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

APPENDIX B
GEOTECHNICAL STUDIES

SECTION 205 DETAILED PROJECT REPORT
RIO CULEBRINAS
AGUADILLA, PUERTO RICO

APPENDIX B
GEOTECHNICAL

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CORE BORING LOGS, TEST PIT LOGS,
AND LABORATORY TEST DATA

GEOTECHNICAL

1. Purpose. This appendix presents the results of the subsurface investigations, laboratory work, and subsequent Geotechnical analysis and design for each major feature of the Rio Culebrinas flood control project.

2. General. The study area is located on the northwest coast of Puerto Rico between the community of Espinar and the town of Aguadilla. The main feature of this flood control project will be the construction of two separate levee segments identified as Aguadilla and Espinar and the proposed drainage structures passing through them. These levees will cross three existing highways and as a result, two road ramps will be required along the alignment of the Aguadilla levee and one along the alignment of the Espinar levee. A short "cutoff" channel is also proposed to mitigate the impact of the Aguadilla levee crossing two oxbows of the Cano Madre Vieja channel. All stationing is in meters. For clarity, various measurements and other engineering properties will be reported in English units with the metric equivalent following in parentheses.

3. Investigations Performed.

a. Core Borings. For use in the design of the project features, 15 core borings were performed in June of 1998. Eight borings were drilled along the proposed Aguadilla levee alignment, six borings along the proposed Espinar levee alignment, and one boring along the proposed cutoff channel alignment. A single boring was also drilled within the limits of a potential borrow site located just to the southwest of the study area. These borings were drilled to depths ranging from 15 feet (4.57 m) to 49.5 feet (15.09 m). The average spacing between the levee borings was 800 feet (243.8 m).

Standard Penetration Tests (SPT) were performed during the drilling to determine the consistency, relative density, and approximate strength of the materials sampled. The test consists of dropping a hammer weighing 140 pounds (63.5 kg) onto the drill rod from a height of 30 inches (0.76 m). The number of blows (N) necessary to produce a penetration of 1 foot (0.3 m) is regarded as the Standard Penetration Resistance. To avoid seating errors, the blows for the first 6 inches (0.15 m) of penetration are not taken into account; those required to increase the penetration from 6 to 18 inches (0.15 to 0.46 m) constitute the N-value. The split-spoon sampler is 24 inches (0.61 m) long with an outside diameter of 2 inches (5.08 cm) and an inside diameter of 1-3/8 inch (3.49 cm). The relation between the number of blows, the

consistency of the cohesive soils, and the relative density of noncohesive soils (from Terzaghi and Peck, 1948) are as follows:

(N)	Density	(N)	Consistency
< 4	Very Loose	< 2	Very Soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium	4 - 8	Medium
30 - 50	Dense	8 - 15	Stiff
> 50	Very Dense	15 - 30	Very Stiff
		> 30	Hard

A site plan showing the core boring locations is shown on Plates B-1 and B-2. Copies of the boring logs are included at the end of this appendix.

b. Undisturbed Sampling. Three undisturbed samples were obtained during the core drilling phase of the subsurface investigation. Each sample was obtained by pushing a 3-inch diameter (7.62 cm) Shelby Tube into the soil for a distance of two feet (0.61 m) beginning at a pre-selected depth. The site location for the sampling was within 5 feet (1.52 m) of core boring CB-CUL-05, CB-CUL-13, and CB-CUL-14.

c. Bulk Sampling. As a part of the subsurface investigation program, a potential borrow site was examined to determine the suitability of the subsurface material for embankment fill. This site is located approximately 2.45 kilometers southwest of the center of the study area. In addition to the core boring performed there, two test pits were excavated within the limits of the site and bulk samples were obtained for laboratory testing. A copy of the test pit logs is included at the end of this appendix.

d. Laboratory Testing. Laboratory tests were performed on a number of soil samples obtained at various depths from each core boring and test pit. A combination of two or more "classification" tests (moisture content, Atterberg Limits, grain size distribution, specific gravity) were performed on each sample selected for testing. Each bulk sample also received a Standard Proctor compaction test in a 6-inch (15.24 cm) diameter mold. Classification tests, triaxial shear tests, and consolidation tests were performed on each undisturbed sample obtained. One Q test (unconsolidated-undrained test) and one

consolidation test were performed on the undisturbed sample obtained next to core boring CB-CUL-13 and on the undisturbed sample obtained next to boring CB-CUL-14. One R-bar test (consolidated-undrained test with pore pressure measurements during testing) and one consolidation test were performed on the undisturbed sample obtained next to core boring CB-CUL-05. The laboratory test results are included at the end of this appendix.

4. Materials Encountered.

a. Aguadilla Levee Segment - Station 1+00 to 7+00. Core borings CB-CUL-01 and CB-CUL-03 found a layer of low-plasticity clay (with sand) overlying a deposit of well-graded sand with gravel. Core boring CB-CUL-02 encountered silty sand and well-graded sand overlying a deposit of poorly-graded sand. The consistency of the low-plasticity clay ranged from soft to medium stiff. The density of the sand layers ranged from very loose to medium.

b. Aguadilla Levee Segment - Station 7+00 to 18+00. Core borings CB-CUL-05 through CB-CUL-08 encountered interbedded layers of high-plasticity clay, clayey sand, low-plasticity clay, low-plasticity silt, high-plasticity silt, silty sand, well-graded sand, and well-graded gravel. Root and/or plant fragments were present in all silt and clay layers sampled. The consistency of these soils ranged from very soft to medium stiff. The density of the coarse-grained soils ranged from very loose to medium.

c. Proposed Channel Cut. Core boring CB-CUL-04 found a brown-and-gray layer of high-plasticity silt overlying a loose deposit of well-graded gravelly sand. The consistency of the silt ranged from very soft to medium stiff and was 2.74 meters in thickness.

d. Espinar Levee Segment - Station 0+00 to 5+00. Core boring CB-CUL-13 found a layer of brown-and-gray high-plasticity silt overlying a thin layer of low-plasticity clay and well-graded gravelly sand. The consistency of the high-plasticity silt layer was soft to very soft and was 3.66 meters in thickness. Boring CB-CUL-14 found interbedded layers of silty sand, well-graded sand, high-plasticity clay, and clayey sand overlying a layer of high-plasticity clay (1.37 m thick). Below this clay layer, the boring encountered a layer of well-graded sand with gravel to the end of the boring. The density of the sand layer ranged from loose to medium.

e. Espinar Levee Segment - Station 5+00 to 14+96. Borings CB-CUL-09 through CB-CUL-12 encountered silty sand, well-graded

sand, and clayey sand overlying a layer of poorly-graded coarse-grained sand. The coarse-grained sand contained calcite cemented sand nodules (up to gravel size) and was sampled to the end of each boring. The density of the upper sand layers ranged from very loose to dense while the density of the lower sand layer ranged from medium to dense.

f. Potential Borrow Site. Core boring CB-CUL-15 encountered slightly to thoroughly weathered limestone to the depth of the boring. The classification of the material recovered varied with depth (well-graded gravel, clayey gravel, silty gravel, low and high-plasticity silt, and low and high-plasticity clay) but was fairly uniform with respect to density (dense to very dense). Test pits TP-CUL-01 and TP-CUL-02 sampled the same limestone formation to a depth of 1.37 meters and 2.90 meters respectively. The excavated material was classified as clayey gravel and silty gravel.

A geologic section has been prepared along the proposed centerline for each levee. All applicable boring logs have been shown at their respective station locations. These geologic sections are shown on Plates B-3 and B-4. It should be noted that the sections do not indicate any specific material type limits other than that shown by the individual borings, as any reasonable interpretation made from the boring logs could at best be a poor representation of the actual subsurface conditions.

5. Embankment Material. Fill material for the proposed embankments will most likely come from a commercial borrow source located near the project site. Suitable fill for the road ramps will be limited to only course-grained soils with less than 15 percent by weight passing the number 200 sieve. Materials classified by the Unified Soil Classification System as GW, GP, GM, GC, SW, SP, SC, SM, CL, and CH may be used for levee fill. As discussed in paragraph 4f above, one potential borrow site was examined to determine the suitability of the subsurface material for embankment fill. Based on the findings from core boring CB-CUL-15 and test pits TP-CUL-01 and TP-CUL-02, material from this site may be used for the levees as long as care is taken in accurately classifying the materials excavated.

6. Stability Analysis. Slope stability analyses were performed using the UTEXAS-3 Slope Stability Program available through the U.S. Army Engineer Waterways Experiment Station, Corps Program Library. The slopes for the proposed road ramp and levee embankments and cutoff channel were analyzed under the following conditions - End of Construction and Long Term. Shear strength values for the foundation soils and overlying embankment fill were based on Standard Penetration Test (SPT) N-Values and

laboratory test results. Applicable unit weights for each soil type were determined by using laboratory test results. Two different embankment cross sections and soil profiles were modeled for stability (one Aguadilla levee section and one Espinar levee section). In each model a gravel-sand-clay/gravel-sand-silt mixture was assumed for the embankment fill while the underlying soil layers reflected those found where the section was chosen. For the cutoff channel, one cross section was modeled for stability. The shear strength values and unit weights used in each model are shown on Plates B-5 through B-7.

With the End of Construction (EOC) condition, unconsolidated-undrained shear strengths were used and a side slope of 1 vertical to 2.5 horizontal was analyzed as a starting point. The stability of the embankments and channel was also checked with a seismic event occurring at the same time. The results of the analyses were as follows:

END OF CONSTRUCTION CONDITION	Minimum Factor of Safety Computed	Minimum Factor of Safety Required*
Aguadilla Levee		
Station 13+30	1.669	1.3
Espinar Levee		
Station 2+40	1.523	1.3
Cutoff Channel	5.506	1.3
END OF CONSTRUCTION CONDITION WITH SEISMIC ACTIVITY		
Aguadilla Levee		
Station 13+30	1.023	1.0
Espinar Levee		
Station 2+40	1.005	1.0
Cutoff Channel	2.289	1.0

*Per EM-1110-2-1913, Design & Construction of Levees

As the computed factor of safety for each slope was greater than the minimum required, the EOC analyses were ended. Steepening the embankment slopes beyond 1 vertical to 2.5 horizontal would also make the operation of maintenance equipment difficult if not impossible. For each modeled section, the critical failure arc is shown on Plates B-5 through B-7.

With the Long Term (LT) condition, consolidated-drained shear strengths were used and a side slope of 1 vertical to 2.5 horizontal was again analyzed. The results of the analyses were as follows:

LONG TERM CONDITION	Minimum Factor of Safety Computed	Minimum Factor of Safety Required*
Aguadilla Levee		
Station 13+30	1.571	1.4
Espinar Levee		
Station 2+40	1.545	1.4
Cutoff Channel	1.105	1.4
LONG TERM CONDITION WITH SEISMIC ACTIVITY		
Aguadilla Levee		
Station 13+30	1.072	1.0
Espinar Levee		
Station 2+40	1.081	1.0
Cutoff Channel	---	1.0

*Per EM-1110-2-1913, Design & Construction of Levees

Under long term conditions, the embankment sections were stable but the computed factor of safety for the channel slope was less than that required by EM 1110-2-1913. As a result, the stability of the proposed channel cut was reanalyzed with a side slope of 1 vertical to 3.5 horizontal. The results were as follows:

Cutoff Channel	Minimum Factor of Safety Computed	Minimum Factor of Safety Required*
END OF CONSTRUCTION CONDITION	5.676	1.3
EOC COND. W SEISMIC ACTIVITY	2.284	1.0
LONG TERM CONDITION	1.446	1.4
LT CONDITION W SEISMIC ACTIVITY	0.971	1.0

*Per EM-1110-2-1913, Design & Construction of Levees

At a 1 vertical to 3.5 horizontal side slope, the proposed channel cut would be stable under all but the long-term condition with a seismic event. Considering the purpose and location for the cutoff channel, failure of the channel slopes into the flow-way would not threaten human life. As a result, the computed factor of safety for this condition was considered to be acceptable and the stability analyses were ended. The critical failure arc for each modeled section is shown on Plates B-5 through B-7.

Hydraulic analyses show that the effects of the 100-year event will be present on the levee slope for approximately 20 hours or less. Considering both levees, seepage through either levee section is unlikely due to the high percentage of GM/GC type material available for levee fill and the short duration of a saturating pool. Based on the above, a long-term condition with steady-state seepage was not analyzed. Partial Pool and Sudden Drawdown cases were also not analyzed as they were considered to be nonapplicable as well. Once constructed, the vegetative cover on both levees should hold most of the soil (on the slopes) in place during a high water event. Should any loss of material occur due to erosion or saturation, repairs can be made as needed.

7. Embankment Geometry. Based on the slope stability analyses, a side slope of 1 vertical to 2.5 horizontal is recommended for the road ramp and levee embankments. The crest width along both levees will be 3 meters. A maximum vertical height of 3.56 meters occurs along the Aguadilla levee alignment near station 17+15. The combined width of the travel lanes and shoulders on the road ramps will be at least 10.97 meters.

