Vieja.

II. STUDY AUTHORITY

This study was authorized by Section 205 of the Flood Control Act of 1948 as amended, which states:

> *The Secretary of the Army is hereby authorized to allot from any appropriations heretofore or hereafter made for flood control, not to exceed $40,000,000 for any one fiscal year, for the construction of small projects for flood control and related purposes not specifically authorized by Congress, which comes within the provisions of Section 1 of the Flood Control Act of June 22, 1936, when in the opinion of the chief of Engineers such work is advisable. The amount allotted under this Section for a project shall be sufficient to complete Federal participation in the project. Not more than $7,000,000 shall be allotted for a project at any single locality. The provisions of local cooperation specified in Section 3 of the Flood Control Act of June 22, 1936, as amended, shall apply. The work shall be complete in itself and not commit the United States to any additional improvements to insure its successful operation, except as may result from the normal procedure applying to projects authorized after submission of preliminary examination and survey reports.*

By letter dated August 21, 1989, (see enclosure 1) the Municipality of Aguadilla made formal application for a study of the Río Culebrinas and Caño Madre Vieja area under the authority cited above. A reconnaissance report was completed on March 1992, the report showed that a levee alternative to solve the flooding problem at the study area appeared to be feasible and that further detailed studies were warranted. The Division Engineer, therefore, approved the preparation of a Detailed Project Report (DPR). Funds to initiate this DPR were allocated on fiscal year 1995. The Municipalities of Aguadilla and Aguada are the local sponsors for the project.

III. STUDY PURPOSE

The primary purpose of this study is to investigate in detail the frequent flooding and related problems, caused by overflows from Río Culebrinas into Caño Madre Vieja, in the southwest portions of the town of Aguadilla and the community of Espinar in the Municipality of Aguada. The study also investigates if feasible alternatives for reducing the flooding problems exist without causing adverse impacts to the communities, the environment, and the existing infrastructure of the area, and recommends the most appropriate course of action within the Federal and Puerto Rico guidelines and regulations.

The investigations were of sufficient detail to identify the problems being experienced, determine probable future conditions, identify and evaluate possible structural and non-structural alternatives, evaluate all adverse and beneficial impacts of each alternative, determine public support for such alternatives, and recommend the best course of action.

IV. STUDY PROCESS

Section 205 Continuing Authorities studies follow a staged process, which includes the four functional planning tasks of problem identification, formulation of alternatives, impact assessment, and evaluation.

Initially, the study team reviewed previous reports, interviewed local residents and officials, and made field observations. The study process then concentrated on the formulation and development of alternatives, assessment of impacts, and relative evaluations. The activities were based on detailed technical analyses including flood plain topography, hydrology, hydraulic, and geotechnical investigations; socioeconomic analysis; biological and ecological studies; and cultural resources evaluations.

After technical studies are completed, a draft DPR and Environmental Assessment (EA) is prepared for Internal Technical Review (ITR) process and for review by South Atlantic Division (SAD), U.S. Army Corps of Engineers (USACE). Next, the draft report and environmental assessment is circulated for review by the Local Sponsors, Puerto Rico and Federal agencies, and the general public. The subsequent steps involved with project implementations are summarized below:

1. Review and approval of the final Río Culebrinas at Aguadilla and Aguada, Puerto Rico, Section 205 DPR by Commander South Atlantic Division.

2. Allocation of funds for plans and specifications.

3. Preparation of detailed Plans and Specifications.

4. Approval of the project for construction by the Office of the Assistant Secretary of the Army for Civil Works.

5. Execution of the Project Cooperation Agreement (PCA).

6. Sponsor accomplishes required acquisitions, relocations, and certifies project lands.

7. Funds allocation by Secretary of the Army for construction.

8. Advertise, award, and construction of the project.

9. Transfer the completed project over to the Sponsor for continued operation and maintenance.

V. SCOPE OF REPORT

A. Study Area

The detailed study area consists of the Río Culebrinas basin, located in the northwestern coast of Puerto Rico within the municipalities of Aguadilla and Aguada, approximately 115 kilometers west of San Juan, (See Figure 1). The main focus of the study is in the flood plain along the southwestern edge of the town of Aguadilla and the community of Espinar, where flooding is a major frequent problem.

B. Study Participants and Coordination

Coordination of this report was accomplished through numerous formal and informal meetings with various Puerto Rico and Federal agencies, the mayor of Aguadilla, the mayor of Aguada, local legislators, various interested groups, and the residents of the flood plain. Table 1 shows the participating government agencies. The investigation was thoroughly coordinated with the Municipalities of Aguadilla and Aguada, which are the local sponsors for the project.

Meetings held with representatives from the various government agencies were aimed at the collection of data necessary for the investigation and at the assessment and evaluation of impacts from the alternatives considered. A major objective of the coordination effort was to involve the local governments and citizen representatives as equal partners in the study process.

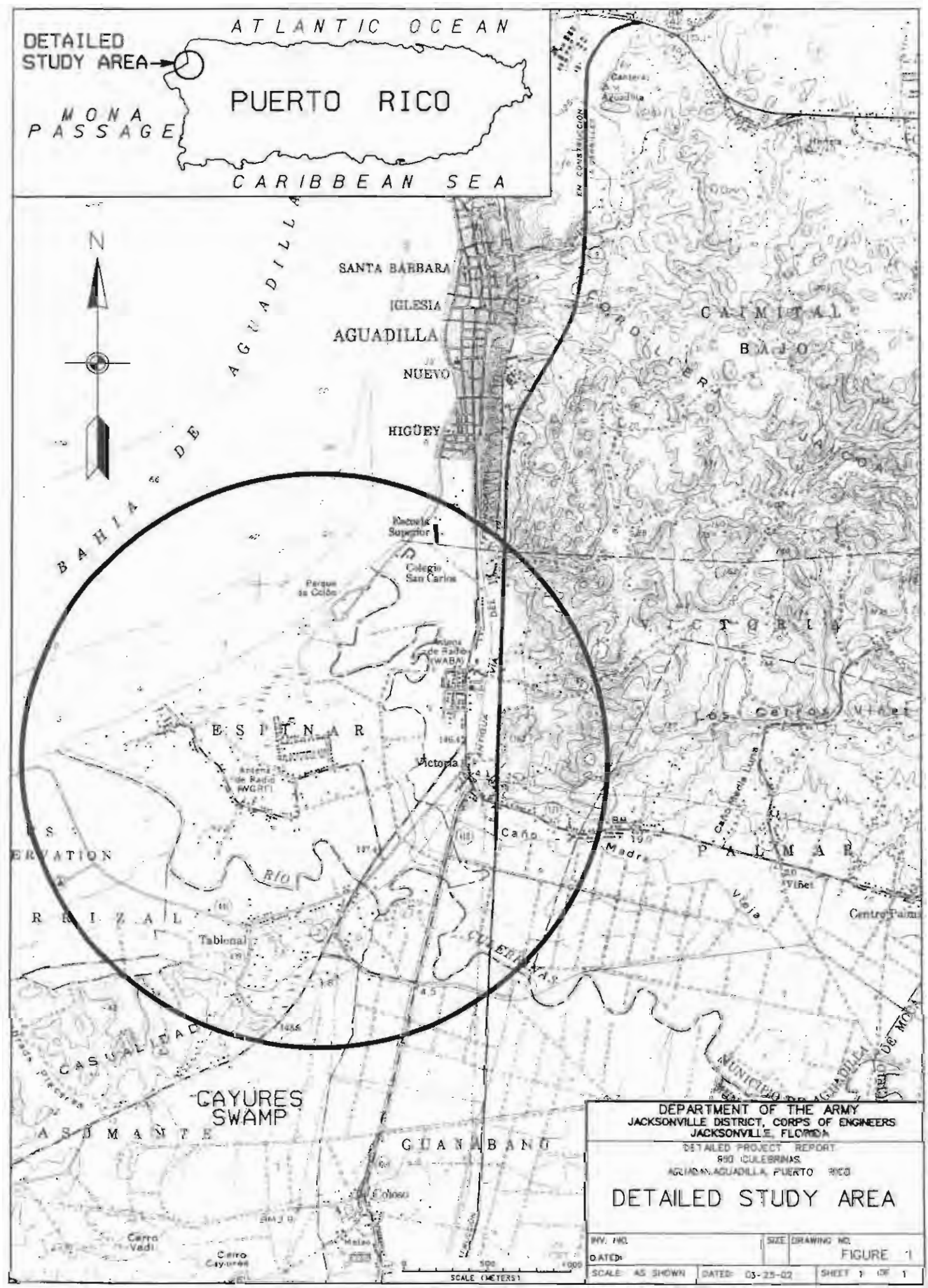

ATLANTIC OCEAN
DETAILED STUDY AREA
PUERTO RICO
MONA PASSAGE
CARIBBEAN SEA
N
SANTA BARBARA
IGLESIA
AGUADILLA
NUEVO
HIGÜEY
BAHIA DE AGUADILLA
CAIMITAL BAJO
VICTORIA
ESPINAR
Victoria
Caño Madre Vieja
PALMAR
RIZAL
Tabonal
CASUALIDAD
CAYURES SWAMP
GUANABANO
Colegio San Carlos
Parque de Colón
Los Carros
Centro Palmas
SCALE (METERS)
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
DETAILED PROJECT REPORT
560 CULEBRINAS
AGUADA, AGUADILLA, PUERTO RICO
DETAILED STUDY AREA
INV. NO.
DATED:
SIZE
DRAWING NO.
FIGURE 1
SCALE: AS SHOWN
DATED: 03-25-02
SHEET 1 OF 1

TABLE 1

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

PARTICIPATING GOVERNMENT AGENCIES

FEDERAL	PUERTO RICO	MUNICIPAL
Department of the Interior U.S. Geological Survey U.S. Fish and Wildlife Service National Park Service Department of Transportation Federal Highway Administration Environmental Protection Agency Department of Housing and Urban Development Department of Agriculture Soil and Conservation Service Forest Service Department of Commerce National Weather Service Office of Coastal Zone Management National Marine Fisheries Service Federal Emergency Management Agency	Department of Natural and Environmental Resources Office of the Governor Planning Board Environmental Quality Board Legislature of Puerto Rico House of Representatives Senate Office of the Resident Commissioner Regulations and Permits Administration Emergency Management Agency Department of Transportation and Public Works Highways Authority Puerto Rico Ports Authority State Historic Preservation Officer Institute of Puerto Rican Culture Department of Agriculture Puerto Rico Land Authority Puerto Rico Land Administration Office of the Budget Department of Housing Department of Social Services Department of Education Department of Labor and Human Resources Police Department Puerto Rico Industrial Development Company Aqueduct and Sewers Authority Electric Power Authority Puerto Rico Telephone Company	Municipality of Aguadilla Office of the Mayor of Aguadilla Office of Community Development Office of Planning Department of Public Works Civil Defense Municipality of Aguada Office of the Mayor of Aguada Office of Planning Department of Public Works Civil Defense