8. Embankment Seepage Analysis. While through seepage should not occur from the 100-year event in either levee, seepage *under* the embankments could occur along portions of both levees. From station 9+00 to 14+96 along the Espinar levee alignment (approx.), a layer of well-graded sand (SW) exists at and near the ground surface. This material was also encountered near the ground surface around station 3+80 along the Aguadilla levee alignment. (Where the boring logs did not show SW material at the ground surface, a layer of silty sand was present.) With a calculated horizontal permeability of 86 ft/day (26.21 meters/day), this well-graded sand could act as a conduit for the removal of embankment material during high water events. As a result, a cross section through each levee was modeled using GMS (version 2.1) for the purpose of analyzing the underseepage. With each section, a high ground water table was assumed to exist during the 100-year event. Using total-head values from program's solution file, the exit gradients (in both the horizontal and vertical direction) were calculated for a rectangular area located directly below the "landside" levee toe. The factor of safety against piping in both directions was then calculated by dividing the respective critical gradient by the respective exit gradient.

The results of the seepage analyses, shown below, indicate that the potential for loss of material due to piping is the greatest underneath the Aguadilla levee around station 3+80.

Levee	Station	Calculated Exit Gradient in the Horizontal Direction	Calculated Exit Gradient in the Vertical Direction	Factor of Safety in the Horizontal Direction	Factor of Safety in the Vertical Direction	Minimum Factor of Safety Required*
Aguadilla	3+80	0.282	0.45	1.964	2.05	2.5 -- 3
Espinar	9+60	0.0645	0.106	8.59	8.7	2.5 -- 3

* Per Cedergren 1977

Even though the duration of the 100-year event is expected to be relatively short, over time the cumulative effects of high-water events against the levee could lead to the production of seepage cavities directly below the levee. To prevent the loss of material from piping along the toe in this area, a gravel filter should be placed below the "landside" toe for a length that will be determined prior to the preparation of plans and specifications.

9. Embankment Settlement. Due to the anticipated loading from each levee upon the ground surface, long-term consolidation of the silt and clay layers located below portions of each levee is expected. As a result, settlement calculations were performed to determine the magnitude of this post-construction consolidation and the amount of overbuild that will be necessary to account for it. Settlement calculations were based on cross sections made at selected locations along both of the proposed levee alignments. Each modeled section consisted of a levee section bearing on the soils encountered by one of the project core borings. All calculations were performed by hand. The following equation from Das (see reference "b") was used to calculate the settlement.

$$S = [C_c*H/(1 + e_o)]*\log((p_o-\Delta p)/p_o) \qquad \text{(Equ. 7.20)}$$

where:

C_c = the compression index (obtained from the empirical expression $C_c = 0.30[e_o - 0.27]$)

H = initial thickness of the compressible sublayer

e_o = the initial void ratio (obtained from laboratory test results)

p_o = initial average effective overburden pressure on the compressible sublayer

Δp = increase in vertical pressure on the compressible sublayer due to the construction of the levee

The results of the settlement calculations, shown below, indicate that settlement will be the greatest where the levee alignment passes near or crosses over the Cano Madre Vieja

channel. The recommended amount of overbuild for each levee is simply the calculated amount of settlement rounded up to the nearest half-foot (15.24 cm) increment.

Levee	Modeled Station	Core Boring used for Foundation Conditions	Calculated Settlement (inches)	Recommended Amount of Overbuild (inches)	Application Range (levee station)
Aguadilla	6+00	CB-CUL-03	4.66	6	4+40 to 7+00
Aguadilla	8+30	CB-CUL-05	9.79	12	7+00 to 9+60
Aguadilla	10+50	CB-CUL-06	4.93	6	9+60 to 14+60
Aguadilla	13+40	CB-CUL-07	5.3	6	9+60 to 14+60
Espinar	---	CB-CUL-14	8.89	12	0+00 to 0+80 and 3+40 to 5+00
Espinar	2+40	CB-CUL-13	17.85	18	0+80 to 3+40

10. Foundation Conditions for Structures. Three 60-inch diameter (1.52 m) corrugated metal pipe (CMP) culverts will be placed through the Aguadilla levee at station 1+39.50 (see Plate B-1). The design invert elevation for these culverts is -0.3 meters. Based on core boring CB-CUL-01, the subgrade material below this elevation is a fine-to-medium-grained well-graded sand with a density ranging from loose to medium. The ground-water table was recorded at an elevation of -0.79 meters. Based on the above information, no special foundation preparation measures should be necessary outside of running a vibratory compactor over the cleared subgrade surface to increase the density of the existing subgrade material.

Six 60-inch diameter (1.52 m) CMP culverts will be placed through the Aguadilla levee at station 6+05.50 (see Plate B-1). The design invert elevation for these culverts is -0.3 meters. Based on boring CB-CUL-03, the subgrade material below this elevation is a well-graded sand/gravel mix to a depth of 1.37 meters. Below the well-graded sand, a 0.91-meter layer of clayey sand exists followed by a small silt layer and then another well-graded sand layer to the end of the boring. The ground-water table was recorded at an elevation of +1.97 meters. Based on the above information, dewatering may be necessary at the time of construction to insure that the backfill around the culvert is placed and compacted in the dry. A vibratory compactor should also be run over the cleared subgrade surface prior to installing the culverts.

Three 60-inch diameter (1.52 m) CMP culverts will be placed through the Aguadilla levee at station 10+52.90 (see Plate B-1). The design invert elevation for these culverts is -0.3 meters.

Based on boring CB-CUL-06, the subgrade material below this elevation is a very-soft layer of high-plasticity silt to a depth of 0.91 meters. Below the silt layer, a 3.2-meter layer of medium-dense clayey sand exists followed by a layer of well-graded sand to the end of the boring. The ground-water table was recorded at an elevation of -1.74 meters. Based on the above information, the culvert subgrade should be undercut by 1.07 meters and then backfilled with select materials (in compacted lifts) to the invert elevation.

Two 60-inch diameter (1.52 m) CMP culverts will be placed through the Espinar levee at station 2+50 (see Plate B-1). The design invert elevation for these culverts is also -0.3 meters. Based on boring CB-CUL-13, the subgrade material below this elevation will be a very-soft layer of high-plasticity silt to an elevation of -2.74 meters. Below the silt layer, a small layer of low-plasticity clay was encountered overlying a layer of well-graded gravelly sand. The ground-water table was recorded at an elevation of +0.60 meters. Based on the above information, the culvert subgrade should be undercut by 2.44 meters and then backfilled with select materials (in compacted lifts) to the invert elevation. The required excavation will most likely require dewatering in order to insure that the backfill is placed and compacted in the dry.

All of the above mentioned culverts will have a flapgate installed on the floodplain side of the levee.

11. Foundation Preparation and Embankment Construction. After all clearing and grubbing has been completed and prior to any fill placement, the foundation area for each levee should be thoroughly broken to a depth of 15 cm. This will help to insure a good bond between the first lift of fill and the existing natural ground surface. All scarifying and breaking of the ground surface should be done parallel to the proposed centerline of the levee.

Fill material selected for the levee embankments should be spread by bulldozers (or other approved means) in horizontal layers to the final grade. Prior to compaction, these layers should not exceed 1 foot (0.3 m) in thickness when coarse-grained materials are being placed and 8 inches (20.3 cm) in thickness when fine-grained materials are being placed. The levee fill should be compacted to at least 95 percent of the maximum dry density obtained at optimum moisture, as defined by the Standard Proctor Compaction Test. Compaction may be accomplished by using a sheepsfoot roller, rubber-tire roller, or other approved device well suited to the type of material being compacted.

Fill material for the road-ramp embankments should be placed in horizontal layers of loose material no greater than 8 inches (20.3 cm) in thickness. Each layer should be compacted to at least 95 percent of the maximum dry density obtained at optimum moisture, as defined by the Modified Proctor Compaction Test. Compaction may be accomplished by using a vibratory steel-wheel roller or other approved device well suited to the type of material being compacted.

12. Geotechnical Design References.

a. Das, Braja. Principles of Geotechnical Engineering. Boston: PWS Publishers, 1985.

b. Department of the Army, Office of the Chief of Engineers. Engineering Manual EM 1110-2-1913: Design and Construction of Levees, 31 March 1978.

c. Duncan, J. M., R. C. Horz, and T. L. Yang. Shear Strength Correlations For Geotechnical Engineering, Virginia Tech Department of Civil Engineering, Geotechnical Engineering. Virginia: Virginia Polytechnic Institute and State University, 1989.

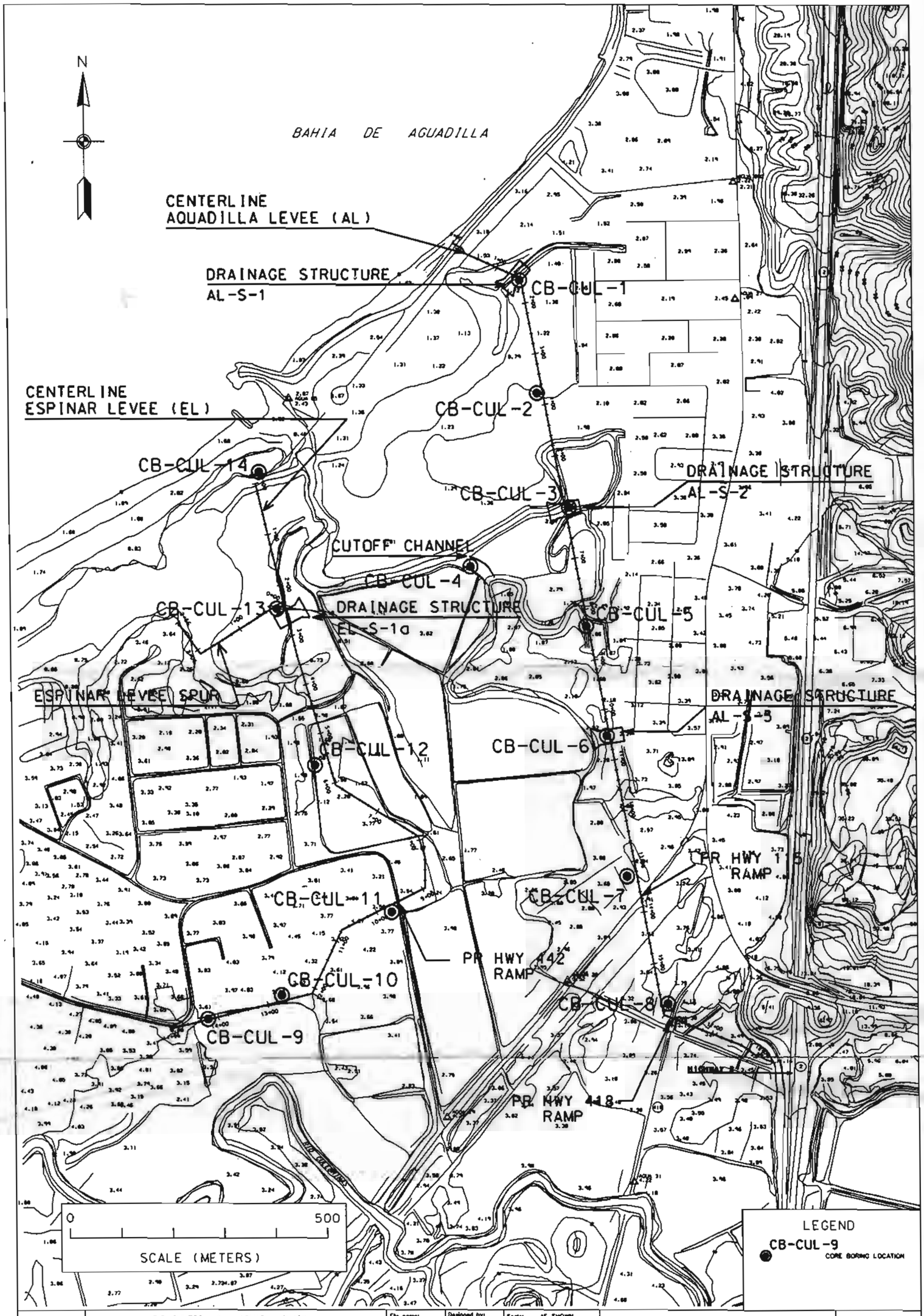

PLATE B-1

RIO CULEBRINAS at AGUADA/AGUADILLA
PUERTO RICO
SITE PLAN and BORING LOCATION

File name: PLATEBIR.DGN
Reference files:

Designed by:
Drawn by: M.W.V.
Chk by:
Dated: April 2001
D.O. FILE NO.

Scale: AS SHOWN
Plot date:
Plot scale:

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JACKSONVILLE, FLORIDA

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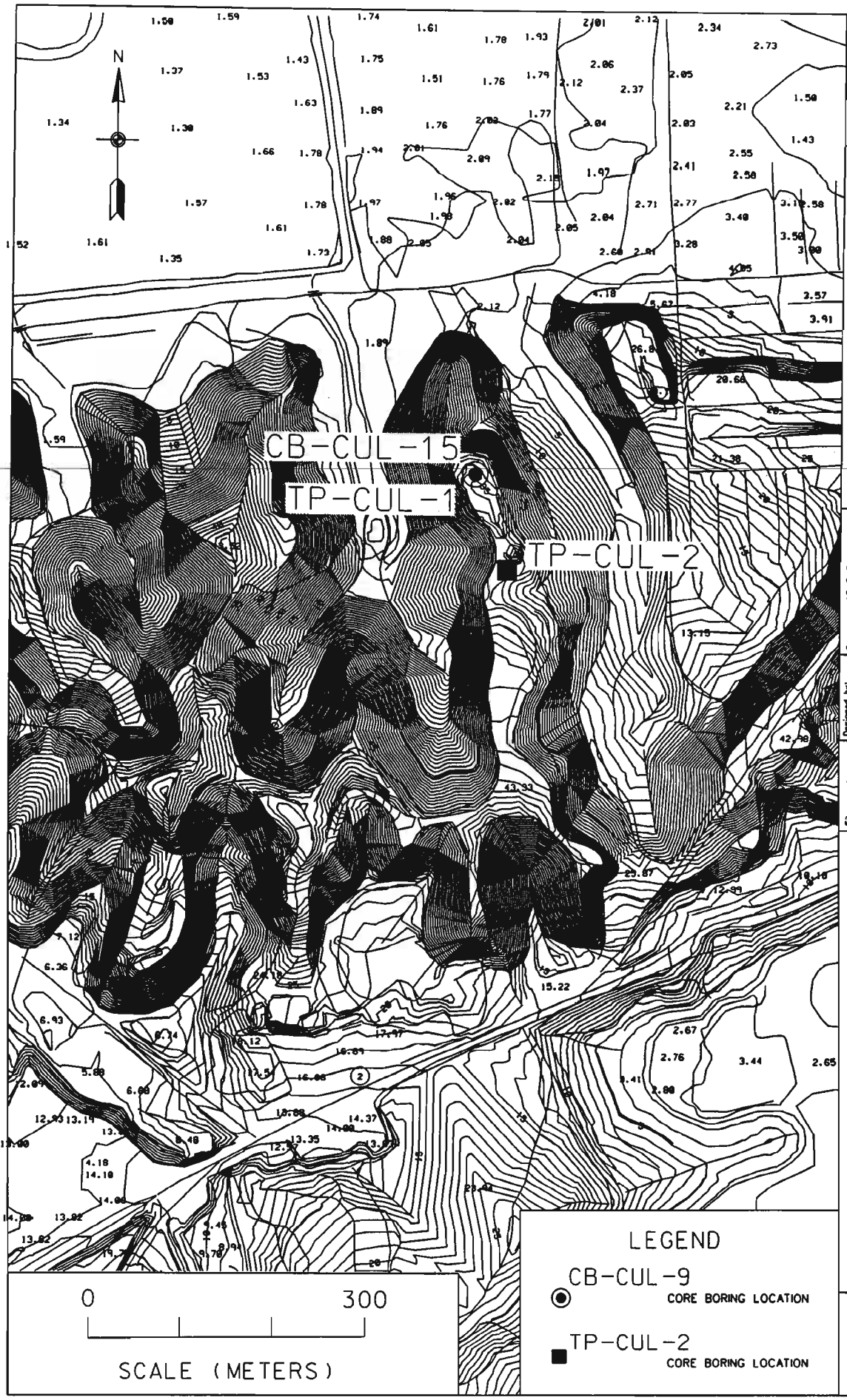

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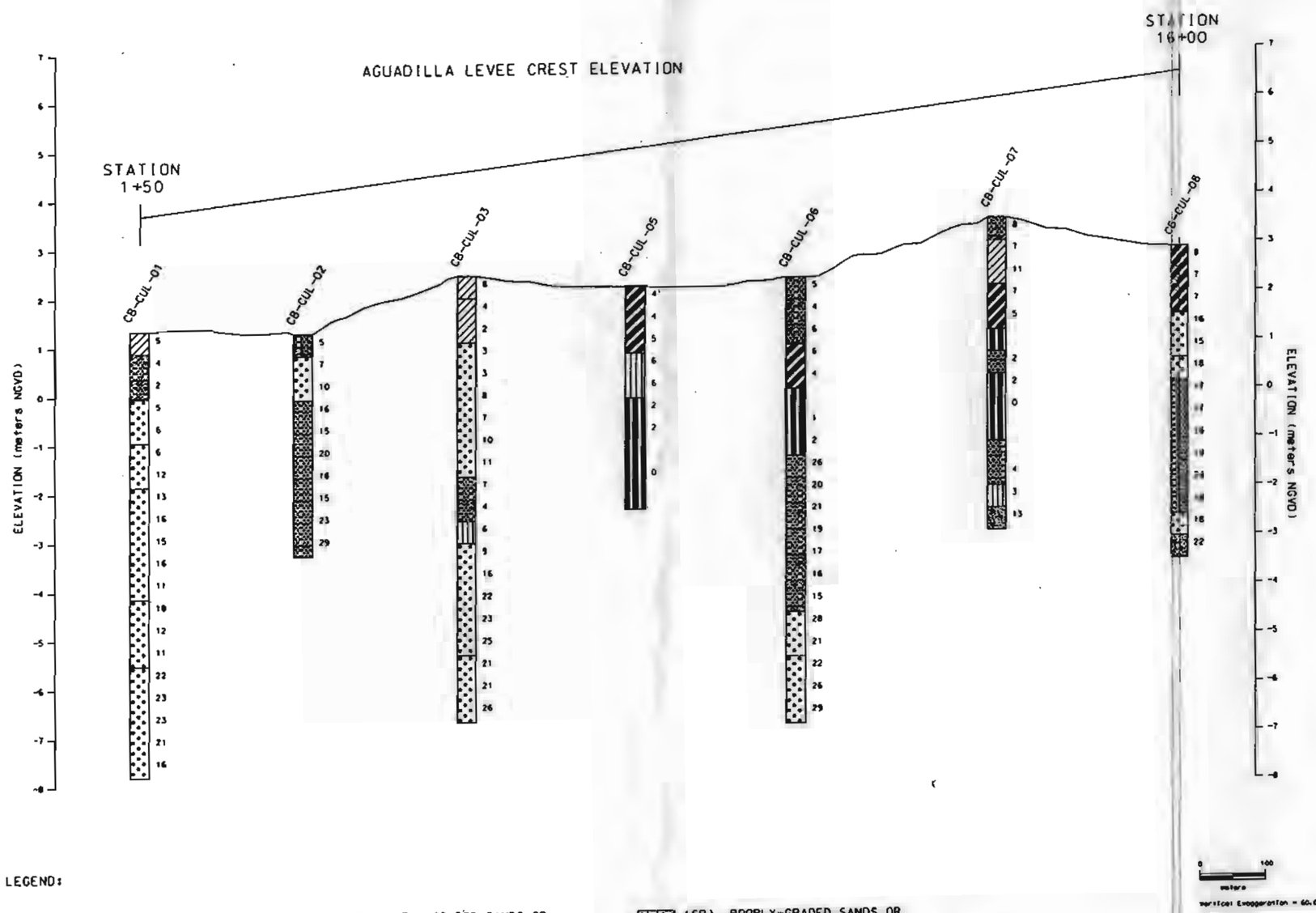
Scale: AS SHOWN

Designed by:
Dwn by: M.W.V.
Ckd by:
Dated: April 2001
D.O.FILE NO.

File name: PLATEB2.DGN
Reference files:

RIO CULEBRINAS at AGUADA/AGUADILLA
PUERTO RICO
SITE PLAN and BORING LOCATIONS

PLATE
B-2



SOIL LEGEND:

(GW) WELL-GRADED GRAVELS OR GRAVEL-SAND MIXTURES. LITTLE OR NO FINES

(SW) WELL-GRADED SANDS OR GRAVELLY SANDS. LITTLE OR NO FINES

(SP) POORLY-GRADED SANDS OR GRAVELLY SANDS. LITTLE OR NO FINES.

(SM) SILTY SANDS. SAND-SILT MIXTURES

(SC) CLAYEY-SANDS. SAND-SILT MIXTURES

(ML) INORGANIC SILTS AND VERY FINE SANDS. ROCK FLOUR. SILTY OR CLAYEY FINE SANDS

(CL) INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY. GRAVELLY CLAYS. SANDY CLAYS. SILTY CLAYS

(MH) INORGANIC SILTS. MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS. ELASTIC SILTS

(CH) INORGANIC CLAYS OF HIGH PLASTICITY. FAT CLAYS

NOTES:

1. THE GEOLOGIC SECTION SHOWN REFLECTS THE FIELD VISUAL CLASSIFICATION (SHOWN ON THE CORE BORING LOGS) AND LABORATORY CLASSIFICATION OF SELECTED SOIL SAMPLES.
2. NUMBERS SHOWN ON BORINGS ARE STANDARD PENETRATION TEST RESULTS IN BLOWS PER FOOT.
3. FOR A COMPLETE PLAN VIEW WITH LEGEND, SEE PLATES B-1 AND B-2.

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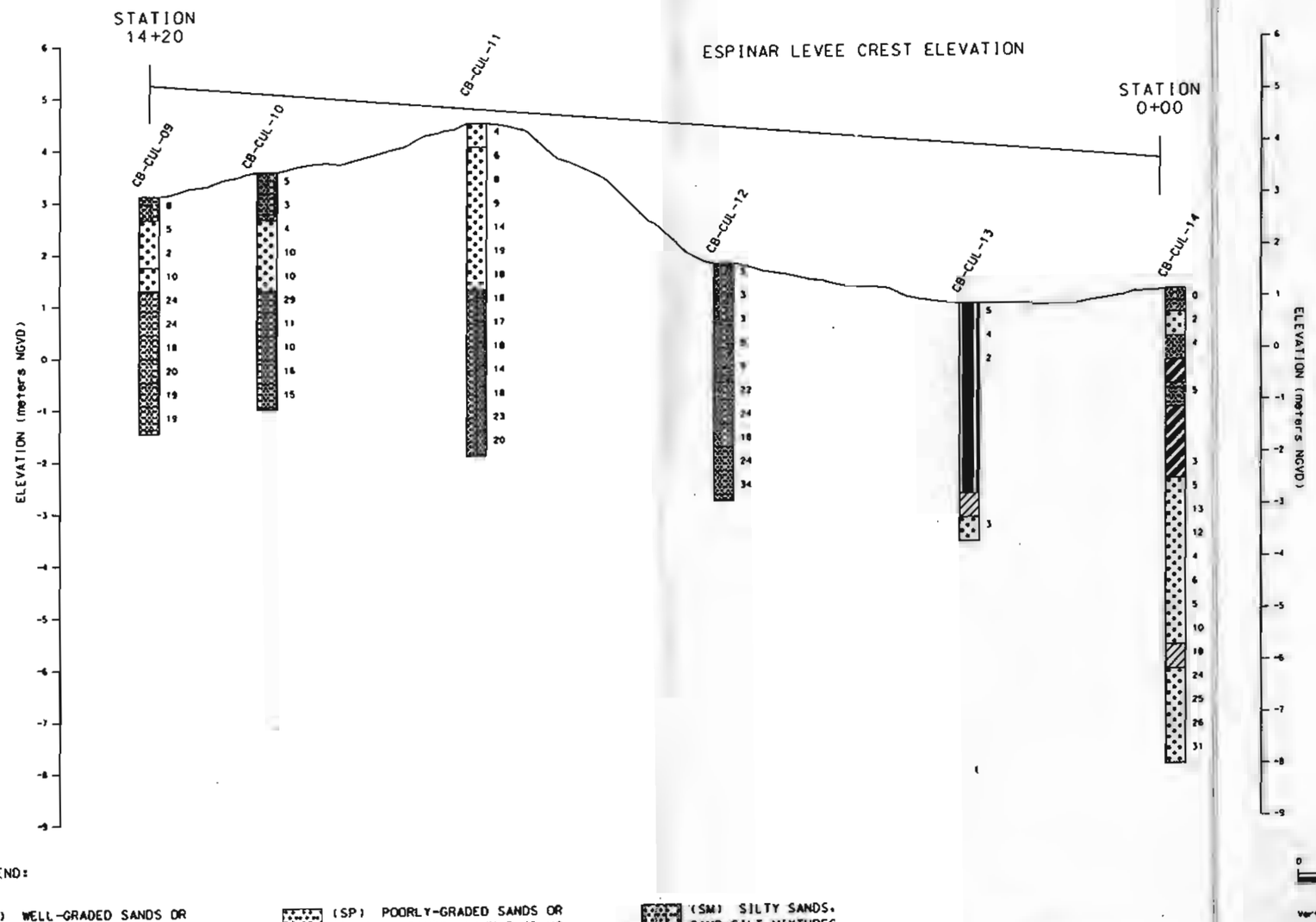
File name: PLATEB3.DGN
Reference files:

RIO CULEBRINAS at AGUADA/AGUADILLA
PUERTO RICO

GEOLOGIC SECTION -- AGUADILLA LEVEE

PLATE
B-3



SOIL LEGEND:

(SW) WELL-GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES

(SP) POORLY-GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES.

(SM) SILTY SANDS, SAND-SILT MIXTURES

(SC) CLAYEY-SANDS, SAND-SILT MIXTURES

(CL) INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS

(MH) INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS

(CH) INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS

NOTES:

1. THE GEOLOGIC SECTION SHOWN REFLECTS THE FIELD VISUAL CLASSIFICATION (SHOWN ON THE CORE BORING LOGS) AND LABORATORY CLASSIFICATION OF SELECTED SOIL SAMPLES.
2. NUMBERS SHOWN ON BORINGS ARE STANDARD PENETRATION TEST RESULTS IN BLOWS PER FOOT.
3. FOR A COMPLETE PLAN VIEW WITH LEGEND, SEE PLATES B-1 AND B-2.

US Army Corps of Engineers
Jacksonville District

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

Designed by:
Scale: AS SHOWN
Dwn by: M.R.V.
Ckd by:
Plot date:
Plot scale:
File name: PLATEB4R.DGN
Reference files:
Dated: April 2001
D.O. FILE NO.