C. Organization of the Report and Study Process

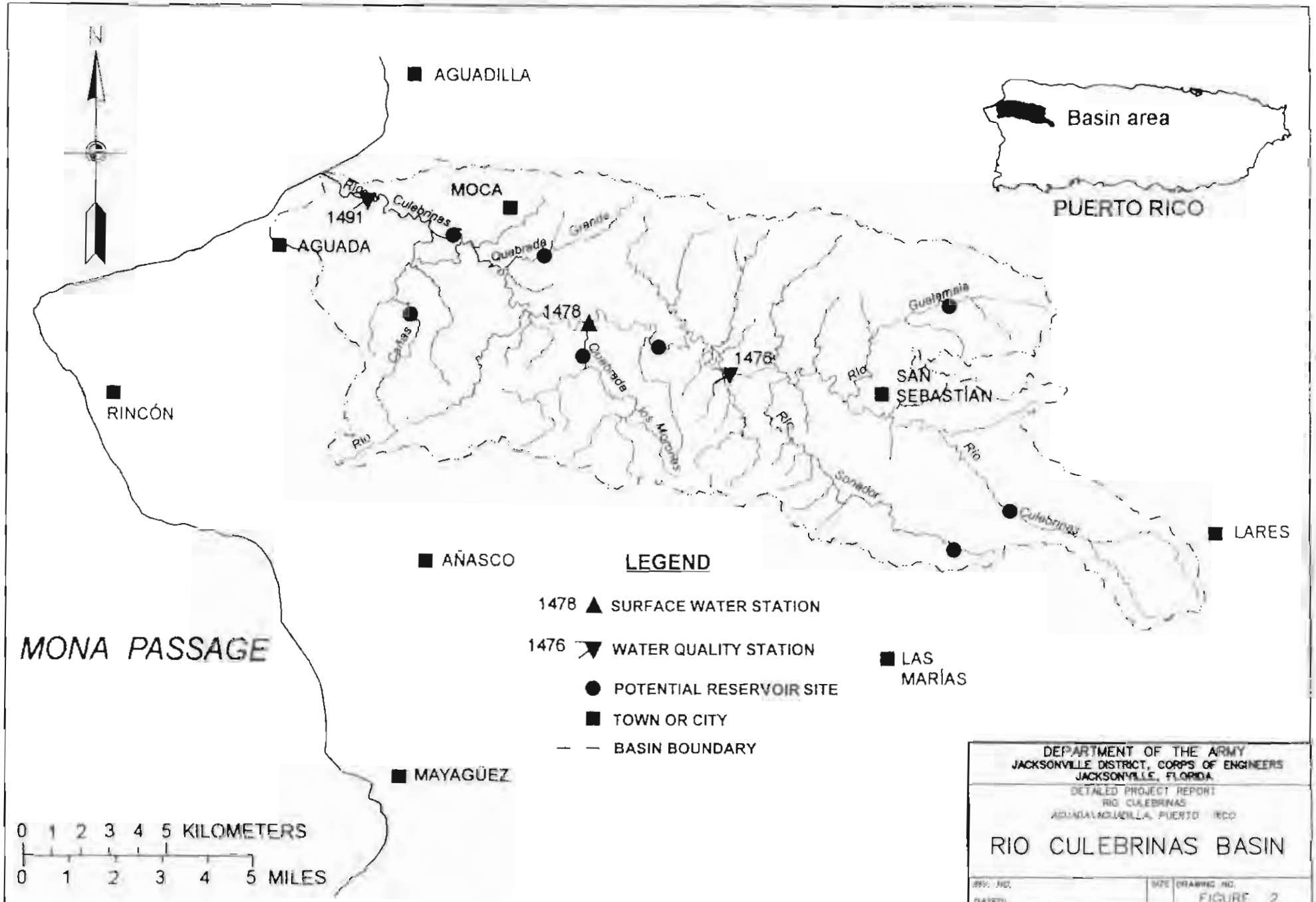
The results of these investigations are presented in a main report, and Environmental Assessment (EA), and five appendices. The main report includes the description of the river basin, analysis of the study area's flooding problems, plan formulation and evaluation process, and conclusions and recommendations of the study. The EA documents the description and analysis of the environmental resources as well as the evaluation of the potential effects that the plan of action would have on these resources and the rest of the area's human environment. The EA made reference to inputs and comments from other Federal agencies, particularly the Fish and Wildlife Service (USFWS) and the Environmental Protection Agency (EPA). The appendices present the supporting data and detailed investigations conducted as part of the study. These include: Appendix A, Hydrology and Hydraulics; Appendix B, Geotechnical Studies; Appendix C, Design and Cost Estimates; Appendix D, Economic Analysis; and Appendix E, Real Estate Plan.

VI. DESCRIPTION OF THE STUDY AREA

A. Physiography

1. The river basin. The Rio Culebrinas basin is located within the Municipalities of Lares, San Sebastian, Moca, Aguada, and Aguadilla on the northwestern coast of Puerto Rico. The Río Culebrinas basin is bordered to the north and east by the Río Guajataca basin, to the south by the Río Cuiebra and Río Grande de Añasco basins, and to the west by the Aguadilla Bay. The basin is considered a fairly gently sloping basin. A prominent feature of the basin is a 100-meter high limestone escarpment that extends along its northern boundary. There are no impounding reservoirs within the river basin. The total drainage area is approximately 267 square kilometers (103 square miles) at the mouth (See Figure 2). There may be additional drainage area in the limestone karst terrain along the northern side of the basin that cannot be precisely delineated using topographic maps.

The Río Culebrinas originates in the western part of the central mountain range of Puerto Rico at an elevation of approximately 450 meters (1,500 feet) above mean sea level. Its main tributaries are Río Guatemala, Río Caño, Río Sonador, and Quebrada Grande. The river flows in a westerly direction through the towns of San Sebastián, Moca, Aguadilla, and Aguada to discharge into the Aguadilla Bay in the Mona Passage. The total length of the river channel is approximately 44 kilometers (27.3 miles). The Caño Madre Vieja, a 2.1 kilometer (1.3 miles) distributary of Río Culebrinas, is an old river outlet that flows across the study area and discharges into the Aguadilla Bay. This small intermittent stream is the political boundary dividing the municipalities of Aguadilla and Aguada.


N
AGUADILLA
Basin area
PUERTO RICO
MOCA
1491
Río Culebrinas
AGUADA
Quebrada Granate
1478
Canas
Guatemala
1476
Río
SAN SEBASTIÁN
RINCÓN
Río
Quebrada Los Morones
Río
Río
Sonador
Culebrinas
LARES
AÑASCO
LEGEND
1478 SURFACE WATER STATION
1476 WATER QUALITY STATION
POTENTIAL RESERVOIR SITE
TOWN OR CITY
BASIN BOUNDARY
LAS MARÍAS
MONA PASSAGE
MAYAGÜEZ
0 1 2 3 4 5 KILOMETERS
0 1 2 3 4 5 MILES
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
DETAILED PROJECT REPORT
RIO CULEBRINAS
AGUADA/AGUADILLA, PUERTO RICO
RIO CULEBRINAS BASIN
FIGURE 2
SCALE: AS SHOWN
DATED: 03-29-02

2. Geology and soils. The principal soil associations found in the Río Culebrinas basin area the Voladora-Moca, Colinas-Soler, Caguabo-Múcara, and the Consumo-Humatas, in the uplands and the Coloso-Toa and Bejucos-Jobos in the lower flood plain. These soils are mostly of the "D" type, with a high runoff potential. Type "B" soils with moderate degree of drainage potential is also found within this basin. The flood plain is composed of alluvial deposits of sands, silts, clays, and gravels of various sizes.

3. Climate. According to the U. S. Weather Bureau climatological zone designations, the upper part of the basin lies within the western interior zone; the north part and the flood plain are in the northern slopes zone. Daily temperature ranges are relatively small, with a mean annual temperature ranging from 21 to 26 degrees centigrade (70 to 80 degrees Fahrenheit). Mean annual precipitation varies from 115 to 205 centimeters (45 to 80 inches).

B. Natural Resources

1. Water resources. There are significant surface and groundwater resources in the Río Culebrinas basin. The average discharge of the Río Culebrinas from 23 years of record is 8.44 cms (298 cfs or 215,900 acre-ft/yr), which is the fifth largest of all the basins in Puerto Rico. Groundwater occurs in more than one aquifer in the area, but the alluvial aquifer is the most important. Lack of adequate flow control structures limits further development of present surface water supply.

2. Coastal resources. Coastal resources within the study area include some wetlands near the mouth of the rivers, extensive agricultural coastal plains, and a long stretch of undeveloped sandy beaches designated as a Coastal Barrier under the Coastal Barrier Resources Act (CBRA) of 1982 (Public Law 97-348).

3. Environmental resources. The river valley was cleared of its original vegetation before the Twentieth Century and extensively planted with sugar cane. Sugar cane is no longer a major crop in the study area, although it is still sparsely grown near the coast. Most of the lands in the detailed study area are now fallow or unimproved pasture, but climax vegetation would be an open-crowned semi-deciduous hardwood forest dominated by the native tree úcar (*Bucida buceras*). Cattle grazing have limited tree and shrub vegetation to a few sporadic patches or riverbank stands.

The major environmental resources within the study area are the Cayures swamp near Central Coloso, the coastal barrier along the Espinar beach, and the mangrove and herbaceous wetlands near the mouth of Caño Madre Vieja. Other environmental resources include aquatic habitat within the river channel, estuarine habitat at the river mouth, the near shore saltwater habitat where the river enters the ocean, the agricultural lands adjacent to the river, and the riparian habitat within the river banks. According to the U.S. Fish and Wildlife Service (USFWS), there are no known threatened or endangered species occurring within the proposed project area.

4. Cultural resources. The Rio Culebrinas valley is a very important area in the prehistory and history of Puerto Rico. The area was inhabited throughout the Ceramic age of prehistory, demonstrated by archeological sites containing Saladoid and Ostionoid series ceramics. A nine-kilometer (5.4 mile) stretch of coastline encompassing the study area is the conjectured 1493 landing site of Columbus. Sir Francis Drake visited the area in 1595. The Iglesia de Espinar, identified as the "Ruins of the Hermitage of Immaculada Concepción of Barrio Espinar, Aguada" on the property's draft National Register form, is one of Puerto Rico's earliest churches and is located adjacent to the Espinar levee. The church was originally constructed in 1526. Numerous sugar producing haciendas and sugar processing molinos (sugar mills) were established in the river floodplain in the 19th and 20th centuries.

C. Socio-Economic Characteristics

1. General. The Municipality of Aguadilla was officially established in 1775. It covers an area of 93.2 square kilometers (23,030 acres). It is bounded to the north by the Atlantic Ocean, with the Municipalities of Isabela and Moca to the east, Municipality of Aguada to the south, and the Mona Passage to the west. It is territorially subdivided in 16 "barrios" or wards.

The Municipality of Aguada was initially established in 1510. It covers an area of 78 square kilometers (19,274 acres). It is bounded to the north by the Mona Passage and the Municipality of Aguadilla, with the Municipality of Moca to the east, Municipality of Añasco to the south, and the Municipality of Rincón and the Mona Passage to the west. It is territorially subdivided in 18 "barrios" or wards.

The Municipalities of Aguadilla and Aguada are connected to the island's primary highway system through Highway 2. Highway 115 connects the towns of Aguadilla, Aguada, and Rincón. Highway 111 connects the towns of Aguadilla, Moca, and San Sebastián. There are several second and third order highways and municipal roads linking all the "barrios" and rural communities with each other, with the town of Aguadilla, and with the neighboring towns.

The economic base of both neighboring municipalities revolves around major and diversified manufacturing activities, local tourism, trade, educational and health services. The second largest airport in Puerto Rico is located at Aguadilla's former Ramey Air Force Base.

2. Demographics. The town of Aguadilla, which is the main urban center of the study area, is a dense urban area located on the northwestern tip of the island to the north of Río Culebrinas. According to the U. S. Census Bureau, the population of the Municipality of Aguadilla totaled 59,335 persons in 1990, of which approximately 40 percent live within the urban area of Aguadilla. U.S Census Bureau estimates for July 2000, showed a 7 percent increase for a total population of 63,511 persons. The urban area includes the wards of Aguadilla Pueblo, Borinquen, Caimital Bajo, Camaceyes, and Victoria.

The Community of Espinar is a relatively large coastal rural community located in the northwestern corner of the Municipality of Aguada. According to the U. S. Census Bureau, the population of the Municipality of Aguada totaled 35,911 persons in 1990, of which approximately 4 percent 1,382 persons live in Espinar community. U.S Census Bureau estimates for July 2000, showed a 9.2 percent increase for a total population of 39,536 persons for the Municipality of Aguada of which approximately 1,582 persons live within the Espinar Community.

3. Employment and labor force. Local economy was traditionally centered around agricultural pursuits, mainly sugar cane, coffee, tobacco, minor crops, and cattle at higher ground. The sugar industry, however, as in the rest of the island, has been rapidly declining. Sugar cane is still cultivated in the flood plain and hills in the upper basin. Central Coloso is the only sugar mill still operating in Puerto Rico.

Fishing was, and still is, an important activity. Today, Manufacturing and local tourism are the most important sectors of the local economy. Ramey Air Force Base was an important source of revenue and employment during the 40 years that it was in operations. Today, the former Air Force Base houses a large residential community, several beaches, one golf course, an International Airport, many government offices and facilities, schools and universities, several commercial and industrial activities, and other military and national defense activities.

D. Future Conditions

1. Population and labor force. Considerable population and economic growth in the study area, and particularly in the towns of Aguadilla and Aguada, are expected to continue with or without a flood control project. Completion of San Juan-Arecibo Expressway (Highway 22) and ongoing improvements to Highway 2, and improvement of secondary roads would contribute significantly to this growth. The construction of new industries, shopping malls, hotels, airports, harbors, and the expansion of the services sector would stimulate further development of the area. According to projections of the Puerto Rico Planning Board (PRPB), the combined population of the municipalities of Aguadilla and Aguada are projected to increase from 95,246 in 1990 to approximately 106,200 persons by the year 2005. The total combined labor force will be concentrated in the services particularly tourist and professional services, retail trade, and government.

2. Land use. According to the PRPB land use plan for the year 1992, the land proposed for future urban expansion is mostly located east of the town of Aguadilla and to some extent southwest of the urban core, and to the south of the town of Aguada. The area has a large potential for additional industrial and residential development because of improvements to its infrastructure like the ongoing improvements to Highway 2, construction of the Aguadilla Harbor, and the utilization of former Ramey Airfield by commercial airlines.

VII. PROBLEMS, NEEDS, AND OPPORTUNITIES

A. Flooding

1. General. During flood seasons the Río Culebrinas and Caño Madre Vieja are a potential danger to the lives of the residents of the study area and are a source of frequent flood damage. Floods can occur anytime during the year; however, they are most frequent during the period of May through December. Large peak discharges resulting from storm rainfall, generally associated with the passage of hurricanes, tropical depressions and tropical waves over or near the island. Cloudburst storms can occur anytime during the year; and because of the very steep slopes in the upper basin, flash floods are another common type of event affecting this area.

There is only one principal floodable area within the watershed: the mostly confined and relatively flat Río Culebrinas flood plain between the towns of Aguada, Aguadilla, and Moca. Below Highway 115, the 100-year flood from Río Culebrinas inundates over 1,500 acres of land. The community of Espinar in Aguada is located in the middle of the flood plain between Río Culebrinas and Caño Madre Vieja (refer to Figure 1). Floods inundate all the major highways and roads in the Río Culebrinas flood plain. The entire community of Espinar is surrounded by floodwater during large floods.

2. Historical floods. Since the turn of the century there have been at least 38 large floods on the Río Culebrinas. The largest flood of record occurred in September 16, 1975 during Tropical Storm Eloise. This flood had an estimated recurrence interval of approximately 50 years. The discharge associated with this flood was estimated at 1,955 cms (69,000 cfs), and stages just downstream of Highway 2, where ground elevation average approximately 4.0 meters, reached approximately 7.2 meters (23.6 feet) above mean sea level.

The most outstanding recent floods in the Aguadilla area for which stream gaging station records exceeded 850 cms (30,000 cfs) were those which occurred during October 1972, May 1980, October 1981, May 1985, May 1986 and August 1988. There are twenty-three other large floods in the Río Culebrinas for which records at the stream gaging station exceeded 566 cms (20,000 cfs).

3. Potential floods. It is estimated that the 100-year flood would inundate over 1,500 acres of land below highway 115. The 100-year flood would cause severe flooding along the southern portions of the town of Aguadilla and inside most of the Espinar and Tablonal in Aguada. Flooding would occur along some large portions of Highway 2, Highway 115, Highway 111, Highway 418 and Highway 442 as well as flooding a large portion of the agricultural lands and industrial and commercial areas in the lower flood plain (refer to Figure 3).

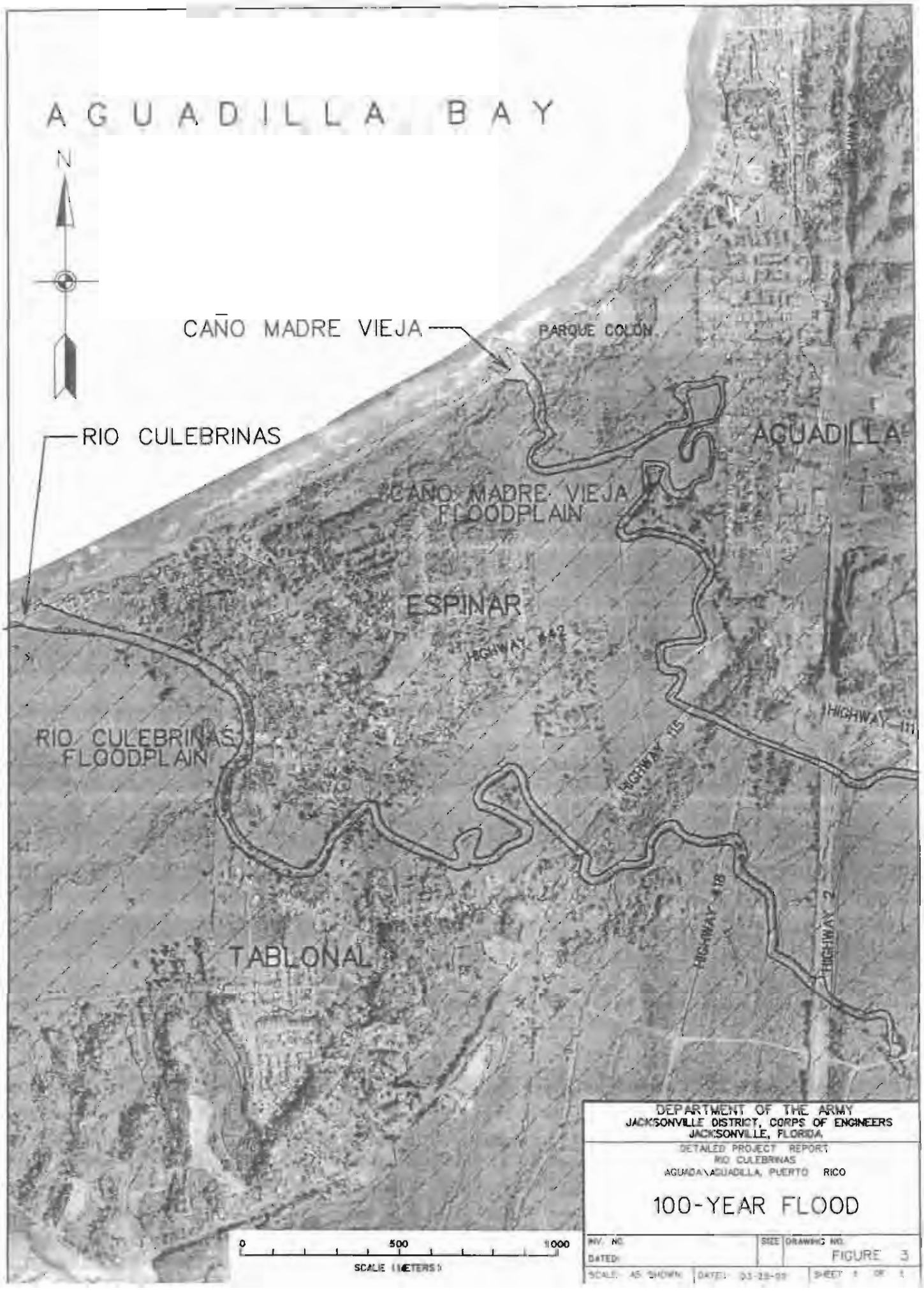
4. Floodable area. As recorded by flood records presented by the U. S. Geological Survey Floods in Aguadilla Area, Puerto Rico, Hydrologic Investigations, Atlas HA-457, 1972, the event of November 27, 1968 covered the southern portions of the town of Aguadilla and the northeast portions of Espinar in Aguada with up to two meters of floodwaters.

At the town of Aguadilla, where the average ground elevation is approximately 2.5 meters above mean sea level, the computed 100-year flood will produce an average maximum stage of 4.3 meters (14.1 feet) above mean sea level and the computed 500-year flood will produce an average maximum stage of 5.0 meters (16.4 feet) above mean sea level. Both floods will cover over 5.9 square kilometers (1,500 acres) of land below Highway 115 of which approximately 1.0 square kilometers (247 acres) have urban development (refer to Figure 3).

5. Flood damage. Under existing conditions, the floodable area is affected by two sources, Río Culebrinas and Caño Madre Vieja. The main source of residual flooding for with project condition will come from interior drainage. The inventory of the urban property subject to damage by the SPF flood from Río Culebrinas and Caño Madre Vieja included some 797 housing units, 96 commercial establishments, 49 public buildings and utilities, and 7 nonprofit establishments. Table 2 summarizes the number of structures subject to flooding for selected frequencies at Aguadilla and Espinar. Appendix E, Economic Analysis, provides a detailed description of affected property.

The 100-year flood would produce damage of $12.2 million, while the Standard Project Flood (SPF) would produce damage reaching $19.2 million. Expected average annual damage is estimated to be $1,157,500. Table 3 shows damage estimates for existing conditions by flood frequencies and land use categories.

6. Hurricane tides. Historically, the detailed study area has never been extensively flooded by hurricane or storm tides because of its location relative to the direction of winds and historical storm tracks. According to the report Storm Tide Frequency Analysis for the Coast of Puerto Rico, prepared by NOAA on August 1973, the 500-year, 100-year and 25-year storms will produce an average maximum tide of 2.7 meters (9.0 feet), 1.6 meters (5.3 feet), 0.8 meters (2.5 feet), respectively, above mean sea level.



DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DETAILED PROJECT REPORT
RIO CULEBRINAS
AGUADA\AGUADILLA, PUERTO RICO

100-YEAR FLOOD

INV. NO.	SIZE	DRAWING NO.
DATED:		FIGURE 3
SCALE: AS SHOWN	DATE: 03-29-99	SHEET 1 OF 1

TABLE 2

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

NUMBER OF STRUCTURES SUBJECT TO FLOODING
FOR SELECTED FLOOD EVENTS
AT AGUADILLA AND ESPINAR

Flood Frequency	Aguadilla	Espinar	Total
2-Year	27	48	75
5-Year	208	56	264
10-Year	271	63	334
25-Year	363	88	451
50-Year	521	217	738
100-Year	550	293	843
SPF	561	381	942

Source: Field Survey U.S. Army Corps of Engineers.

TABLE 3

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

POTENTIAL FLOOD DAMAGE ESTIMATES
FOR SELECTED FLOOD EVENTS AT AGUADILLA AND ESPINAR
EXISTING CONDITIONS WITHOUT PROJECT
($1,000 OF 2002)

Flood Frequency	Aguadilla	Espinar	Total
2-Year	430	101	531
5-Year	774	288	1,062
10-Year	1,839	418	2,257
25-Year	3,277	682	3,959
50-Year	9,068	1,593	10,661
100-Year	10,046	2,099	12,245
SPF	13,796	5,434	19,230
AAED	938.4	219.1	1,157.6

Average Annual Equivalent Damages (AAED): $ 1,157,600

Heavy wave action occurs every year during the passage of strong cold fronts and some tropical storms. Over the years, heavy wave action induced substantial beach sand movements forming sand bars in some areas and causing severe coastal erosion in other areas.

In 1918, a very rare tsunami caused by a nearby ocean earthquake, estimated at over 8.0 Richter's Scale, destroyed many buildings and flooded the low-lying coastal areas. The earthquake and resulting tsunami caused several deaths of Aguadilla residents.

B. Water Supply

There are significant water resources potential in the Río Culebrinas watershed. There are seven potential water supply reservoir sites within the Río Culebrinas Basin (refer to Figure 2). The Puerto Rico Aqueduct and Sewer Authority (PRASA), is taking up to 17 millions gallons per day from an intake structure located just upstream from the Highway 2 bridge.

C. Water Quality

According to U. S. Geological Survey, the water from Río Culebrinas is of good quality and suitable for most purposes. Analyses of water samples collected at the Moca water quality station in May 1990 indicate that high concentrations of zinc and iron may be the most serious water quality problem. On the other hand, water quality records on groundwater are not available.

D. Erosion and Sedimentation

The central mountains of Puerto Rico are comprised of igneous and sedimentary rocks. The intensive processes of chemical weathering, which characterizes the humid tropical climate, have produced moderate and deep soil profiles, which might fail during a prolonged period of rainfall. The steep portions of Río Culebrinas basin are mostly undeveloped and are covered by a thick rain forest. There is no evidence of problems related to debris flows reaching Highway 2 during past floods. At flood stage, the Río Culebrinas carries normal amounts of sediments, which are deposited along the lower flood plain and in the Mona Passage.

E. Land Use

The topographic restrictions of the region would eventually limit the growth of the town of Aguadilla and the Espinar community. The Río Culebrinas and Caño Madre Vieja flood plain, the Aguadilla Bay, and steep slopes are physical barriers that would eventually limit the growth of the area. There is sufficient flood free land for future urban development within the study area.

F. Hazardous and Toxic Wastes

An initial HTRW assessment was conducted in May 1995 and updated in May 1999. The assessment included an investigation of the water quality and air quality potential impacts in the project area, review of available literature and documents, and site reconnaissance. The predominant land use is agricultural and poses little or no HTRW threat. No signs of potential HTRW problems were identified and no sites with potential for contamination with HTRW were found. During the development of plans and specifications or during project construction, the development of a response plan for dealing with any HTRW encountered is the exclusive responsibility of the local sponsors as stated in ER 1165-2-132 "Water Resources Policies and Authorities HTRW Guidance for Civil Works Projects", dated June 1992.

G. Flood Plain Development

Executive Order 11988 ties together the need to protect human lives and property with the need to restore and preserve all natural and beneficial flood plain values. The objective of the executive order is to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of development wherever there is a practicable alternative. The test of what is a practicable alternative depends upon the situation and includes consideration of many pertinent factors such as environment, cost, design, and construction technology.

The order is based in part on the National Environmental Policy Act (NEPA) of 1969, and it adds new prominence to the environmental aspects of flood plain management. Consideration must be given, therefore, to natural and beneficial flood plain values and to the public benefits to be derived from their restoration or preservation. Section 2(a)(2) of the order requires that if an agency has determined to, or proposes to, conduct, support, or allow an action to be located in a flood plain, the agency shall:

1. Consider all practical alternatives to avoid effects and incompatible development in the flood plains.

2. Design or modify its action in order to minimize potential harm to or within the flood plain.

3. Prepare and circulate a notice containing an explanation of why the action is proposed to be located in the flood plain.