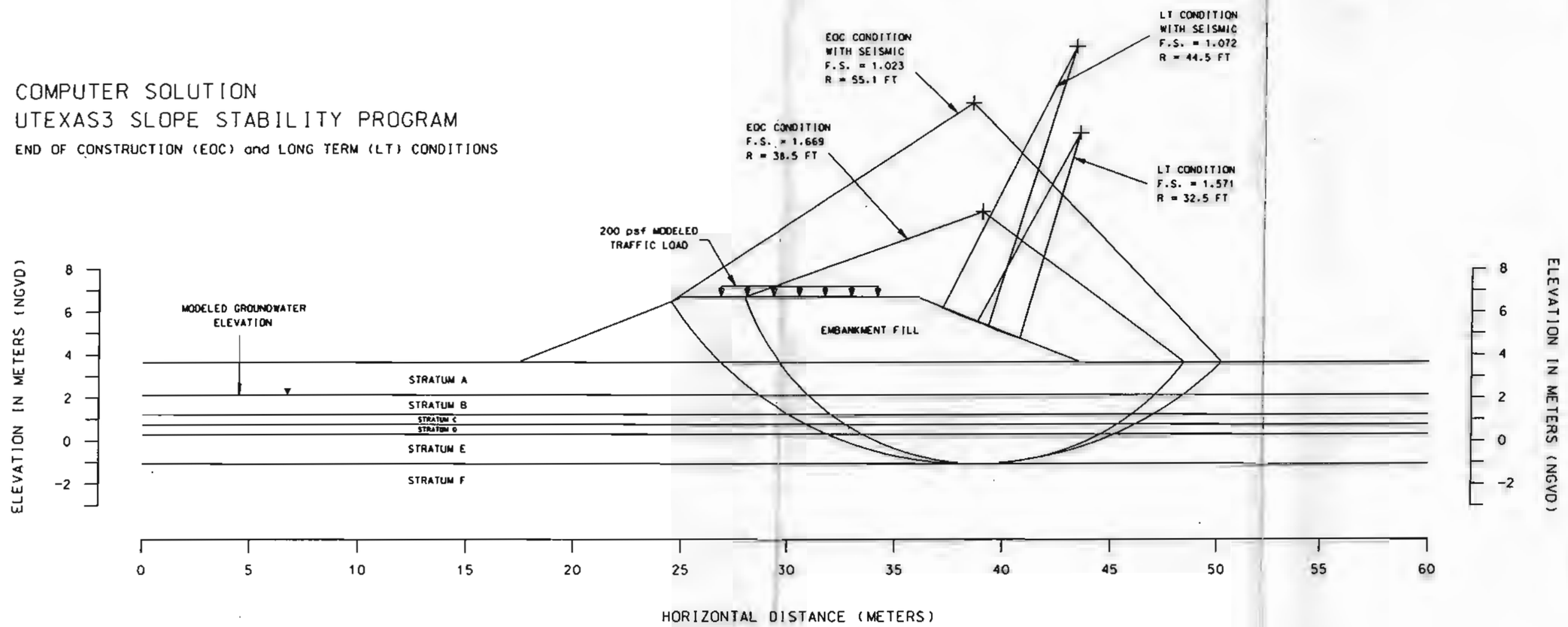
RIO CULEBRINAS at AGUADA/AGUADILLA
PUERTO RICO

GEOLOGIC SECTION -- ESPINAR LEVEE

PLATE
B-4

COMPUTER SOLUTION
UTEXAS3 SLOPE STABILITY PROGRAM

END OF CONSTRUCTION (EOC) and LONG TERM (LT) CONDITIONS



DESIGN DATA				Q		S	
STRATUM	GENERALIZED STRATUM TYPE	MOIST WT. PCF	SATURATED WT. PCF	COHESION PSF	Ø DEGREES	COHESION PSF	Ø DEGREES
EMB. FILL	(GM/GC)	127		0	32	0	32
A	(CH)	110		500	0	0	25
B	(CH)		104	750	0	0	23
C	(MH)		92	300	0	0	30
D	(SM)		107	0	28	0	28
E	(MH)		103	300	0	0	27
F	(SM)		107	0	28	0	28

LEGEND:

F.S. = FACTOR OF SAFETY
R = RADIUS
Ø = ANGLE OF INTERNAL FRICTION
Q = UNCONSOLIDATED-UNDRAINED SHEAR STRENGTH
S = CONSOLIDATED-DRAINED SHEAR STRENGTH
WT. = WEIGHT
PCF = POUNDS PER CUBIC FOOT
PSF = POUNDS PER SQUARE FOOT

NOTES:

1. SECTION MODELED NEAR CORE BORING CB-CUL-07. SEE PLATE B-1 FOR THE CORE BORING LOCATION.
2. EMBANKMENT SIDE SLOPES ARE 1 VERTICAL TO 2.5 HORIZONTAL.

US Army Corps of Engineers
Jacksonville District

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

Scale: AS SHOWN
Designed by:
Dwn by: M.W.V.
Ckd by:
Date: April 2001
D.O.FILE NO.
File name: PLATE5.DGN
Reference files:

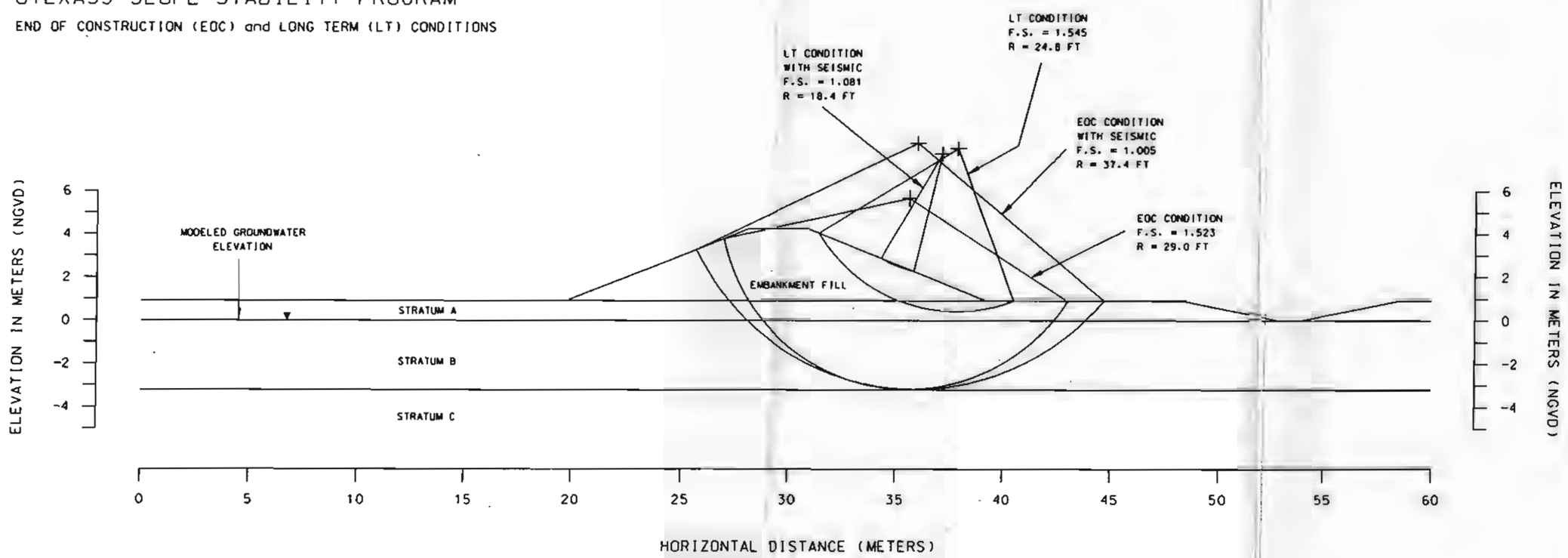
RIO CULEBRINAS at AGUADA/AGUADILLA
PUERTO RICO

SLOPE STABILITY ANALYSIS - SECTION NO. 1

PLATE
B-5

COMPUTER SOLUTION
UTEXAS3 SLOPE STABILITY PROGRAM

END OF CONSTRUCTION (EOC) and LONG TERM (LT) CONDITIONS



DESIGN DATA				Q		S	
STRATUM	GENERALIZED STRATUM TYPE	MOIST WT. PCF	SATURATED WT. PCF	COHESION PSF	Ø DEGREES	COHESION PSF	Ø DEGREES
EMB. FILL	(GM/GC)	127		0	32	0	32
A	(MH)	98		500	0	0	24
B	(MH)		97	350	0	0	25
C	(SW)		125	0	28	0	28

LEGEND:

F.S. = FACTOR OF SAFETY
R = RADIUS
Ø = ANGLE OF INTERNAL FRICTION
Q = UNCONSOLIDATED-UNDRAINED SHEAR STRENGTH
S = CONSOLIDATED-DRAINED SHEAR STRENGTH
WT. = WEIGHT
PCF = POUNDS PER CUBIC FOOT
PSF = POUNDS PER SQUARE FOOT

NOTES:

1. SECTION MODELED NEAR CORE BORING CB-CUL-13. SEE PLATE B-1 FOR THE CORE BORING LOCATION.
2. EMBANKMENT SIDE SLOPES ARE 1 VERTICAL TO 2.5 HORIZONTAL.

US Army Corps of Engineers
Jacksonville District

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

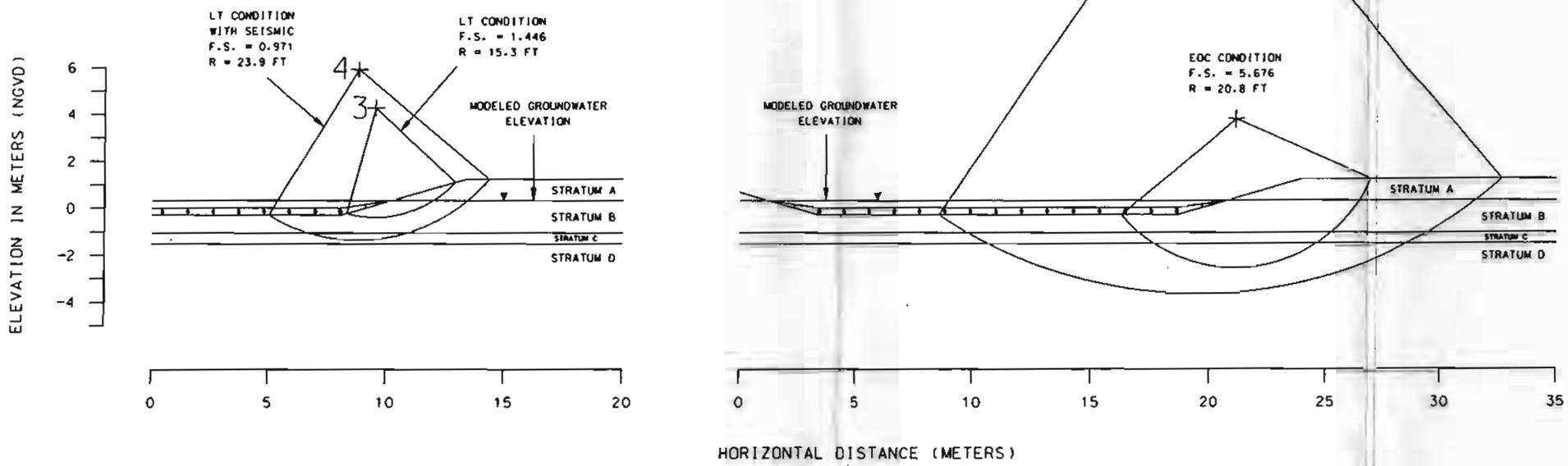
Scale: AS SHOWN
Designed by:
Dwn by: M.W.V.
Ckd by:
Dated: April 2001
D.O. FILE NO.
File name: PLATE B.DGN
Reference files:

RIO CULEBRINAS at AGUADA/AGUADILLA
PUERTO RICO
SLOPE STABILITY ANALYSIS - SECTION NO. 2

PLATE
B-6

COMPUTER SOLUTION
UTEXAS3 SLOPE STABILITY PROGRAM

END OF CONSTRUCTION (EOC) and LONG TERM (LT) CONDITIONS



DESIGN DATA				O		S	
STRATUM	GENERALIZED STRATUM TYPE	MOIST WT. PCF	SATURATED WT. PCF	COHESION PSF	Ø DEGREES	COHESION PSF	Ø DEGREES
A	(MH)	105		750	0	0	28
B	(MH)		100	350	0	0	26
C	(MH)		110	600	0	0	28
D	(SW)		125	0	32	0	32

LEGEND:

F.S. = FACTOR OF SAFETY
R = RADIUS
Ø = ANGLE OF INTERNAL FRICTION
O = UNCONSOLIDATED-UNDRAINED SHEAR STRENGTH
S = CONSOLIDATED-DRAINED SHEAR STRENGTH
WT. = WEIGHT
PCF = POUNDS PER CUBIC FOOT
PSF = POUNDS PER SQUARE FOOT

NOTES:

1. SECTION MODELED NEAR CORE BORING CB-CUL-04. SEE PLATE B-1 FOR THE CORE BORING LOCATION.
2. CHANNEL SIDE SLOPES ARE 1 VERTICAL TO 3.5 HORIZONTAL.