All flood control alternatives considered and evaluated during this study have been carefully formulated to obtain the most practical and feasible alternative in accordance with the flood plain preservation requirements dictated by Executive Order 11988. The proposed project minimizes impacts to flood plain values and does not promote development of land in the flood plain.

H. Prime and Unique Farmlands

The Farmland Protection Policy Act, implemented under the Department of Agriculture's final rule effective 6 August 1984, requires the USACE to coordinate with the Soil Conservation Service for identification of prime and unique farmland which might be impacted by the proposed project. It is within USACE discretion to proceed with a project that would result in conversion of farmland to nonagricultural uses once the potential impacts of the proposed action have been examined and alternatives to lessen the adverse effects have been considered. The final rule also requires that the project be compatible with state and local programs for the protection of farmlands.

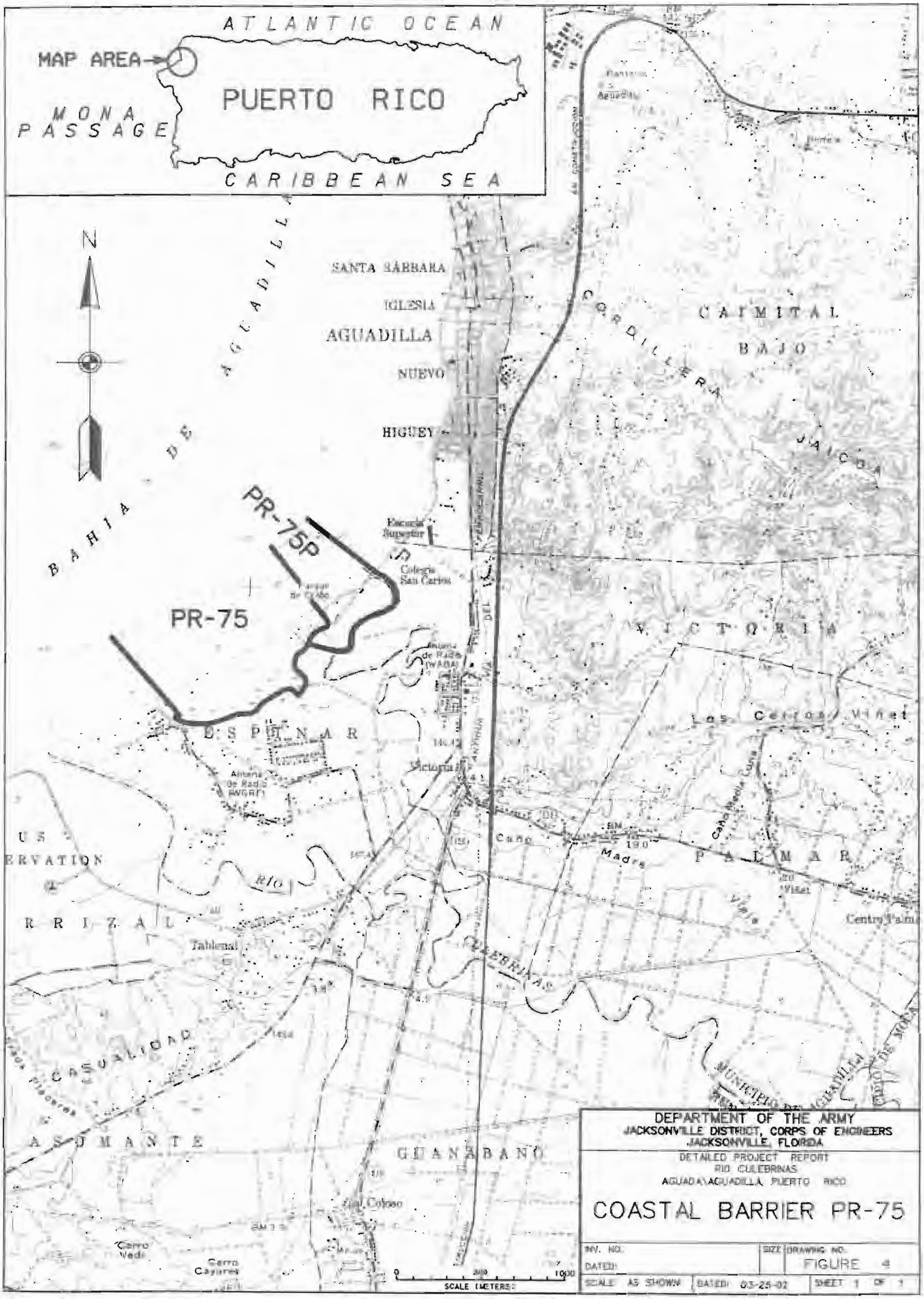
All alternatives considered and evaluated during this study have been formulated in accordance with the prime and unique farmlands preservation requirements of the Farmland Protection Policy Act. The proposed project levees and pilot channel will not impact any areas designated as prime and unique farmlands.

I. Coastal Barrier Resources

The Coastal Barrier Resources Act (CBRA), Public Law 97-348 (96 Stat. 1653; 16 U.S.C. 3501 et. seq.), enacted October 18, 1982, designated various undeveloped coastal barrier islands, depicted by specific maps, for inclusion in the Coastal Barrier Resources System (CBRS). Areas so designated were made ineligible for direct or indirect Federal financial assistance that might support development, including flood insurance, except for emergency life-saving activities. The Coastal Barrier Improvement Act of 1990 (CBIA, P.L. 101-591; 104 Stat. 2931) included in the System additional areas along the Great Lakes, Puerto Rico, the Florida Keys, the Virgin Islands, and secondary barriers within large embayments.

The undeveloped sand berm and mangrove wetlands between the mouth of Río Culebrinas and Caño Madre Vieja encompass CBRS unit PR-75 (See Figure 4). The unit extends for approximately 1 kilometer along the coast northwest of Espinar in the Municipality of Aguada. However, long before CBRA was enacted, the northeast beach end of PR-75 was subjected to significant shoreline manipulation and stabilization by the construction of two rock jetties, construction of recreation facilities, parking facilities, and the construction and maintenance of a man-made Caño Madre Vieja outlet channel. Therefore, the northeast beach end of PR-75 had experienced significant development by the time it was included in the CBRS.

Recently, a 28 acres multifamily housing development presently named "Costa de Marfil" is proposed within CBRS unit PR-75. The proposed private housing development will consist of 240 apartments, 10 luxury villas, recreation facilities, and parking facilities. The developers of the housing project have proposed to donate for permanent conservation about 12 acres of adjacent wetlands within PR-75 to DNER.


ATLANTIC OCEAN
MAP AREA
PUERTO RICO
MONA PASSAGE
CARIBBEAN SEA
N
SANTA BARBARA
IGLESIA
AGUADILLA
NUEVO
HIGUEY
BAHIA DE AGUADILLA
PR-75P
PR-75
CORDILLERA
CAIMITAL BAJO
JAICOA
VICTORIA
Los Cerros Viñet
ESPINAR
Victoria
Caño Madre Vieja
PALMAR
Centro Palma
RIO CULEBRINAS
Tablonal
CASUALIDAD
ASOMANTE
GUANABANO
Cerro Cayures
SCALE (METERS)
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
DETAILED PROJECT REPORT
RIO CULEBRINAS
AGUADA\AGUADILLA, PUERTO RICO
COASTAL BARRIER PR-75
INV. NO.
DATED:
SCALE: AS SHOWN
DATED: 03-25-02
DRAWING NO.
FIGURE 4
SHEET 1 OF 1

CBRS unit PR-75P is located between the existing and the old mouth of Caño Madre Vieja (See Figure 4). Most of PR-75P is within Parque Colón, a large recreation park with several commercial and recreational structures, parking, roads, etc. Portions of PR-75P consist of wetlands along the old Caño Madre Vieja channel.

The recommended project has been carefully formulated to obtain the most practical, feasible, and environmentally acceptable flood control alternative avoiding all impacts to the CBRS.

J. Cultural Resources

Cultural resources investigations and consultation with the Puerto Rico State Historic Preservation Officer (SHPO) are in compliance with the National Historic Preservation Act of 1966 as amended (16U.S.C.470 et seq.), the Archeological and Historic Preservation Act of 1974 (16U.S.C. 469-469c) and 36 CFR Part 800. For those historic properties that will be adversely affected, mitigation plans will be developed in consultation with the SHPO. The USACE will implement the mitigation plans prior to any ground disturbing activities being initiated. Information collected during from cultural resources investigations will be reported in technical and popular reports.

K. Aesthetic Resources

The existing aesthetic resources of the Río Culebrinas area include a scrubby-edged, sandy riverbed where the watercourse is usually a shallow constant water flow. Long-range views are afforded toward the low mountains. Along the urban stretch of the river, mature trees and underbrush enclose the river behind wood and tin houses. Accumulated trash can be found in some portions of the flood plain.

The levee will provide some high relief (2.5 meters) to the west of town, and will obscure views of the flood plain. The view of the hills further to the west will not be obscured and views from the top of the levee will increase the sight distance towards them. Grassing on the levee will assist in helping it blend well along its length.

VIII. PLAN FORMULATION RATIONALE

A. General

Plan formulation involved the identification, analysis, and evaluation of various flood control management plans that addressed several planning objectives within a set of constraints, assumptions, and criteria. This report analyzes flood control alternatives to solve the flooding problem along the western edge of the town of Aguadilla and the community of Espinar in Aguada, and investigates various non-structural and structural alternatives.

B. Planning Objectives

An analysis of the study area's problems, needs, and opportunities relating to water and land related resources resulted in the identification of five important planning objectives. Of foremost importance is the solution of the flooding problem that affects Aguadilla and Aguada and threatens the lives and properties of its residents. The specific objectives identified for this study are:

1. Safeguard the lives of all residents in the flood plain.

2. Reduce property losses in the town of Aguadilla and the community of Espinar due to flooding.

3. Minimize impact on valuable natural flood plain and environmental resources within the detailed study area.

4. Enhance opportunities for redevelopment throughout the study area.

5. Protect, preserve, or minimize impacts on significant historical and cultural resources of the detailed study area.

C. Planning Constraints

The planning constraints that limit or influence the type of measures that were considered include:

1. The scope of the study is limited to the flood prone areas in the western edge of the town of Aguadilla and the community of Espinar of Aguada.

2. Physical constraints related to the proximity of the urban development to the river main channel.

3. Caño Madre Vieja Floodway encroachment by levees that may increase flood stages in the Río Culebrinas flood plain.

4. The need to construct long Highway ramps over high levees may require highway relocation or changes in levee alignment to obtain more space.

5. The need to avoid or minimize impacts to environmental and cultural resources that could be found within the project area.

D. Planning Assumptions and Criteria

Several engineering and economic assumptions and criteria were established to guide the plan formulation and evaluation process.

1. Engineering

a. Each alternative must be complete in itself.

b. High discharges, high velocities, and short time to peak require that degree of protection and type of design minimize potential for catastrophic results should project works fail.

c. The design flood is to be based on most probable future hydrologic conditions.

d. Each alternative should minimize residual flooding and damage.

e. A pilot channel was considered for Caño Madre Vieja, were the proposed levee cutoff the existing channel.

f. Earthen levees were designed to have an alignment, which would minimize floodway encroachment, minimize real estate requirements while affording sufficient area for drainage channels and internal storage of local runoff in order to eliminate the need for pumping stations.

2. Economic and financial

a. Each alternative must be justified in itself and each separate element of an alternative must be incrementally justified.

b. For purpose of optimization of net National Economic Development (NED) benefits not only are different alternatives examined, but similar alternatives are examined for different degree of protection.

c. Total beneficial contributions of each alternative considered must exceed the total adverse impacts, and one of the alternatives must maximize net NED benefits.

d. The study year is taken as 2002, the base year as 2008, and the end of the planning period as the year 2052.

E. Without Project Conditions

The without project conditions scenario would be equivalent to the no action alternative, which envisions no flood control project within the study area. Potential flood hazard to the life, health, and property of detailed study area residents would remain together with the need for additional water supply as the most critical water-related problems.

Periodic disruption of productive economic activities resulting from flooding in the detailed study area would impair further economic development of the western portions of the town of Aguadilla and the community of Espinar. Relocation of all the activities in the area seems unlikely because nowhere else are similar locations and agglomeration economies available.

The manufacturing and tourism industries are expected to remain as the most important sources of income and employment for both municipalities. The increased utilization of the excellent airports and harbors facilities, construction of the north west aqueduct, and the continued growth of the service and construction sector will also make a significant contribution to future economic development.

The without-project condition serves as a benchmark to assess and evaluate the candidate flood-control alternatives.

IX. FORMULATION OF PRELIMINARY PLANS

A. Identification of Relevant Measures

Four nonstructural and four structural measures were identified to fully or partially address the planning objectives previously identified. The non-structural measures considered are flood plain management, flood insurance, temporary and permanent flood plain evacuation, and channel maintenance. The structural measures considered included flood proofing, multipurpose reservoirs, channel improvements, and levees and/or floodwalls. All measures considered are described below:

1. Nonstructural measures.

a. Flood plain management. The most important and relevant nonstructural measure that the government of Puerto Rico has to manage development in the study area's flood-prone areas is the Puerto Rico Planning Board Regulation 13. This regulation, which predates FEMA flood plain regulations and which in 1987 was revised to make it consistent with FEMA, regulates all new developments and expansion of, or improvements to, existing developments in flood-prone areas.

To receive a construction permit in a flood-prone area a developer must establish through a detailed hydrologic and hydraulic study that his project is above the 100-year flood event or that it will not increase flood stages by more than 0.3 meters. During the past years the PRPB have denied several permits for new developments in the study area's flood plain because they do not comply with flood plain management regulations. Flood plain management regulations are assumed to be in effect under all plans. This measure will have very limited effect in reducing potential flood damage to existing development.

b. Flood insurance program. The National Flood Insurance Program (NFIP) is administered by the Federal Flood Insurance Administration (FIA), which is part of FEMA. The Puerto Rico Planning Board (PRPB) serves as the local coordinating agency for the Flood Insurance Program in Puerto Rico. Puerto Rico entered the Emergency Flood Insurance Program (EFIP) in 1972 and entered the Regular Flood Insurance Program in 1978. Puerto Rico is considered a single community by the FIA.

Flood insurance would not reduce or eliminate the flooding problem but it would serve to reimburse property owners for flood losses incurred. The measure, however, seems to have been of very limited acceptance in Puerto Rico for despite frequent and significant flood damage, less than ten percent of the families living in the flood plain have acquired the insurance. However, during recent years financial institutions have required flood insurance as a condition for mortgage approval for structures located below the 100-year base flood elevation. For structures without mortgages, flood insurance is voluntary. However, flood insurance protection it is expected to be in effect under all plans considered.

c. Temporary and permanent flood plain evacuation. Temporary evacuation of persons and personal property from flood-prone areas could be accomplished when a flood threat exists. Temporary evacuation can be very effective when operated in conjunction with reliable flood warning system and where movable, damageable objects are concerned. However, at the present time there is no flood warning system in operation for the Río Culebrinas basin. The complicated process could save many lives, but leaves no time and no additional resources for taking any measures to protect and save personal property.

Permanent evacuation of the flood plain areas could be used to reduce flood damage potential. Such a measure involves land purchase, removal of buildings and infrastructure, and relocation of population. Lands acquired in this manner could be used for parks or other purposes that would not interfere with flood flows or receive material damage from floods. The permanent relocation of hundreds of concrete housing units, and hundreds of commercial establishments in a highly urbanized area is to a large extent impractical and would have very little acceptance. Therefore, permanent evacuation is not considered any further.

d. Stream cleanup program. This measure primarily consists of removal of trash, debris, and sediments from the existing stream channel. Experience with cleanup programs in other rivers suggest that such works have the effect of restoring the natural capacity of the rivers. The cleanup programs have proved to be effective in alleviating the effects of small periodic flooding; however, they do not contribute to solve the flooding associated with intermediate and large floods. These floods are a continuous menace in the study area. Stream cleanup should be a recurring activity.

2. Structural measures

a. Flood proofing. Flood proofing is a structural change and/or adjustments, which allow floodwaters to rise around or within a structure with little or no damaging effects to the structure. Flood proofing techniques do not eliminate residual nuisance damage, loss of access, loss of business, possible utility and community interruptions, and potential danger to public health and safety. This is difficult to implement on a large number of structures and therefore is not considered any further.

b. Multipurpose reservoir. The construction of a multipurpose reservoir could reduce flood levels by holding back peak flows until downstream flood plain conditions permit a controlled release of stored floodwaters. They can also be effective in fulfilling other water resources needs such as water supply and recreation. Previous USACE studies identified several potential reservoir sites in the upper Río Culebrinas. None of the reservoir sites identified, as shown on Figure 2, would have significant flood reduction in the lower flood plain.

c. Channel improvements. Channel improvements for Río Culebrinas along a straight alignment from Highway 2 towards the ocean would provide effective flood control to the entire lower flood plain. Any type of channel improvement would require an improved outlet and some type of velocity-control measures and channel revetment. An improved outlet to the ocean would require revetments to stabilize it and perhaps also jetties to protect it from coastal sand movements.

d. Levees and floodwalls. These measures preclude floodwaters from entering damage-susceptible areas. They are considered in detail because of the physical and natural conditions of the area, and also because they appear to be the most practicable, acceptable, and efficient flood control measure for the detailed study area. Levees and floodwalls could provide considerable flood protection to the detailed study area. The physical conditions of the detailed study area are; the urban development is located to just one side of the flood plain, for most reaches there is sufficient available open space between the river and the urban area to accommodate the levee, and levee construction materials are readily available in the area. A ring levee around the community of Espinar and a levee between Caño Madre Vieja and the town of Aguadilla, investigated during the reconnaissance study, will require minimal channel relocations and minimal structure acquisitions and utilities relocations.

B. Description and Evaluation of Preliminary Plans

As described during the identification of relevant measures, the initial plan formulation considered several non-structural and structural measures. All non-structural measures examined, except permanent flood plain evacuation, are expected to be in effect under all plans considered. Because of difficult implementation, flood proofing of structures was eliminated from consideration.

The relatively small size of all the potential reservoir sites within the Río Culebrinas basin (see Figure 2) would have little effect on reducing flood stages in the lower flood plain and their cost would be over $50.0 million. Therefore, the multipurpose reservoir alternative was not considered any further.

Widening and deepening the present Río Culebrinas channel and route realignment practically throughout the lower flood plain could provide flood control to the entire coastal flood plain. The substantial channel improvements required for Río Culebrinas, in order to control major floods, could adversely impact the stream habitat of the native river shrimp and the natural water flow into the adjacent estuary and swamp. Since the cost of the required channel work would be over $30.0 million, which is beyond the funding limitation of the Continuing Authority Program, negative net benefits, adverse impact to environmental and cultural resources in the flood plain, the channel improvement alternative was not considered any further.

Levees could provide low cost and effective flood protection to the town of Aguadilla and the community of Espinar. Therefore, flood control levee alternatives are considered the only practicable, acceptable, and efficient flood control measure for the Río Culebrinas lower flood plain. Three alternative levee alignments were developed into two preliminary plans, a short levee alignment and a twin levee alignment. The most cost effective and environmentally acceptable alignment identified during the preliminary plan formulation process would be examined in detail during the final plan formulation process.

1. Preliminary Plan 1. This alternative would consist of a single short levee from Highway 2 to the Espinar community. The levee would prevent flood from Río Culebrinas to enter and flood the Caño Madre Vieja flood plain (refer to Figure 5). This alternative would protect the entire lower Caño Madre Vieja flood plain and the urban area of Aguadilla and Espinar against the 100-year floods from Río Culebrinas.

The average levee height would be approximately 3 meters above natural ground. The total length of the levee would be approximately 1.1 kilometers. Drainage canals would be provided at locations were natural overland runoff would be disrupted by the levee. The drainage canals would collect and direct storm water runoff into Caño Madre Vieja and Río Culebrinas without the need for providing drainage structures through the levee. The drainage canals would be of trapezoidal cross section with 1 meter of depth, 1 meter of bottom width, and 1V on 3H side slopes. The total length of drainage canals would be approximately 1,600 meters.

The existing Caño Madre Vieja channel would be utilized mainly for local drainage. Normal daily flow to Caño Madre Vieja from upstream of Highway 2 would be maintained as under existing conditions through existing culverts placed under Highway 2. Continued use of these culverts will maintain the existing normal freshwater flow from areas upstream of Highway 2 to mangroves located near the Caño Madre Vieja outlet. The maximum flow through these culverts under the differential head caused by a 100-year flood conditions would be 27.1 cubic meters per second (957 cfs).

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DETAILED PROJECT REPORT
RIO CULEBRINAS
AGUADA\AGUADILLA, PUERTO RICO

PRELIMINARY PLAN 1

INV. NO.		SIZE	DRAWING NO.
DATED:			FIGURE 5
SCALE: AS SHOWN	DATED: 03-25-02		SHEET 1 OF 1

This alternative would require the construction of three road ramps were the levee crosses Highways 418, 115, and 442. This alternative would not require the replacement of highway bridges. This alternative would require the acquisition of hundred of structures in the floodway at Tablonal community and hundreds of acres of flowage easements, due to an increase in flood stages in the floodway between Highway 115 and Highway 2.

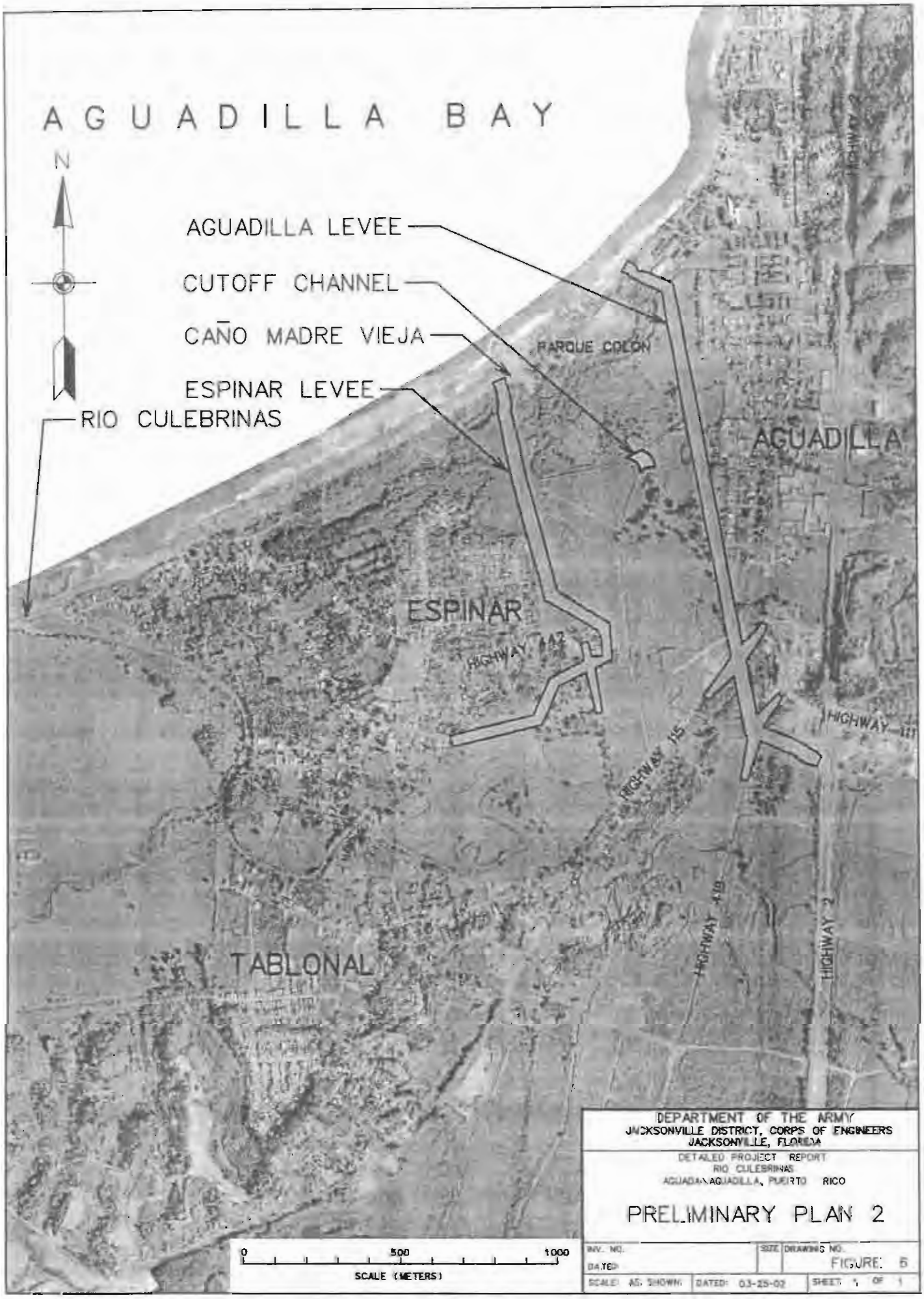
The estimated cost of this alternative is $8.0 million, of which $5.5 million are attributed to real estate cost due to an increase in flood stages. Since the real estate cost of the short levee alternative would be very high, and there would be adverse impact to residents of Tablonal community, the short levee alternative was not considered any further.