US Army Corps of Engineers
Jacksonville District

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

Scale: AS SHOWN
Designed by:
Dwn by: M.R.V.
Ckd by:
Dated: April 2001
D.O. FILE NO.
File name: PLATEB.DGN
Reference files:

RIO CULEBRINAS at AGUADA/AGUADILLA
PUERTO RICO
SLOPE STABILITY ANALYSIS - SECTION NO. 3

PLATE
B-7

CORE BORING LOGS

Hole No.CB-CUL-01

DRILLING LOG

DIVISION	South Atlantic
INSTALLATION	Jacksonville District
SHEET 1 OF 2	
1. PROJECT	Rio Culebrinas Project, Aguadilla, P.R.
2. LOCATION (Coordinates or Station)	X=248,651 Y=212,523
3. DRILLING AGENCY	GEO CIM, INC.
4. HOLE NO. (As shown on drawing title and file number)	CB-CUL-01
5. NAME OF DRILLER	Evaristo Santiago
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN	30.0 Ft.
8. DEPTH DRILLED INTO ROCK	0 Ft.
9. TOTAL DEPTH OF HOLE	30.0 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: 20 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES	1
15. ELEVATION GROUND WATER	-2.60
16. DATE HOLE STARTED / COMPLETED	06/18/98 06/18/98
17. ELEVATION TOP OF HOLE	4.40 Ft.
18. TOTAL CORE RECOVERY FOR BORING	52.2 %
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'
4.4	0.0					4.4	
2.9	1.5		Sandy CLAY, medium stiff, brown, some root and plant fragments. (CL)	55.6	1	SPLIT SPOON 2.9	1, 2, 3
-.1	4.5		Clayey Sand, very loose, olive green. (SC) -brown	61.1	2	SPLIT SPOON 1.4	2, 2, 2
				61.1	3	SPLIT SPOON -.1	2, 1, 1
-3.1	7.5		Terrigenous SAND, medium dense, medium to fine-grained, subangular, gray; little beach sand. (SW) -medium-grained	50	4	SPLIT SPOON -1.6	2, 2, 3
				55.6	5	SPLIT SPOON -3.1	3, 3, 3
-6.1	10.5		SAND, trace silt, medium to fine, loose, dark gray. (SW-SM) -little silt, little gravel (consisting mostly of white coral fragments)	55.6	6	SPLIT SPOON -4.6	2, 3, 3
				44.4	7	SPLIT SPOON -6.1	3, 6, 6
-13.6	18.0		Gravelly SAND, trace silt, mostly very coarse-grained, well graded, subrounded, medium dense, dark gray. (SW) -trace silt -as above -as above -no recovery	55.6	8	SPLIT SPOON -7.6	4, 6, 7
				50	9	SPLIT SPOON -9.1	6, 8, 8
				50	10	SPLIT SPOON -10.6	4, 7, 8
				55.6	11	SPLIT SPOON -12.1	6, 8, 8
				0	12	SPLIT SPOON -13.6	5, 5, 6
-18.1	22.5		Terrigenous SAND, mostly fine-grained, medium dense, well-graded, subrounded to angular, dark gray; some beach sand. (SW) -medium-grained -fine-grained	61.1	13	SPLIT SPOON -15.1	8, 9, 9
				55.6	14	SPLIT SPOON -16.6	4, 6, 6
				50	15	SPLIT SPOON -18.1	5, 5, 6

0 2.5 5 7.5 10 12.5 15 17.5 20 22.5

(continued)

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT	HOLE NUMBER
Rio Culebrinas Project, Aguadilla, P.R.	CB-CUL-01

Hole No.CB-CUL-01

DRILLING LOG (Cont. Sheet)

ELEVATION TOP OF HOLE 4.40 Ft.

SHEET 2 OF 2

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'
-18.1	22.5					-18.1	
			Terrigenous SAND, medium dense, well-graded, medium to coarse-grained, subrounded to angular, dark olive green; some beach sand. (SW)	55.6	16	SPLIT SPOON -19.6	1, 11, 11
			-medium to fine	55.6	17	SPLIT SPOON -21.1	12, 12, 11
			-medium sand	55.6	18	SPLIT SPOON -22.6	10, 11, 12
			-as above	44.4	19	SPLIT SPOON -24.1	11, 11, 10
-25.6	30.0			72.2	20	SPLIT SPOON -25.6	6, 7, 9

END OF BORING CB-CUL-01 AT 30.0 FEET DEPTH.

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.
2	33.4	2.71	50.0	24.9
6	32.4	2.77	--	--

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

Hole No.CB-CUL-02

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 1

1. PROJECT Rio Culebrinas Project, Aguadilla, P.R.	10. SIZE AND TYPE OF BIT See Remarks
2. LOCATION (Coordinates or Station) X=248,795 Y=211,804	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY GEO CIM, INC.	12. MANUFACTURER'S DESIGNATION OF DRILL CME-45
4. HOLE NO. (As shown on drawing title and file number) CB-CUL-02	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN disturbed: 10 undisturbed: 0
5. NAME OF DRILLER Evaristo Santiago	14. TOTAL NUMBER OF CORE BOXES 1
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED	15. ELEVATION GROUND WATER 0.19
	16. DATE HOLE STARTED 06/17/98 COMPLETED 06/17/98
7. THICKNESS OF BURDEN 15.0 Ft.	17. ELEVATION TOP OF HOLE 4.19 Ft.
8. DEPTH DRILLED INTO ROCK 0 Ft.	18. TOTAL CORE RECOVERY FOR BORING 62.8 %
9. TOTAL DEPTH OF HOLE 15.0 Ft.	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'
4.2	0.0					4.2	
2.7	1.5		SAND, well-graded, some silt, some root fragments, loose, subrounded to subangular, dark brown. (SM)	83.3	1	SPLIT SPOON 2.7	1 2 3
-.3	4.5		Beach SAND, well-graded, loose, subrounded to subangular, yellowish brown. (SW)	72.2	2	SPLIT SPOON 1.2	3 3 4
			-medium to coarse, trace calcite cemented sand nodules	88.9	3	SPLIT SPOON -.3	4 5 5
			SAND, coarse-grained, medium dense, brown. (SP)	72.2	4	SPLIT SPOON -1.8	6 8 8
			-as above, trace silt	72.2	5	SPLIT SPOON -3.3	7 7 8
			-little calcite cemented sand nodules	66.7	6	SPLIT SPOON -4.8	8 10 10
			-as above	50	7	SPLIT SPOON -6.3	6 9 9
			-coarse to very coarse-grained	50	8	SPLIT SPOON -7.8	5 7 8
			-as above	72.2	9	SPLIT SPOON -9.3	12 11 12
			-no recovery	0	10	SPLIT SPOON -10.8	13 13 16
-10.8	15.0						

END OF BORING CB-CUL-02 AT 15.0 FEET DEPTH.

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.
5	27.7	2.73	--	--

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 CB-CUL-02

Hole No.CB-CUL-03

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 2

1. PROJECT Rio Culebrinas Project, Aguadilla, P.R.	10. SIZE AND TYPE OF BIT See Remarks
2. LOCATION (Coordinates or Station) X=248,955 Y=211,084	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY GEO CIM, INC.	12. MANUFACTURER'S DESIGNATION OF DRILL CME-45
4. HOLE NO. (As shown on drawing title and file number) CB-CUL-03	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN disturbed: 20 undisturbed: 0
5. NAME OF DRILLER Evaristo Santiago	14. TOTAL NUMBER OF CORE BOXES 1
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED	15. ELEVATION GROUND WATER 6.48 Ft.
	16. DATE HOLE STARTED 06/12/98 COMPLETED 06/15/98
7. THICKNESS OF BURDEN 30.0 Ft.	17. ELEVATION TOP OF HOLE 7.98 Ft.
8. DEPTH DRILLED INTO ROCK 0 Ft.	18. TOTAL CORE RECOVERY FOR BORING 49.4 %
9. TOTAL DEPTH OF HOLE 30.0 Ft.	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'
8.0	0.0					8.0	
6.5	1.5		CLAY, trace silt and trace sand, stiff, dark brown; little root fragments. (CL)	77.8	1	SPLIT SPOON 6.5	2 4 4
3.5	4.5		Sandy Clay, low plasticity, sand is very fine-grained, soft to medium stiff, dark gray to brown. (CL)	44.4	2	SPLIT SPOON 5.0	2 2 2
			-little very fine-grained terrigenous sand, very soft.	33.3	3	SPLIT SPOON 3.5	1 1 1
.5	7.5		SAND, some gravel, trace silt, loose, well -graded, sub-rounded, dark gray; sand and gravel consists of terrigenous sediments. (SW)	44.4	4	SPLIT SPOON 2.0	1 2 1
			-as above	55.6	5	SPLIT SPOON .5	2 1 2
-4.0	12.0		Sandy GRAVEL, subrounded, loose, dark gray. (SW)	61.1	6	SPLIT SPOON -1.0	3 4 4
			-no recovery	0	7	SPLIT SPOON -2.5	3 3 4
				44.4	8	SPLIT SPOON -4.0	4 5 5
-5.5	13.5		Terrigenous SAND, well-graded, trace gravel, medium dense, subrounded, to subangular, olive green, trace beach sand. (SW)	55.6	9	SPLIT SPOON -5.5	4 5 6
-8.5	16.5		-sand, little gravel, little clay, loose, olive green (SC)	55.6	10	SPLIT SPOON -7.0	3 3 4
			-no recovery	0	11	SPLIT SPOON -8.5	2 2 2
-10.0	18.0		SILT, little clay and trace sand, medium stiff, gray to dark brown. (ML)	55.6	12	SPLIT SPOON -10.0	2 3 3
			Beach SAND, coarse to very coarse, medium dense, well-graded, subrounded to subangular, brown to gray. (SW)	50	13	SPLIT SPOON -11.5	4 4 5
			-medium to coarse-grained	83.3	14	SPLIT SPOON -13.0	7 8 8
			-coarse-grained	55.6	15	SPLIT SPOON -14.5	9 10 12

(continued)

Hole No.CB-CUL-03

DRILLING LOG (Cont. Sheet)

ELEVATION TOP OF HOLE 7.98 Ft.

SHEET 2 OF 2

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'
-14.5	22.5		~~as above~~			-14.5	
				55.6	16	SPLIT SPOON	10, 11, 12
			-no recovery			-16.0	
				0	17	SPLIT SPOON	11, 12, 13
-17.5	25.5					-17.5	
			Beach SAND, medium dense, well-graded, subrounded to subangular, gray to brown. (SW)	50	18	SPLIT SPOON	10, 10, 11
			-medium to coarse-grained			-19.0	
				66.7	19	SPLIT SPOON	10, 11, 10
						-20.5	
				100	20	SPLIT SPOON	11, 13, 13
-22.0	30.0					-22.0	

END OF BORING CB-CUL-03 AT 30.0 FEET DEPTH.

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.	Att. Limits P.I.
2	37.9	2.86	47.8	24.9
5	18.1	2.72	--	--
10	19.9	2.72	--	--

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

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

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

HOLE NUMBER: CB-CUL-03

Hole No.CB-CUL-04

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=248,336 Y=210,707
3. DRILLING AGENCY	GEO CIM, INC.
4. HOLE NO. (As shown on drawing title and file number)	CB-CUL-04
5. NAME OF DRILLER	Evaristo Santiago
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN	15.0 Ft.
8. DEPTH DRILLED INTO ROCK	0 Ft.
9. TOTAL DEPTH OF HOLE	15.0 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: 10 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES	1
15. ELEVATION GROUND WATER	1.11 Ft.
16. DATE HOLE STARTED / COMPLETED	06/12/98 06/12/98
17. ELEVATION TOP OF HOLE	4.11 Ft.
18. TOTAL CORE RECOVERY FOR BORING	47.2 %
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'
4.1	0.0					4.1	
			High Plasticity SILT, little root fragments, trace sand, medium stiff, dark brown. (MH)	55.6	1	SPLIT SPOON	2 3 5
			-some sand, soft to medium			2.6	
				55.6	2	SPLIT SPOON	2 2 2
1.1	3.0					1.1	
			High Plasticity, trace very fine terrigenous sand, very soft, dark gray; trace decomposing fragments. (MH)	50	3	SPLIT SPOON	1 1 1
			-no clay, no plant fragments			-.4	
				50	4	SPLIT SPOON	1 1 1
			-little terrigenous sand			-1.9	
				55.6	5	SPLIT SPOON	P P P
-3.4	7.5					-3.4	
			Sandy SILT, medium stiff, dark gray; sand consist of medium to coarse terrigenous sand. (MH)	61.1	6	SPLIT SPOON	1 2 3
-4.9	9.0					-4.9	
			Gravelly SAND, little silt, medium dense, well-graded, subrounded to subangular, coarse to very coarse, loose, dark gray; sand consists of terrigenous sediments. (SW)	50	7	SPLIT SPOON	3 4 4
			-as above			-6.4	
			-very coarse	22.2	8	SPLIT SPOON	3 4 5
						-7.9	
				33.3	9	SPLIT SPOON	4 5 5
			-as above.			-9.4	
				38.9	10	SPLIT SPOON	5 5 6
-10.9	15.0					-10.9	
			END OF BORING CB-CUL-04 AT 15.0 FEET DEPTH.				