2. Preliminary Plan 2. This alternative would consist of twin levees, one protecting the urban area of southwest Aguadilla and the other protecting the community of Espinar (refer to Figure 6). The twin levee alternative would protect these two areas against the 100-year flood.

The average height of both levees is approximately 3.2 meters above natural ground. The total length of both levees would be approximately 3.3 kilometers. Drainage canals and drainage structures would be provided at locations were natural overland runoff was disrupted by the levees. The drainage canals would collect and direct storm water through the levee into Caño Madre Vieja by drainage structures consisting of 72 inch corrugated metal culverts with flap gates. The drainage canals would be of trapezoidal cross section with 1 meter of depth, 1 meter of bottom width, and 1V on 3H side slopes. The total length of drainage canals would be 3,100 meters. The vacant lands behind the levees would provide temporary storage for the 25-year storm water during high tail water caused by flood from Río Culebrinas.

A Caño Madre Vieja pilot channel would be required to accommodate the levee along the edge of the urban area without the acquisition of any existing structures. The pilot channel would be of trapezoidal cross section with 4 meters of depth, 43.2 meters width, and 1V on 3.5H side slopes. All unsuitable excavated material from the channel would be used as topsoil on the levees. The total length of the pilot channel would be approximately 60 meters.

This alternative would require the construction of three road ramps were the levee crosses Highways 418, 115 and 442. This alternative would not require the replacement of any bridges. This alternative would not require the acquisition of structures. The preliminary cost of this plan is $4.1 millions, net benefits of approximately $300,000, and a benefit to cost ratio of 2.0.


AGUADILLA BAY
N
AGUADILLA LEVEE
CUTOFF CHANNEL
CAÑO MADRE VIEJA
ESPINAR LEVEE
RIO CULEBRINAS
PARQUE COLON
AGUADILLA
ESPINAR
HIGHWAY 442
HIGHWAY 115
HIGHWAY 111
HIGHWAY 419
HIGHWAY 2
TABLONAL
0
500
1000
SCALE (METERS)
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
DETAILED PROJECT REPORT
RIO CULEBRINAS
AGUADA & AGUADILLA, PUERTO RICO
PRELIMINARY PLAN 2
INV. NO.
DATED
SIZE
DRAWING NO.
FIGURE 6
SCALE: AS SHOWN
DATED: 03-25-02
SHEET 1 OF 1

X. DESCRIPTION AND ANALYSIS OF FINAL PLANS

A. General.

Based on the results of the preliminary plan formulation, the twin levee alternative is the only practical, acceptable, and feasible flood control alternative that warrants to be examined in detail as part of the final plans.

To facilitate the identification and description of the final plans and the recommended plan, the twin levee alternative was divided in two sections, the Aguadilla Levee and the Espinar Levee.

B. Description of Final Plans.

1. Plan 1. This alternative plan combines 3.3 kilometers of levees, a small pilot channel, three road ramps, and interior drainage facilities protecting the southwestern section of the town of Aguadilla and the community of Espinar, in Aguada, against the 50-Year flood from Río Culebrinas. The general right-of-way alignment and features of plan 1 are similar to the recommended plan and are shown in Figure 8.

The Aguadilla Levee would begin at high ground near Highway 2 and extend towards the north for approximately 1.8 kilometers to end at high ground near Yumet Avenue. A 4 meters deep and 43.2 meters wide Caño Madre Vieja cutoff channel would be constructed at Caño Madre Vieja to reconnect a stream meander to be obstructed by construction of the Aguadilla Levee. The Espinar levee would begin at high ground on the southern end of the Espinar Community and extend to the east and then to the north for approximately 1.5 kilometers to end at an existing rock jetty just south of the existing mouth of Caño Madre Vieja. Both levees would have an average height of 1 meter, 1 on 2.5 side slopes, and a levee crest of 3 meters. The interior drainage facilities would consist of a 1 meter deep and 7 meters wide drainage channel along the protected side of each levee. One two-way drainage structure would be constructed near the north end of the Espinar Levee and three one-way drainage structures would be constructed along the Aguadilla Levee. Drainage structure outlets would be connected to Caño Madre Vieja.

2. Plan 2. This plan considers the same project features as described for Plan 1, but it provides a 100-year level of protection levee. The proposed 100-year levee would have an average height above ground of approximately 2.5 meters, 1 on 2.5 side slopes, and a levee crest of 3 meters. The general right-of-way alignment and features of plan 1 are the same as those of the recommended plan and are shown in Figure 8.

3. Plan 3. This plan considers the similar Aguadilla Levee features as described for Plan 1 and Plan 2, but it provides protection for the Standard Project Flood (SPF). The proposed SPF Espinar Levee alignment would be much longer than the levee alignment considered for Plan 1 and Plan 2.

The SPF levee alignment would begin north of the mouth of Rio Culebrinas and extend to the south, to the east, and then to the north, around the community of Espinar, for approximately 3.3 kilometers to end just south of the existing mouth of Caño Madre Vieja. The proposed SPF levee would have an average height above ground of approximately 3.0 meters, 1 on 2.5 side slopes, and a levee crest of 3 meters. The general alignment and features of this plan are shown on Figure 7.

C. Analysis of Final Plans

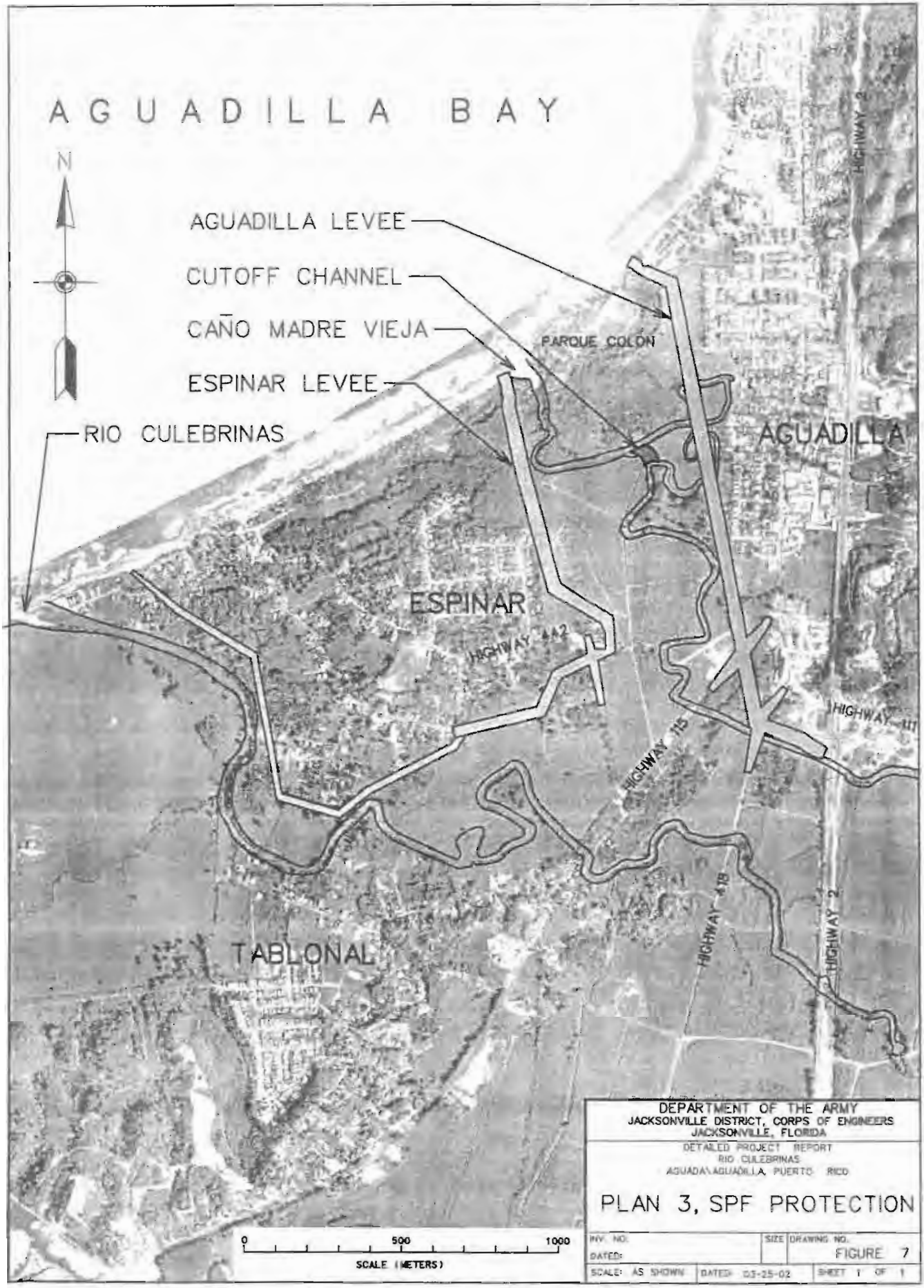
1. General. The purpose of this analysis is to arrive at a recommended plan on the basis of the contributions of the final plans to the planning objectives and the trade-offs among the alternative plans. Table 4 is a summary of the benefits and costs as well as environmental and social impacts for each final plan.

2. Plan 1. This alternative would eliminate the frequent flooding problem in the detailed study area. The construction of a 50-Year levee, interior drainage facilities, and pilot channel would take approximately 38 acres of lands and would require approximately 95,000 cubic yards of fill of which approximately 32,000 cubic yards would come from the pilot and drainage channels and the rest from the commercial borrow site at Tablonal Quarry. This alternative would provide flood protection for approximately 247 acres of urban area. The recommended plan would not provide flood protection to vacant lands in the flood plain. There would be temporary adverse impacts on air quality, water quality, and aquatic life from clearing, excavating and compacting materials during the construction of levees and channels. No net loss of wetlands is expected and no significant cultural resources sites will be impacted by the recommended project.

3. Plan 2. This plan would have the same features and impacts as Plan 1, except that the flood protection afforded would be greater, and temporary and permanent impacts would be similar because of the similar levee footprint.

4. Plan 3. This plan would have the same features and impacts as Plan 1, except that the flood protection afforded would be greater, and temporary and permanent impacts would be similar because of the similar levee footprint.

5. No Action. The no-action plan supposes continued suffering of many study area residents. A "no-action" plan would require acceptance of approximately $830,680 in average annual damage to existing properties. This would not be acceptable to the residents of Aguadilla and Aguada. The "no-action" plan would result in a physical deterioration of the detailed study area and would seriously undermine its potential for further economic development. Inhabitants of the area would continue to suffer social and economic stresses associated with frequent flooding. Continuous government relief would be necessary to help the victims of the frequent flooding in the area.



DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DETAILED PROJECT REPORT
RIO CULEBRINAS
AGUADA\AGUADILLA, PUERTO RICO

PLAN 3, SPF PROTECTION

INV. NO.		SIZE	DRAWING NO.
DATED:			FIGURE 7
SCALE: AS SHOWN	DATED: 03-25-02		SHEET 1 OF 1

TABLE 4

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

SUMMARY OF COMPARATIVE IMPACTS FOR FINAL PLANS
(Figures in $1,000 of 1999)

	PLAN 1 50-YEAR	PLAN 2 100-YEAR	PLAN 3 SPF	NO ACTION
I. National Economic Development Effects				
A. Value of Increased Output of Goods and Services (Annual)				
Inundation Reduction Benefits	637.0	726.0	831.0	0.0
B. Value of Resources Required for the Plan				
Total First Cost	3,872.0	3955.0	6047.0	0.0
Interest During Construction (6.625%)	124.0	127.0	205.0	0.0
Total Investment Cost	3996.0	4082.0	6252.0	0.0
Annual Investment Cost (6.625%)	276.0	282.0	431.0	0.0
Annual Operations and Maintenance	20.0	20.0	25.0	0.0
Total Annual Cost	296.0	302.0	456.0	0.0
Net Benefits Effects (Annual)	341.0	424.0	375.0	0.0
Benefit/Cost Ratio	2.2	2.4	1.8	0.0

TABLE 4 (Cont.)

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

SUMMARY OF COMPARATIVE IMPACTS FOR FINAL PLANS
(Figures in $1,000 of 1999)

	PLAN 1 50-YEAR	PLAN 2 100-YEAR	PLAN 3 SPF	NO ACTION
II. Environmental Effects				
A. Cultural	Archeological deposits associated with the Iglesia de Espinar and deposits at PCI Site 1 will be adversely affected. Archeological data recovery will be undertaken to mitigate adverse effects. The old church ruins will be protected by the project from future flooding. A Phase II archeological assessment will be conducted at PCI Site 2.	Same as Plan 1.	Same as Plan 1.	None.
B. Flora and Wetlands	Project area is pasture lands on former sugar cane fields. No significant impact to flora. No net loss of wetlands.	Same as Plan 1	Same as Plan 1	None.
C. Fauna Avian and Fisheries	No significant impact.	Same as Plan 1.	Same as Plan 1.	None.
D. Federal Threatened and Endangered Species	None in the area.	Same as Plan 1.	Same as Plan 1.	None.
E. Noise	Temporary noise level increased during project construction.	Same as Plan 1.	Same as Plan 1.	None.
F. Water Quality	Temporary increase in river water turbidity during construction.	Same as Plan 1.	Same as Plan 1.	None.
G. Water Supply				None.
Surface Water	No significant impact.	Same as Plan 1.	Same as Plan 1.	None.
Ground Water	No significant impact	Same as Plan 1.	Same as Plan 1.	None.