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.
2	46.9	2.78	73.0	32.3
5	66.3	2.70	87.0	42.3

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: CB-CUL-04

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=249,055 Y=210,334
3. DRILLING AGENCY	GEO CIM, INC.
4. HOLE NO. (As shown on drawing title and file number)	CB-CUL-05
5. NAME OF DRILLER	Evaristo Santiago
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN	15.0 Ft.
8. DEPTH DRILLED INTO ROCK	0 Ft.
9. TOTAL DEPTH OF HOLE	15.0 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: 10 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES	1
15. ELEVATION GROUND WATER	
16. DATE HOLE STARTED / COMPLETED	06/22/98 06/22/98
17. ELEVATION TOP OF HOLE	7.19 Ft.
18. TOTAL CORE RECOVERY FOR BORING	60.5 %
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'
7.2	0.0					7.2	
			High Plasticity CLAY, soft to medium stiff, dark brown; some root and plant fragments. (CH)	66.7	1	SPLIT SPOON	1, 2, 2
			-little sand, brown to dark brown			5.7	
				61.1	2	SPLIT SPOON	2, 2, 2
			-medium stiff, trace gravel, trace root and plant fragments, gray to brown			4.2	
				38.9	3	SPLIT SPOON	2, 2, 3
2.7	4.5					2.7	
			SILT to Clayey SILT, medium stiff, brown to grayish brown to black, trace root fragments, trace disseminated oxides. (ML)	66.7	4	SPLIT SPOON	2, 3, 3
			-as above			1.2	
				72.2	5	SPLIT SPOON	2, 3, 3
-.3	7.5					-.3	
			SILT to Clayey SILT, very soft, dark gray, some black decomposing plant fragments. (MH)	38.9	6	SPLIT SPOON	1, 1, 1
-1.8	9.0					-1.8	
			SILT, some sand, very soft to soft, dark gray. (MH)	44.4	7	SPLIT SPOON	1, 1, 1
			-some to little sand, some wood and plant fragments			-3.3	
				44.4	8	SPLIT SPOON	1, 1/12
			-no wood fragments, trace plant fragments			-4.8	
				72.2	9	SPLIT SPOON	1/18
			-some to little clay, gray and brown			-6.3	
				100	10	SPLIT SPOON	1/18
-7.8	15.0					-7.8	

END OF BORING CB-CUL-05 AT 15.0 FEET DEPTH.

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.)

Groundwater was not observed during drilling.

X and Y Coordinates are given in feet.

Sample No.	Moisture Content%	Spec. Gravity	Att. Limits L.L.	P.I.
2	38.5	2.77	76.0	41.9
7	53.2	2.68	61.6	21.8

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

DRILLING LOG

DIVISION South Atlantic	INSTALLATION Jacksonville District
	SHEET 1 OF 2
1. PROJECT Rio Culebrinas Project, Aguadilla, P.R.	10. SIZE AND TYPE OF BIT See Remarks
2. LOCATION (Coordinates or Station) X=249,180 Y=209,626	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY GEO CIM, INC.	12. MANUFACTURER'S DESIGNATION OF DRILL CME-45
4. HOLE NO. (As shown on drawing title and file number) CB-CUL-06	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN disturbed: 20 undisturbed: 0
5. NAME OF DRILLER Evaristo Santiago	14. TOTAL NUMBER OF CORE BOXES 1
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED	15. ELEVATION GROUND WATER -5.73 Ft.
	16. DATE HOLE STARTED 06/22/98 COMPLETED 06/22/98
7. THICKNESS OF BURDEN 30.0 Ft.	17. ELEVATION TOP OF HOLE 7.72 Ft.
8. DEPTH DRILLED INTO ROCK 0 Ft.	18. TOTAL CORE RECOVERY FOR BORING 55.8 %
9. TOTAL DEPTH OF HOLE 30.0 Ft.	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'
7.7	0.0					7.7	
			Clayey SAND, loose to medium dense, well-graded, mostly medium sand, black brown; some root fragments. (SC)	55.6	1	SPLIT SPOON	2 3 2
			-loose, trace gravel			6.2	
			-no recovery	27.8	2	SPLIT SPOON	3 2 2
						4.7	
				0	3	SPLIT SPOON	3 3 3
3.2	4.5					3.2	
			High Plasticity CLAY, medium stiff, brown to gray, trace root fragments. (CH)	66.7	4	SPLIT SPOON	3 3 3
			-soft, trace to little silt, little root fragments, trace sand, gray			1.7	
				77.8	5	SPLIT SPOON	2 2 2
.2	7.5					.2	
			High Plasticity SILT, traace sand, very soft, graay; some decomposing wood fragments. (MH)	94.4	6	SPLIT SPOON	1 1/12
			-as above			-1.3	
			-little to some sand	100	7	SPLIT SPOON	1/12 1
						-2.8	
				100	8	SPLIT SPOON	1 1 1
-4.3	12.0					-4.3	
			Beach SAND, some clay, medium dense, well-graded, medium to coarse, brown to gray; some decomposing plant fragments. (SC)	83.3	9	SPLIT SPOON	3 11 15
			-no clay, subangular			-5.8	
			-no recovery	44.4	10	SPLIT SPOON	7 10 10
						-7.3	
			-medium to very coarse	0	11	SPLIT SPOON	5 10 11
						-8.8	
			-some calcite cemented sand nodules	55.6	12	SPLIT SPOON	9 9 10
						-10.3	
			-as above	55.6	13	SPLIT SPOON	9 9 8
						-11.8	
			-little sand nodules	44.4	14	SPLIT SPOON	6 8 8
						-13.3	
				50	15	SPLIT SPOON	6 7 8
-14.8	22.5					-14.8	
						(continued)	

0 2.5 5 7.5 10 12.5 15 17.5 20 22.5

DRILLING LOG (Cont. Sheet)

ELEVATION TOP OF HOLE 7.72 Ft.

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'
-14.8	22.5					-14.8	
			Calcite cemented Beach Sand, some loose sand, medium dense, well- graded,coarse to medium sand, brown. (SW)	55.6	16	SPLIT SPOON	14, 15, 13
			-medium coarse	44.4	17	SPLIT SPOON	9, 10, 11
-17.8	25.5					-17.8	
			Beach SAND, calcite cemented sand nodules, medium dense, well-graded, fine to medium, brown. (SW)	50	18	SPLIT SPOON	10, 10, 12
			-as above	55.6	19	SPLIT SPOON	10, 13, 13
			-medium to coarse	55.6	20	SPLIT SPOON	11, 14, 15
-22.3	30.0					-22.3	

END OF BORING CB-CUL-06 AT 30.0 FEET DEPTH.

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.

Groundwater level was taken during drilling.

Sample No.	Moisture Content%	Spec. Gravity	Att. Limits L.L.	Att. Limits P.I.
5	58.1	2.69	92.6	62.7
7	55.7	2.71	73.0	30.3

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

Hole No.CB-CUL-07

DRILLING LOG

DIVISION	South Atlantic
INSTALLATION	Jacksonville District
SHEET	1 OF 2
1. PROJECT	Rio Culebrinas Project, Aguadilla, P.R.
2. LOCATION (Coordinates or Station)	X=249,301 Y=208,733
3. DRILLING AGENCY	GEO CIM, INC.
4. HOLE NO. (As shown on drawing title and file number)	CB-CUL-07
5. NAME OF DRILLER	Evaristo Santiago
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN	21.0 Ft.
8. DEPTH DRILLED INTO ROCK	0 Ft.
9. TOTAL DEPTH OF HOLE	21.0 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: 14 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES	1
15. ELEVATION GROUND WATER	10.06 Ft.
16. DATE HOLE	STARTED 06/17/98 COMPLETED 06/17/98
17. ELEVATION TOP OF HOLE	11.56 Ft.
18. TOTAL CORE RECOVERY FOR BORING	74.9 %
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'
11.6	0.0					11.6	
10.1	1.5		FILL - Clayey SAND, some gravel and asphalt fragments, medium dense, well-graded, medium sand, dark brown. (SC)	50	1	SPLIT SPOON 10.1	3 4 4
7.1	4.5		FILL - CLAY, some limestone fragments, stiff, pale brown. (CL) -as above	50	2	SPLIT SPOON 8.6	4 3 4
				66.7	3	SPLIT SPOON 7.1	6 6 5
4.1	7.5		CLAY, little gravel, little sand, medium stiff, very dark brown. (CH) -medium stiff, trace gravel, trace sand, some decomposing plant fragments	83.3	4	SPLIT SPOON 5.6	3 3 4
				72.2	5	SPLIT SPOON 4.1	2 2 3
2.6	9.0		High Plasticity SILT, some fine-grained sand, some decomposing plants, very soft, dark gray. (MH)	83.3	6	SPLIT SPOON 2.6	1 1/12
1.1	10.5		Silty SAND, some wood and plant fragments, very loose, fine, well-graded, dark gray. (SM)	83.3	7	SPLIT SPOON 1.1	1 1 1
-3.4	15.0		High Plasticity SILT, some sand, little wood and plant fragments, very soft, dark gray. (MH) -some root fragments	83.3	8	SPLIT SPOON -.4	1 1 1
			-little sand, brown to dark gray (MH)	83.3	9	SPLIT SPOON -1.9	1/18
				100	10	SPLIT SPOON -3.4	P P P
-6.4	18.0		Silty SAND, some decomposing wood and plant fragments, very loose, well-graded, coarse, dark gray. (SM) -very coarse, loose, little decomposing wood and plant fragments	77.8	11	SPLIT SPOON -4.9	P P P
				83.3	12	SPLIT SPOON -6.4	1 1 3
-7.9	19.5		SILT, some gravel and sand, soft, dark gray; some root fragments. (ML)	50	13	SPLIT SPOON -7.9	3 1 2
-9.4	21.0		Gravel, some sand and silt, medium dense, well-graded, subrounded, dark gray. (GW)	83.3	14	SPLIT SPOON -9.4	3 6 7
			END OF BORING CB-CUL-07 AT 21.0 FEET DEPTH.				

0 2.5 5 7.5 10 12.5 15 17.5 20 22.5

(continued)

DRILLING LOG (Cont. Sheet)

ELEVATION TOP OF HOLE 11.56 Ft.

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	20.3	2.72	33.8	20.8
5	60.0	2.78	87.0	57.2
6	90.5	2.60	86.0	17.8
8	74.5	2.73	60.0	14.2
10	51.2	2.74	62.8	28.3

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

Hole No.CB-CUL-08

DRILLING LOG

DIVISION South Atlantic	INSTALLATION Jacksonville District
SHEET 1 OF 2	
1. PROJECT Rio Culebrinas Project, Aguadilla, P.R.	10. SIZE AND TYPE OF BIT See Remarks
2. LOCATION (Coordinates or Station) X=249,555 Y=207,932	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY GEO CIM, INC.	12. MANUFACTURER'S DESIGNATION OF DRILL CME-45
4. HOLE NO. (As shown on drawing title and file number) CB-CUL-08	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN disturbed: 14 undisturbed: 0
5. NAME OF DRILLER Evaristo Santiago	14. TOTAL NUMBER OF CORE BOXES 1
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED	15. ELEVATION GROUND WATER 5.55 Ft.
	16. DATE HOLE STARTED 06/15/98 COMPLETED 06/15/98
7. THICKNESS OF BURDEN 21.0 Ft.	17. ELEVATION TOP OF HOLE 9.55 Ft.
8. DEPTH DRILLED INTO ROCK 0 Ft.	18. TOTAL CORE RECOVERY FOR BORING 66.72 %
9. TOTAL DEPTH OF HOLE 21.0 Ft.	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'
9.6	0.0					9.6	
			High Plasticity CLAY, little silt and trace sand, stiff, dark brown; some root fragments. (CH)	66.7	1	SPLIT SPOON	2, 4, 4
			-as above, some sand			8.1	
				66.7	2	SPLIT SPOON	2, 3, 4
			-some beach sand found in the lower 2 inches of penetration			6.6	
				72.2	3	SPLIT SPOON	2, 3, 4
5.1	4.5					5.1	
			Beach SAND, well-graded, medium dense, well-graded, subangular to subrounded, brown, some calcite cemented sand nodules. (SW)	83.3	4	SPLIT SPOON	5, 8, 8
			-little sand nodules			3.5	
				66.7	5	SPLIT SPOON	6, 7, 8
2.0	7.5					2.0	
			Gravelly Sand, medium dense, well-graded, subrounded to subangular, brown; gravel consist of calcite cemented beach sand nodules. (SW)	77.8	6	SPLIT SPOON	7, 9, 9
.6	9.0					.6	
			Gravelly Sand, fine to medium-grained, trace silt, light brown. (SP-SM)	72.2	7	SPLIT SPOON	7, 8, 9
			-fine to medium sand, trace silt			-.9	
				72.2	8	SPLIT SPOON	6, 8, 9
			-coarse sand, little terrigenous gravel			-2.5	
				83.3	9	SPLIT SPOON	7, 8, 8
			-little silt			-3.9	
				66.7	10	SPLIT SPOON	4, 9, 10
			-gravel consist of terrigenous rock fragments			-5.4	
				66.7	11	SPLIT SPOON	6, 11, 13
			-no recovery			-6.9	
				0	12	SPLIT SPOON	7, 8, 10
-8.4	18.0					-8.4	
			Beach SAND, medium to fine, medium dense, well-graded, subangular, brown. (SW)	100	13	SPLIT SPOON	8, 8, 10
-9.9	19.5					-9.9	
			Terrigenous GRAVEL, trace sand, medium dense, well-graded, subrounded, brown to black. (GW)	38.9	14	SPLIT SPOON	6, 10, 12
-11.4	21.0					-11.4	
			END OF BORING CB-CUL-08 AT 21.0 FEET DEPTH.				
						(continued)	

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 CB-CUL-08

Hole No.CB-CUL-08

DRILLING LOG (Cont. Sheet)

ELEVATION TOP OF HOLE 9.55 Ft.