TABLE 4 (Cont.)

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

SUMMARY OF COMPARATIVE IMPACTS FOR FINAL PLANS
(Figures in $1,000 of 1999)

	PLAN 1 50-YEAR	PLAN 2 100-YEAR	PLAN 3 SPF	NO ACTION
H. Coastal Barrier Resources System	The Espinar Levee alignment would impact a small portion of CBRS PR-75. The recommended plan levee would be modified to avoid any impacts to CBRS PR-75.	Same as Plan 1.	Same as Plan 1.	None.
I. Land Use	Requires about 38 acres of land for levees and channels, about 6 acres for borrow areas.	Requires about 42 acres of land for levees and channels, about 6 acres for borrow areas.	Requires about 80 acres of land for levees and channels, about 8 acres for borrow areas.	None.
J. Excavated Material	About 32,000 c.y. excavated from pilot and drainage channels and 95,000 c.y. excavated from borrow areas.	About 32,000 c.y. excavated from pilot and drainage channels and 110,000 c.y. excavated from borrow areas.	About 45,000 c.y. excavated from pilot and drainage channels and 150,000 c.y. excavated from borrow area.	None.
III. Social Well-Being				
A. Life, Health, and Safety of Residents	Will protect 3,300 persons.	Same as Plan 1.	Same as Plan 1.	None.
B. Cohesiveness	Maintains cohesiveness & prevents disruption of family life in the detailed study area.	Same as Plan 1.	Same as Plan 1.	None.
C. Urbanization	No induced development of the flood plain. Protects 247 acres of existing urban area.	Same as Plan 1.	Same as Plan 1.	None.
D. Reduction in Property Losses(in percent)	77	87	100	0
E. Residual Flooding (in $1,000 annual)	194.0	105.0	0	831.0

D. Optimization of NED Benefits

As shown in Table 4 the plan maximizing the net NED benefits is Plan 2, which provides 100-year protection. This plan is selected as the recommended plan among three other similar structural plans offering different levels of flood protection and the no-action plan.

XI. RECOMMENDED PLAN

A. Description of Proposed Improvements

1. General. The recommended plan combines 3.3 kilometers of levees, a small pilot channel, three road ramps, and interior drainage facilities protecting the southwestern section of the town of Aguadilla and the community of Espinar, in Aguada, against the 100-Year flood from Río Culebrinas. The recommended plan is the National Economic Development (NED) plan.

The Aguadilla Levee would begin at high ground near Highway 2 and extend towards the north for approximately 1.8 kilometers to end at high ground near Yumet Avenue. A 4 meters deep and 43.2 meters wide Caño Madre Vieja cutoff channel would be constructed at Caño Madre Vieja to reconnect a stream meander to be obstructed by construction of the Aguadilla Levee. The Espinar levee would begin at high ground on the southern end of the Espinar Community and extend to the east and then to the north for approximately 1.5 kilometers to end at an existing rock jetty just south of the existing mouth of Caño Madre Vieja. Both levees would have an average height of 2.5 meters, 1 on 2.5 side slopes, and a levee crest of 3 meters. The interior drainage facilities would consist of a 1 meter deep and 7 meters wide drainage channel along the protected side of each levee. One two-way drainage structure would be constructed near the north end of the Espinar Levee and three one-way drainage structures would be constructed along the Aguadilla Levee. Drainage structure outlets would be connected to Caño Madre Vieja. Drainage channels would reconnect cutoff sections of Caño Madre Vieja and would provide 8.6 acres of additional open water.

The recommended plan would substantially reduce the flooding problem in the detailed study area. The construction of a 100-Year levee, interior drainage facilities, and pilot channel would take approximately 19.6 acres of lands and would require approximately 110,000 cubic yards of fill of which approximately 32,000 cubic yards would come from the pilot and drainage channels and the rest from the commercial borrow site at Tablonal Quarry. The plan would provide flood protection for approximately 247 acres of urban area. The recommended plan would not provide flood protection to vacant lands in the flood plain. There would be temporary adverse impacts on air quality, water quality, and aquatic life from clearing, excavating and compacting materials during the construction of levees and channels. No net loss of wetlands is expected and no significant cultural resources sites will be impacted by the recommended project.

The general right-of-way alignment and features of the recommended plan are shown in the attached Figure 8. Typical cross sections for the recommended plan are shown on Figure 9.

2. Design considerations

a. Access during construction. Existing town streets, state highways and agricultural roads in the vicinity of the project would provide adequate access for construction, future maintenance, and to the borrow and disposal areas. The only detour road would be for the construction of Highway 442 ramp. Highway 418 could be utilized as a detour while constructing the Highway 115 ramp and vice versa.

b. Construction methods. Excavation from the borrow areas for the construction of levees would be accomplished by bulldozer, front-end loader, or other similar types of equipment. Excess material and material unsuitable for construction would be hauled to the nearby disposal area.

c. Real estate requirements. It is estimated that right-of-way for construction of the levees, drainage channels, and pilot channel would require 42.3 acres of permanent easements, and borrow and disposal areas would require approximately 6.3 acres of temporary easements.

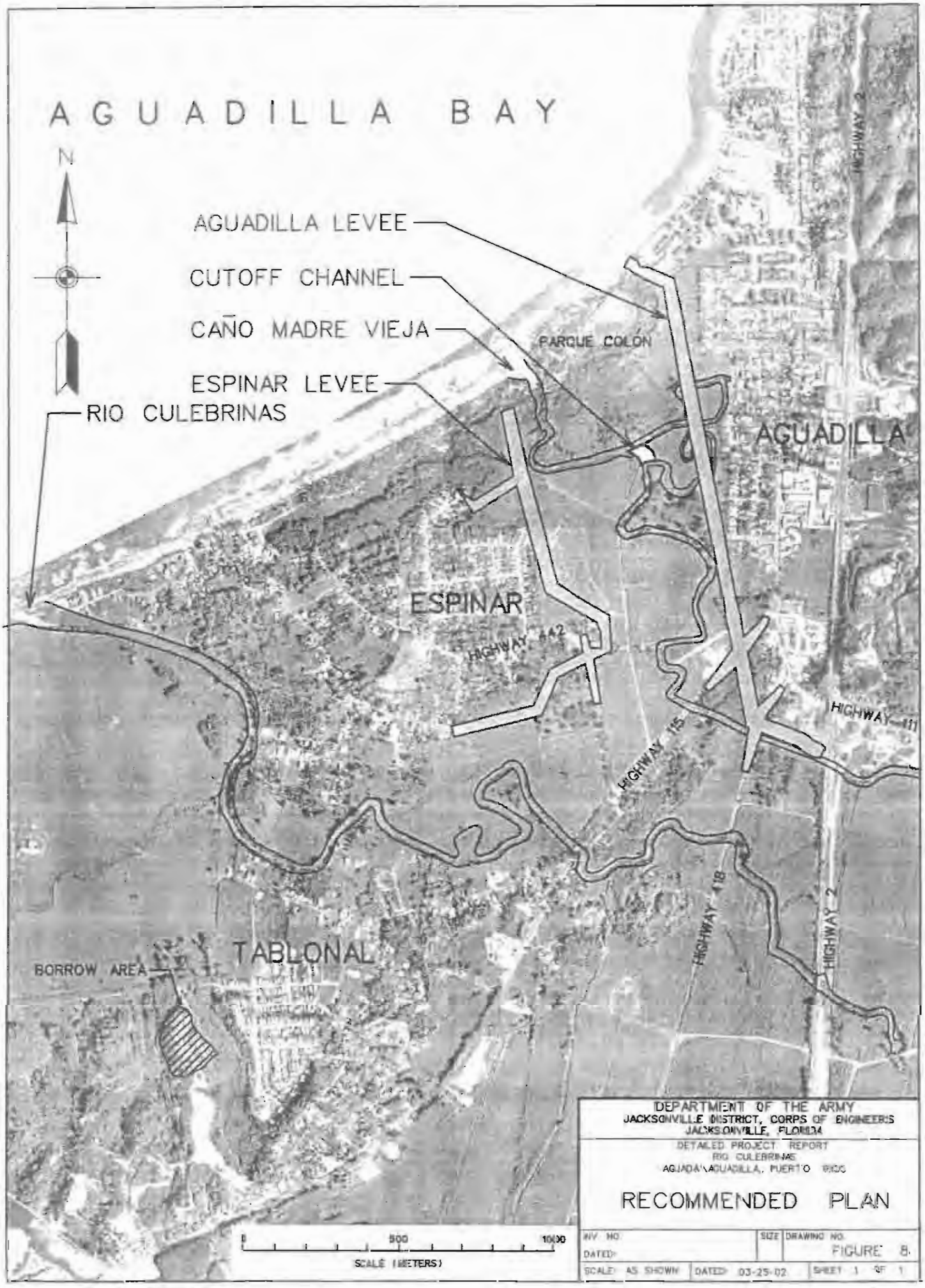
d. Operation and maintenance. The local sponsor would be responsible for maintenance of the proposed project upon completion of the construction contract. The contractor would be responsible for all maintenance during the construction contract. The annual operations and maintenance for flood control features was estimated at $15,000 a year.

B. Economics of Recommended Plan

1. General. The tangible economic justification of the recommended plan was determined by comparing the average annual charges with the estimated average annual equivalent benefits anticipated to accrue over the 50-year economic life of the project. A discount interest rate of 6 ⅛ percent was used to discount cost and benefits.

2. Cost estimate. Construction cost estimates for flood control for the proposed improvements, showing quantities and unit prices costs, are presented in Table C-1, Appendix C. Estimates of first costs were based on October 2001 price level and a construction period of 16 months. Table 5 summarizes each feature cost and the total first cost for each levee segment and for the entire project.

3. Benefits. Tangible benefits to be derived as a result of the implementation of the recommended plan result from inundation reduction benefits, redevelopment benefits, and flood insurance cost saved. The base year for project analysis was taken to be 2008.