SHEET 2 OF 2

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.
2	31.9	2.79	61.8	33.5
8	15.7	2.77	--	--

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

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

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

HOLE NUMBER: CB-CUL-08

Hole No.CB-CUL-09

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=246,627 Y=207,832
3. DRILLING AGENCY	GEO CIM, INC.
4. HOLE NO. (As shown on drawing title and file number)	CB-CUL-09
5. NAME OF DRILLER	Evaristo Santiago
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN	15.0 Ft.
8. DEPTH DRILLED INTO ROCK	0 Ft.
9. TOTAL DEPTH OF HOLE	15.0 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: 10 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES	1
15. ELEVATION GROUND WATER	3.24 Ft.
16. DATE HOLE STARTED / COMPLETED	06/16/98 06/16/98
17. ELEVATION TOP OF HOLE	10.23 Ft.
18. TOTAL CORE RECOVERY FOR BORING	71.1 %
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'
10.2	0.0					10.2	
8.7	1.5		Silty SAND, loose, well-graded, dark brown, some root fragments. (SM)	72.2	1	SPLIT SPOON 8.7	1 4 4
5.7	4.5		SAND, loose, little to trace silt, dark brown. (SW)	77.8	2	SPLIT SPOON 7.2	2 2 3
			-very loose, lower 8 inches of sample consisted of clean beach sand	72.2	3	SPLIT SPOON 5.7	1 1 1
4.2	6.0		Beach SAND, medium dense, well-graded, subangular to subrounded, brown; trace calcite cemented sand nodules. (SW)	77.8	4	SPLIT SPOON 4.2	3 4 6
			-coarse-grained, little to some calcite cemented sand nodules (SP)	88.9	5	SPLIT SPOON 2.7	6 11 13
			-some calcite cemented sand nodules (gravel-sized)	83.3	6	SPLIT SPOON 1.2	9 11 13
			-as above, trace silt	83.3	7	SPLIT SPOON -.3	7 8 10
			-coarse to very coarse-grained	55.6	8	SPLIT SPOON -1.8	9 9 11
			-as above	50	9	SPLIT SPOON -3.3	8 9 10
-4.8	15.0		-as above.	50	10	SPLIT SPOON -4.8	8 9 10

END OF BORING CB-CUL-09 AT 15.0 FEET DEPTH.

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.
7	17.3	2.70	--	--

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: CB-CUL-09

Hole No.CB-CUL-10

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=247,099 Y=207,984
3. DRILLING AGENCY	GEO CIM, INC.
4. HOLE NO. (As shown on drawing title and file number)	CB-CUL-10
5. NAME OF DRILLER	Evaristo Santiago
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN	15.0 Ft.
8. DEPTH DRILLED INTO ROCK	0 Ft.
9. TOTAL DEPTH OF HOLE	15.0 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: 10 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES	1
15. ELEVATION GROUND WATER	3.69 Ft.
16. DATE HOLE STARTED / COMPLETED	06/16/98 06/16/98
17. ELEVATION TOP OF HOLE	11.69 Ft.
18. TOTAL CORE RECOVERY FOR BORING	63.3 %
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'
11.7	0.0					11.7	
			SAND, little silt, loose, well-graded, subangular to subrounded, dark brown, some root fragments. (SM)	77.8	1	SPLIT SPOON	2, 2, 3
			-very loose			10.2	
				72.2	2	SPLIT SPOON	2, 2, 1
8.7	3.0					8.7	
			Beach SAND, loose, well-graded, subangular to subrounded, brown. (SW)	55.6	3	SPLIT SPOON	2, 1, 3
			-medium dense			7.2	
				50	4	SPLIT SPOON	4, 4, 6
			-as above			5.7	
				50	5	SPLIT SPOON	4, 4, 6
4.2	7.5					4.2	
			SAND, very coarse-grained, little calcite cemented sand nodules, poorly-graded (SP)	77.8	6	SPLIT SPOON	7, 16, 13
			-coarse-grained			2.7	
				72.2	7	SPLIT SPOON	4, 5, 6
			-medium sand, trace silt, trace gravel (cemented sand)			1.2	
				72.2	8	SPLIT SPOON	4, 4, 6
			-coarse-grained, little calcite cemented sand nodules			-.3	
				55.6	9	SPLIT SPOON	7, 8, 8
			-as above.			-1.8	
				50	10	SPLIT SPOON	5, 7, 8
-3.3	15.0					-3.3	
			END OF BORING CB-CUL-10 AT 15.0 FEET DEPTH.				

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.
2	12.1	2.69	19.1	2.9
8	25.4	2.69	--	--

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: CB-CUL-10

DRILLING LOG

DIVISION	South Atlantic
INSTALLATION	Jacksonville District
SHEET	1 OF 2
1. PROJECT	Rio Culebrinas Project, Aguadilla, P.R.
2. LOCATION (Coordinates or Station)	X=247,805 Y=208,506
3. DRILLING AGENCY	GEO CIM, INC.
4. HOLE NO. (As shown on drawing title and file number)	CB-CUL-11
5. NAME OF DRILLER	Evaristo Santiago
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN	21.0 Ft.
8. DEPTH DRILLED INTO ROCK	0 Ft.
9. TOTAL DEPTH OF HOLE	21.0 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: 14 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES	1
15. ELEVATION GROUND WATER	5.66 Ft.
16. DATE HOLE	STARTED 06/11/98 COMPLETED 06/11/98
17. ELEVATION TOP OF HOLE	14.66 Ft.
18. TOTAL CORE RECOVERY FOR BORING	79.4 %
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'
14.7	0.0					14.7	
13.2	1.5		SAND, litt to some silt, well-graded, loose, subrounded, dark; little root fragments. (SW)	83.3	1	SPLIT SPOON 13.2	2 2 2
			Beach SAND, loose, well graded, medium to fine sand, sub-rounded, brown. (SW)	72.2	2	SPLIT SPOON 11.7	2 2 4
			medium sand	83.3	3	SPLIT SPOON 10.2	3 4 4
			-medium to coarse-grained	66.7	4	SPLIT SPOON 8.7	3 4 5
			-trace calcite cemented sand nodules (gravel-sized)	77.8	5	SPLIT SPOON 7.2	4 6 8
			-coarse, little calcite cemented sand nodules	83.3	6	SPLIT SPOON 5.7	9 9 10
			-as above	94.4	7	SPLIT SPOON 4.2	7 8 10
4.2	10.5		SAND, rounded to subrounded, little gravel (cemented sand fragments), trace silt. (SP-SM)	100	8	SPLIT SPOON 2.7	6 9 9
			-as above	83.3	9	SPLIT SPOON 1.2	5 8 9
			-coarse to very coarse	88.9	10	SPLIT SPOON -.3	6 9 9
			-as above	66.7	11	SPLIT SPOON -1.8	6 7 7
			-very coarse	61.1	12	SPLIT SPOON -3.3	7 9 9
			-as above	83.3	13	SPLIT SPOON -4.8	9 11 12
			-as above	66.7	14	SPLIT SPOON -6.3	7 9 11
-6.3	21.0						
			END OF BORING CB-CUL-11 AT 21.0 FEET DEPTH.				

0 2.5 5 7.5 10 12.5 15 17.5 20 22.5

(continued)

Hole No.CB-CUL-11

DRILLING LOG (Cont. Sheet)

ELEVATION TOP OF HOLE 14.66 Ft.

SHEET 2 OF 2

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.	Att. Limits P.I.
8	14.5	2.74	--	--

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

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

HOLE NUMBER: CB-CUL-11

Hole No.CB-CUL-12

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 1

1. PROJECT Rio Culebrinas Project, Aguadilla, P.R.	10. SIZE AND TYPE OF BIT See Remarks
2. LOCATION (Coordinates or Station) X=247,326 Y=209,438	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY GEO CIM, INC.	12. MANUFACTURER'S DESIGNATION OF DRILL CME-45
4. HOLE NO. (As shown on drawing title and file number) CB-CUL-12	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN disturbed: 10 undisturbed: 0
5. NAME OF DRILLER Evaristo Santiago	14. TOTAL NUMBER OF CORE BOXES 1
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED	15. ELEVATION GROUND WATER 1.16 Ft.
	16. DATE HOLE STARTED 06/11/98 COMPLETED 06/11/98
7. THICKNESS OF BURDEN 15.0 Ft.	17. ELEVATION TOP OF HOLE 5.66 Ft.
8. DEPTH DRILLED INTO ROCK 0 Ft.	18. TOTAL CORE RECOVERY FOR BORING 74.4 %
9. TOTAL DEPTH OF HOLE 15.0 Ft.	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'
5.7	0.0					5.7	
			Clayey SAND, loose, dark brown; sand is medium to coarse-grained. (SC)	94.4	1	SPLIT SPOON	3 3 2
			-soft			4.2	
				83.3	2	SPLIT SPOON	2 2 1
			-as above			2.7	
				83.3	3	SPLIT SPOON	1 1 2
1.2	4.5					1.2	
			Beach SAND, some clay and little silt, loose, coarse to medium, well- graded, subrounded to subangular, gray to brown, little calcite cemented sand nodules. (SC)	72.2	4	SPLIT SPOON	2 4 5
						-.3	
				83.3	5	SPLIT SPOON	2 4 5
-1.8	7.5					-1.8	
			Beach SAND, trace silt, medium dense, medium sand, subangular, gray to brown. (SP)	72.2	6	SPLIT SPOON	7 10 12
			-no silt, medium to coarse			-3.3	
				55.6	7	SPLIT SPOON	7 11 13
			-as above			-4.8	
				83.3	8	SPLIT SPOON	6 9 9
			-coarse			-6.3	
				44.4	9	SPLIT SPOON	9 12 12
			-little to some calcite cemented sand nodules			-7.8	
				72.2	10	SPLIT SPOON	13 18 16
-9.3	15.0					-9.3	
			END OF BORING CB-CUL-12 AT 15.0 FEET DEPTH.				

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.
2	22.3	2.68	35.5	19.7
5	27.7	2.70	N/P	N/P

0 2.5 5 7.5 10 12.5 15 17.5 20 22.5

Hole No.CB-CUL-13

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=247,082 Y=210,444
3. DRILLING AGENCY	GEO CIM, INC.
4. HOLE NO. (As shown on drawing title and file number)	CB-CUL-13
5. NAME OF DRILLER	Evaristo Santiago
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN	15.0 Ft.
8. DEPTH DRILLED INTO ROCK	0 Ft.
9. TOTAL DEPTH OF HOLE	15.0 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: 10 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES	1
15. ELEVATION GROUND WATER	1.97 Ft.
16. DATE HOLE STARTED / COMPLETED	06/18/98 06/18/98
17. ELEVATION TOP OF HOLE	2.97 Ft.
18. TOTAL CORE RECOVERY FOR BORING	77.2 %
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'
3.0	0.0					3.0	
			High Plasticity SILT, trace sand and gravel, medium stiff, dark brown; plant fragments. (MH)	61.1	1	SPLIT SPOON	3, 2, 3
			-gray, no sand			1.5	
				61.1	2	SPLIT SPOON	1, 2, 2
			-very soft			0.0	
				66.6	3	SPLIT SPOON	1, 1, 1
-1.5	4.5					-1.5	
			High Plasticity SILT, trace sand, very soft, darl gray; trace decomposing roots and plant fragments. (MH)	100	4	SPLIT SPOON	P, P, P
						-3.0	
				100	5	SPLIT SPOON	P, P, P
-4.5	7.5					-4.5	
				72.2	6	SPLIT SPOON	P, P, P
-6.0	9.0					-6.0	
			High Plasticity SILT, very soft, dark gray. (MH)	83.3	7	SPLIT SPOON	P, P, P
			-trace sand, little decomposing plant fragments			-7.5	
				100	8	SPLIT SPOON	P, P, P
-9.0	12.0					-9.0	
			CLAY, some gravel and sand, soft, dark gray. (CL)	44.4	9	SPLIT SPOON	P, P, 3
-10.5	13.5					-10.5	
			Gravelly SAND, trace silt, loose, mostly very coarse, well-graded, subrounded to subangular, dark gray. (SW)	83.3	10	SPLIT SPOON	1, 2, 1
-12.0	15.0					-12.0	

END OF BORING CB-CUL-13 AT 15.0 FEET DEPTH.