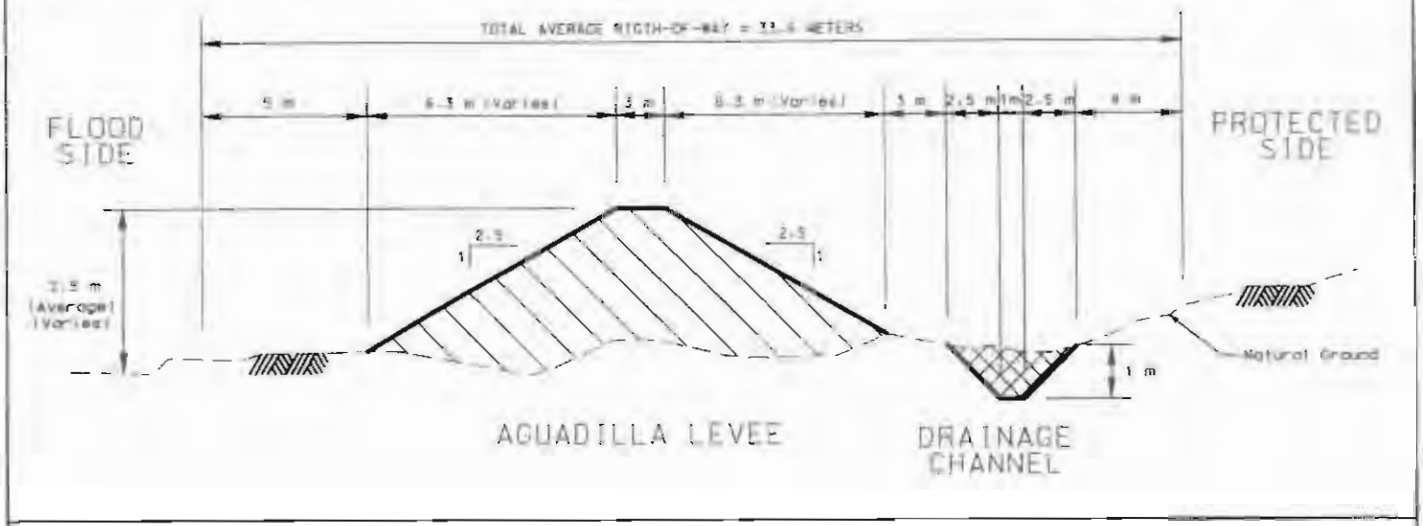


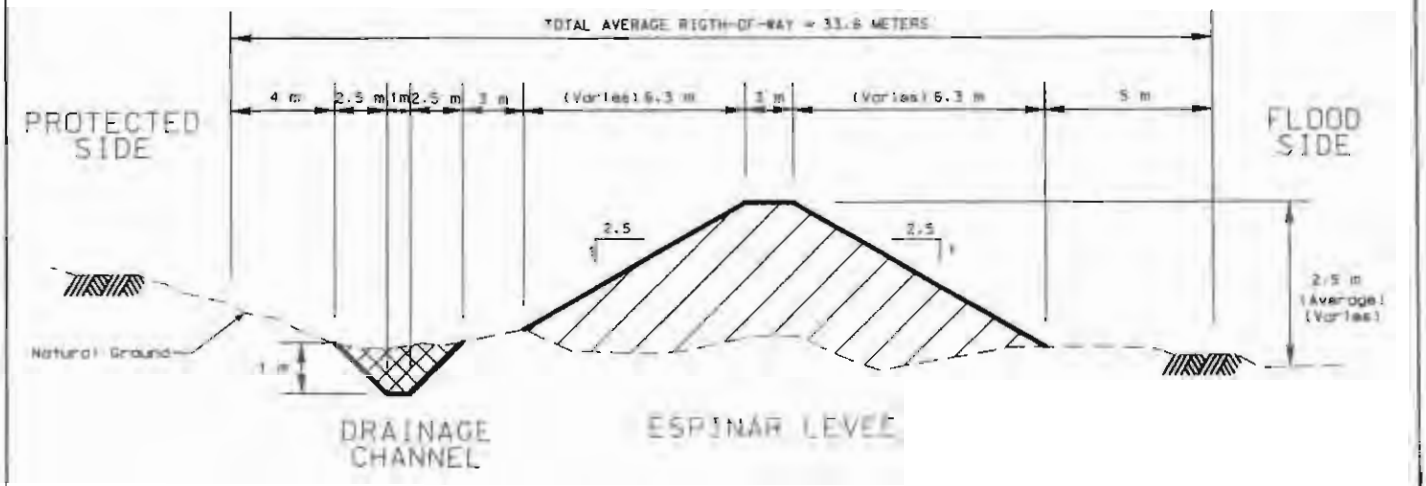
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

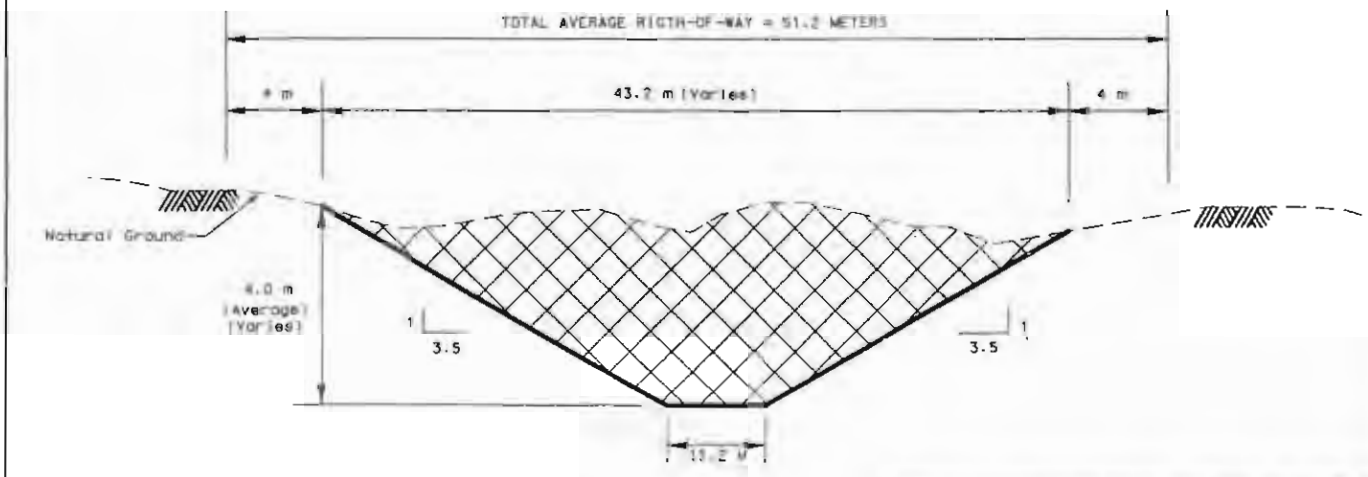
DETAILED PROJECT REPORT
RIO CULEBRINAS
AGUADA\AGUADILLA, PUERTO RICO

RECOMMENDED PLAN

AV. NO.		SIZE	DRAWING NO.
DATED:			FIGURE 8.
SCALE: AS SHOWN	DATED: 03-25-02		SHEET 1 OF 1







DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DETAILED PROJECT REPORT
RIO CULEBRINAS
AGUADA\AGUADILLA, PUERTO RICO

TYPICAL CROSS SECTIONS

REV. NO.		SIZE	DRAWING NO.
DATED:			FIGURE 9
SCALE: NTS	DATED: 03-25-02		SHEET 1 OF 1

TABLE 5

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

COSTS ESTIMATES OF RECOMMENDED PLAN
($1,000 of October 2001)

	ESPINAR LEVEE	AGUADILLA LEVEE	ENTIRE PROJECT
Roads Relocations	82.0	177.0	259.0
Utilities Relocations	0.0	39.0	39.0
Levees and Floodwalls	546.0	600.0	1,146.0
Channels and Canals	30.0	61.0	91.0
Drainage Structures	121.0	776.0	897.0
TOTAL CONSTRUCTION COST	779.0	1,653.0	2,432.0
Real Estate	814.0	798.0	1,612.0
P. L. 91-646	0.0	0.0	0.0
Cultural Resources Studies	25.0	0.0	25.0
Cultural Resources Preservation	40.0	0.0	40.0
Planning, Engineering, & Design	63.0	132.0	195.0
Construction Management	78.0	166.0	244.0
TOTAL FIRST COSTS	1,799.0	2,749.0	4,548.0

NOTES: Figures include appropriate contingency costs.
Detailed Cost estimates are shown in Appendix C.

4. Incremental Justification of Components. As shown on Table 6, net NED benefits were also computed for both levee segments that make up the recommended plan. The analysis of the two levee segments revealed that both levee segments if analyzed individually are incrementally justified.

C. Summary of Impacts

The recommended plan would substantially reduce the flooding problem in the detailed study area. The construction of a 100-Year levee and pilot channel would take approximately 42.3 acres of lands and would require approximately 110,000 cubic yards of fill of which approximately 32,000 cubic yards would come from the pilot channel excavation and the rest from the borrow area at Casualidad Hills in Aguada. The plan would protect approximately 247 square kilometers of urban area from flooding. There would be temporary adverse impacts on air quality, water quality, and aquatic life from clearing, excavating and compacting materials during the construction of levees and channels. No net loss of functional wetlands is expected and no significant cultural resources sites will be impacted by the project. Coastal Barrier Resource System PR-75 would not be impacted by the recommended levee alignment.

Table 6 shows the economic impacts of the recommended plan for each levee segment and for the entire project. MCACES cost estimates are presented in Appendix C, Design and Cost Estimates, while details on benefits are discussed in Appendix E, Economic Analysis. The benefit to cost ratio for the overall plan is 3.8 to 1.0 and net NED benefits are approximately $886,500 annually.

D. Implementation Responsibilities

1. Federal responsibility. The Federal Government would design and prepare detailed plans, and construct the project (exclusive those items specifically required of non-Federal interests). The above is subject to report approval, future-funding approval, and upon completion of a contractual agreement for local cooperation as required by Section 221 of the 1970 Flood Control Act. The maximum Federal contribution under current cost sharing policy would be $7.0 million.

2. Non-Federal responsibility. The local sponsor would be required to provide all lands, easements, and rights-of-way; alterations or acquisition of structures; alterations and relocations to highway bridges and public utilities; to hold and save the Federal Government from damage due to the construction works; and to properly maintain, replace, repair, rehabilitate and operate all works after completion of the project, including establishing and enforcing regulations, to assure the flood control project accomplishes its objectives. In addition, the local sponsor is responsible for a 5 percent minimum cash contribution and any flood control cost in excess of $7.0 million. This later figure includes cost of reconnaissance and detailed project report.

TABLE 6

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

SUMMARY OF ECONOMICS FOR RECOMMENDED PLAN
($1,000 of October 2001)

	ESPINAR LEVEE	AGUADILA LEVEE	ENTIRE PROJECT
TOTAL FIRST COST [1]	1,734.0	2,749.0	4,483.0
Interest During Construction	35.0	74.4	109.4
TOTAL INVESTMENT COST	1,769.0	2,823.4	4,592.4
Interest and Amortization	114.2	182.3	296.5
Annual Operations & Maintenance	5.0	10.0	15.0
TOTAL ANNUAL COST	119.2	192.3	311.5
Annualized Benefits			
Inundation Reduction	219.1	938.4	1,157.5
Employment	7.0	15.0	22.0
Flood Insurance Cost	8.5	10.0	18.5
TOTAL ANNUAL BENEFITS	234.6	963.4	1,198.0
Net NED Benefits	115.4	771.1	886.5
BENEFIT TO COST RATIO	2.0	5.0	3.8

1. Do not include Cultural Resources Preservation.

3. Cost sharing. Table 7 shows the cost sharing of total first cost for the project as established in the Water Resources Development Act (WRDA) of 1986, as amended by WRDA 1996. The non-Federal costs, required from the local sponsor, would be those associated with lands, easements, rights-of-way, relocations, and dredge material disposal areas (LERRD). The LERRD cost would amount to $1,910,000 for the overall plan and represent 42 percent of the total flood control cost of the project, which exceeds the minimum non-Federal sponsor contribution of 35 percent. As required by law, the non-Federal sponsor would have to contribute a minimum 5 percent in cash of the total flood control cost of the project, that is, another $220,300 in addition to the entire cost for LERRD. The Federal contribution would therefore be $2,410,600 while the non-Federal contribution would total $2,137,400 or 47 percent of the total project cost.

4. Steps to plan implementation. Submission of this report by the District Engineer constitutes the first step in a chain of events that must take place before a flood control project can become a reality. It may be modified at any stage of review, and only if it successfully passes each stage will it ultimately be constructed. These events are:

a. Review of the Río Culebrinas Detailed Project Report and the environmental assessment by Jacksonville District Independent Technical Review (ITR) and by South Atlantic Division.

b. Fulfillment of the required measures of local cooperation, including cost sharing and lands, easements, rights-of-way, acquisitions and relocations.

c. Completion of the necessary additional detailed topographic surveys, cultural investigations, geotechnical explorations, preparation of plans, specifications, and an estimate of the construction cost by the District Engineer and acquisition of required permits, followed by an invitation for bids and awarding of the construction contracts.

d. Allocation of funds by Chief of Engineers for construction.

E. Coordination

The study was developed and worked out in close coordination with the municipalities of Aguadilla and Aguada, the local sponsors; the Department of Natural and Environmental Resources, the Puerto Rico Planning Board; the State Historic Preservation Officer; the Puerto Rico Environmental Quality Board; the U.S. Fish and Wildlife Service; the U.S. Geological Survey; and the Environmental Protection Agency. After the local sponsors review the draft Detailed Project Report they would provide a Letter of Intent supporting the report conclusions and recommendations. The Draft Project Management Plan (PMP) and Project Cost Agreement (PCA) will be discussed with the sponsor during the coordination of the draft report. The Letter of Intent, PMP, and draft PCA will be included in the final report.

TABLE 7

RIO CULEBRINAS AT AGUADILLA AND AGUADA
DETAILED PROJECT REPORT

RECOMMENDED PLAN
COST SHARING OF TOTAL FIRST COST
($1,000 of October 2001)

	TOTAL	FEDERAL	NON-FEDERAL
FLOOD CONTROL ITEMS			
Levees and Channels	2,638.0	2,638.0	0.0
Roads/Utilities Relocations	298.0	0.0	298.0
Lands and Damages	1,612.0	0.0	1,612.0
TOTAL FLOOD CONTROL COST	4,548.0	2,638.0	1,910.0
5% Non-Federal Contribution		- 227.4	+ 227.4
SUBTOTAL	4,548.0	2,410.6	2,137.4
35% Minimum Contribution			1,591.8
50% Maximum Contribution			2,274.0
Contribution Adjustment	0.0	0.0	0.0
SUBTOTAL	4,548.0	2,410.6	2,137.4
Ability to Pay Adjustment	0.0	0.0	0.0
SUBTOTAL	4,548.0	2,410.6	2,137.4
TOTAL FIRST COST	4,548.0	2,410.6	2,137.4