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.	Att. Limits P.I.
2	55.8	2.58	90.0	47.3
4	76.2	2.64	84.5	35.8
8	70.0	2.72	71.5	34.6

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

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PROJECT	HOLE NUMBER
Rio Culebrinas Project, Aguadilla, P.R.	CB-CUL-13

DRILLING LOG

DIVISION South Atlantic	INSTALLATION Jacksonville District
	SHEET 1 OF 2
1. PROJECT Rio Culebrinas Project, Aguadilla, P.R.	10. SIZE AND TYPE OF BIT See Remarks
2. LOCATION (Coordinates or Station) X=246,988 Y=211,306	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY GEO CIM, INC.	12. MANUFACTURER'S DESIGNATION OF DRILL CME-45
4. HOLE NO. (As shown on drawing title and file number) CB-CUL-14	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN disturbed: 20 undisturbed: 0
5. NAME OF DRILLER Evaristo Santiago	14. TOTAL NUMBER OF CORE BOXES 1
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED	15. ELEVATION GROUND WATER 2.79 Ft.
	16. DATE HOLE STARTED 06/19/98 COMPLETED 06/19/98
7. THICKNESS OF BURDEN 30.0 Ft.	17. ELEVATION TOP OF HOLE 3.79 Ft.
8. DEPTH DRILLED INTO ROCK 0 Ft.	18. TOTAL CORE RECOVERY FOR BORING 65.3 %
9. TOTAL DEPTH OF HOLE 30.0 Ft.	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'
3.8	0.0					3.8	
2.3	1.5		Beach SAND, some silt, very loose, well-graded, medium sand, brown; some root fragments. (SM)	72.2	1	SPLIT SPOON 2.3	1/18
.8	3.0		-no silt (SW)	72.2	2	SPLIT SPOON .8	2 1 1
-.7	4.5		-loose, little to some silt (SM)	94.4	3	SPLIT SPOON -.7	1 2 2
-2.2	6.0		High Plasticity CLAY, trace sand, very soft, dark gray; some wood and fragments. (CH)	94.4	4	SPLIT SPOON -2.2	P P P
-3.7	7.5		SAND, some clay, loose, mostly medium sand, well-graded, dark gray. (SC)	88.9	5	SPLIT SPOON -3.7	3 3 2
-5.2	9.0		High Plasticity CLAY, very soft, dark gray; little decomposing plant fragments. (CH)	100	6	SPLIT SPOON -5.2	P P P
-6.7	10.5		-some sand	100	7	SPLIT SPOON -6.7	P P P
-8.2	12.0		-little sand, soft	94.4	8	SPLIT SPOON -8.2	1 2 1
			Terrigenous SAND, some clay, medium dense, mostly coarse-grained, well-graded, dark gray. (SW)	38.9	9	SPLIT SPOON -9.7	2 2 3
			-very coarse, little clay, some gravel	44.4	10	SPLIT SPOON -11.2	5 7 6
			-no clay	83.3	11	SPLIT SPOON -12.7	4 6 6
			-loose, gravelly	50	12	SPLIT SPOON -14.2	3 2 2
			-medium dense, little clay	38.9	13	SPLIT SPOON -15.7	2 2 4
			-some clay, little gravel	44.4	14	SPLIT SPOON -17.2	2 2 3
			-no clay	55.6	15	SPLIT SPOON -18.7	3 5 5
-18.7	22.5					(continued)	

0 2.5 5 7.5 10 12.5 15 17.5 20 22.5

DRILLING LOG (Cont. Sheet)

ELEVATION TOP OF HOLE 3.79 Ft.

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'
-18.7	22.5					-18.7	
-20.2	24.0		Sandy CLAY, trace gravel, very stiff, dark gray; little decomposing plant fragments. (CL)	50	16	SPLIT SPOON -20.2	4, 8, 10
			Terrigenous SAND, trace silt, mostly fine-grained, medium dense, well-graded, subangular, dark gray. (SW) subangular, dark gray.	55.6	17	SPLIT SPOON -21.7	8, 12, 12
			-as above	66.7	18	SPLIT SPOON -23.2	10, 12, 13
			-as above	61.1	19	SPLIT SPOON -24.7	9, 13, 13
			-no recovery	0	20	SPLIT SPOON -26.2	9, 15, 16
-26.2	30.0						

END OF BORING CB-CUL-14 AT 30.0 FEET DEPTH.

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.	Att. Limits P.I.
4	96.6	2.71	114.5	72.2
8	92.0	2.74	97.9	59.6

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

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

0 2.5 5 7.5 10 12.5 15 17.5 20 22.5

DRILLING LOG (Cont. Sheet)

ELEVATION TOP OF HOLE 112.76 Ft.

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

DRILLING LOG (Cont. Sheet)

ELEVATION TOP OF HOLE 112.76 Ft.

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.	Att. Limits 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

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

Hole No.TP-CUL-02

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
	SHEET 1 OF 1
1. PROJECT: Rio Culebrinas Project, Aguadilla, P.R.	10. SIZE AND TYPE OF BIT: See Remarks
2. LOCATION (Coordinates or Station): X=243,724 Y=204,022	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: GEO CIM, INC.	12. MANUFACTURER'S DESIGNATION OF DRILL: John Deere 310-digger
4. HOLE NO. (As shown on drawing title and file number): TP-CUL-02	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 2 undisturbed: 0
5. NAME OF DRILLER: Evaristo Santiago	14. TOTAL NUMBER OF CORE BOXES: 2
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED	15. ELEVATION GROUND WATER
	16. DATE HOLE STARTED COMPLETED: 06/24/98 06/24/98
7. THICKNESS OF BURDEN: 9.5 Ft.	17. ELEVATION TOP OF HOLE: 105.34 Ft.
8. DEPTH DRILLED INTO ROCK: 0 Ft.	18. TOTAL CORE RECOVERY FOR BORING: %
9. TOTAL DEPTH OF HOLE: 9.5 Ft.	19. SIGNATURE OF ENGINEER: Jorge R. Parra, P.E.

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel
105.3	0.0					105.3
101.2	4.2		Limestone Formation (wackestone), sampled as Gravel, little sand and silt, highly to moderately to low hardness, weak, intensely to closely fractured, pale brown to pink; large amounts of cavities. (GM)		1	BACKHOE
95.8	9.5		Limestone (packestone) sampled as Gravel, with some clay, highly to moderately weathered, moderately hard, weak to friable, intensely to closely fractured, pale brown; large amounts of cavities filled with clay. (GC)		2	BACKHOE
			END OF TEST PIT TP-CUL-02 AT 9.5 FEET DEPTH.			

NOTES:

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

X and Y Coordinates are given in feet.

Sample No.	Moisture Content%	Spec. Gravity	Att. Limits L.L.	Att. Limits P.I.
1	4.0	2.75	--	--
2	20.7	2.79	34.0	19.9

Sample No.	Max. Dry Density (pcf)	Opt. Moisture Content
1	116.3	11.3%
2	111.7	12.3 %

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-02

LABORATORY TEST DATA

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

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

GEO CIM, INC.

GEOTECHNICAL TESTING SERVICES

LABORATORY TEST DATA SUMMARY TABLE

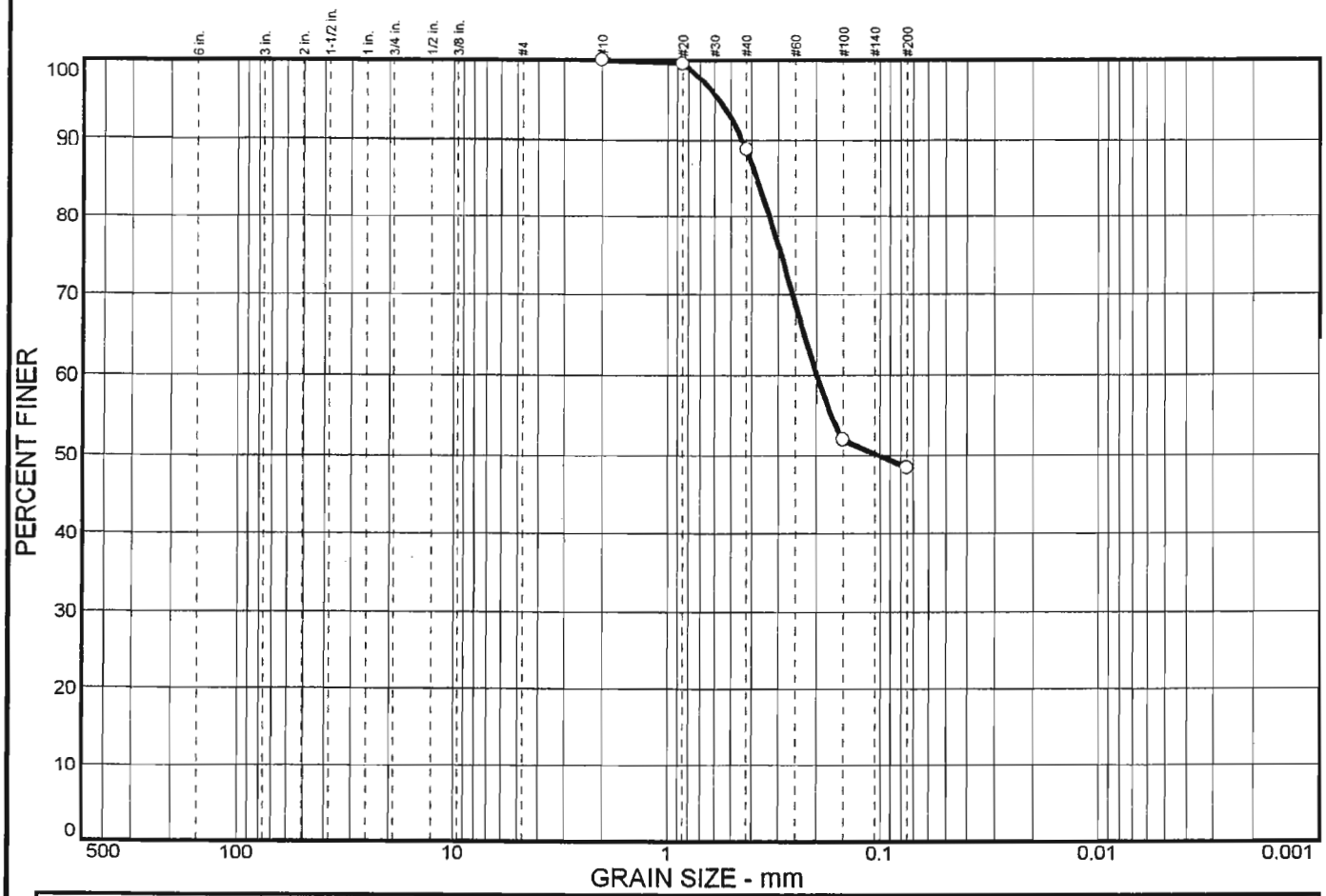
PROJECT: Rio Culebrinas Project **LOCATION:** San Juan, P.R. **JOB NO.:** 2174-98

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-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

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

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=

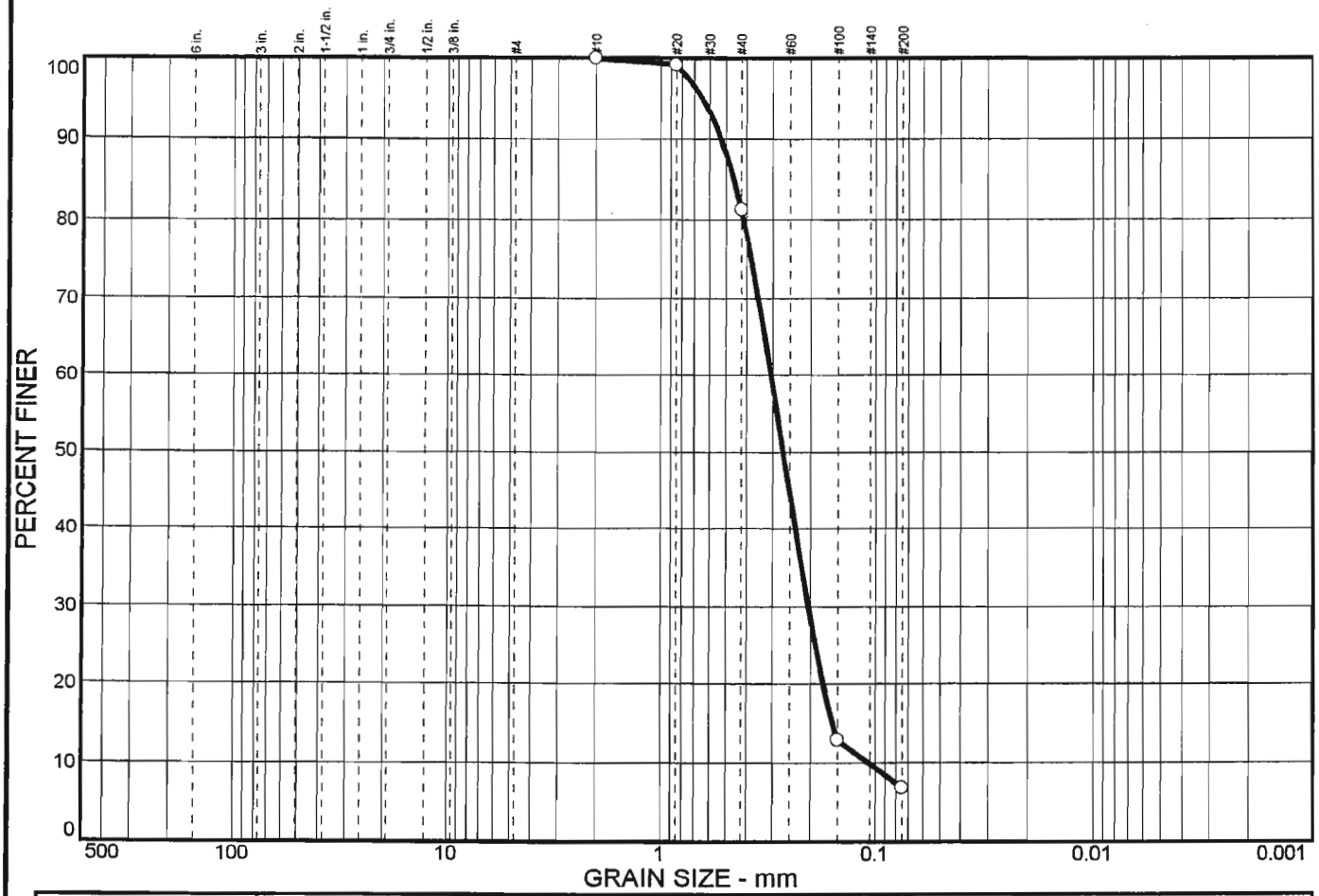
Remarks

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=

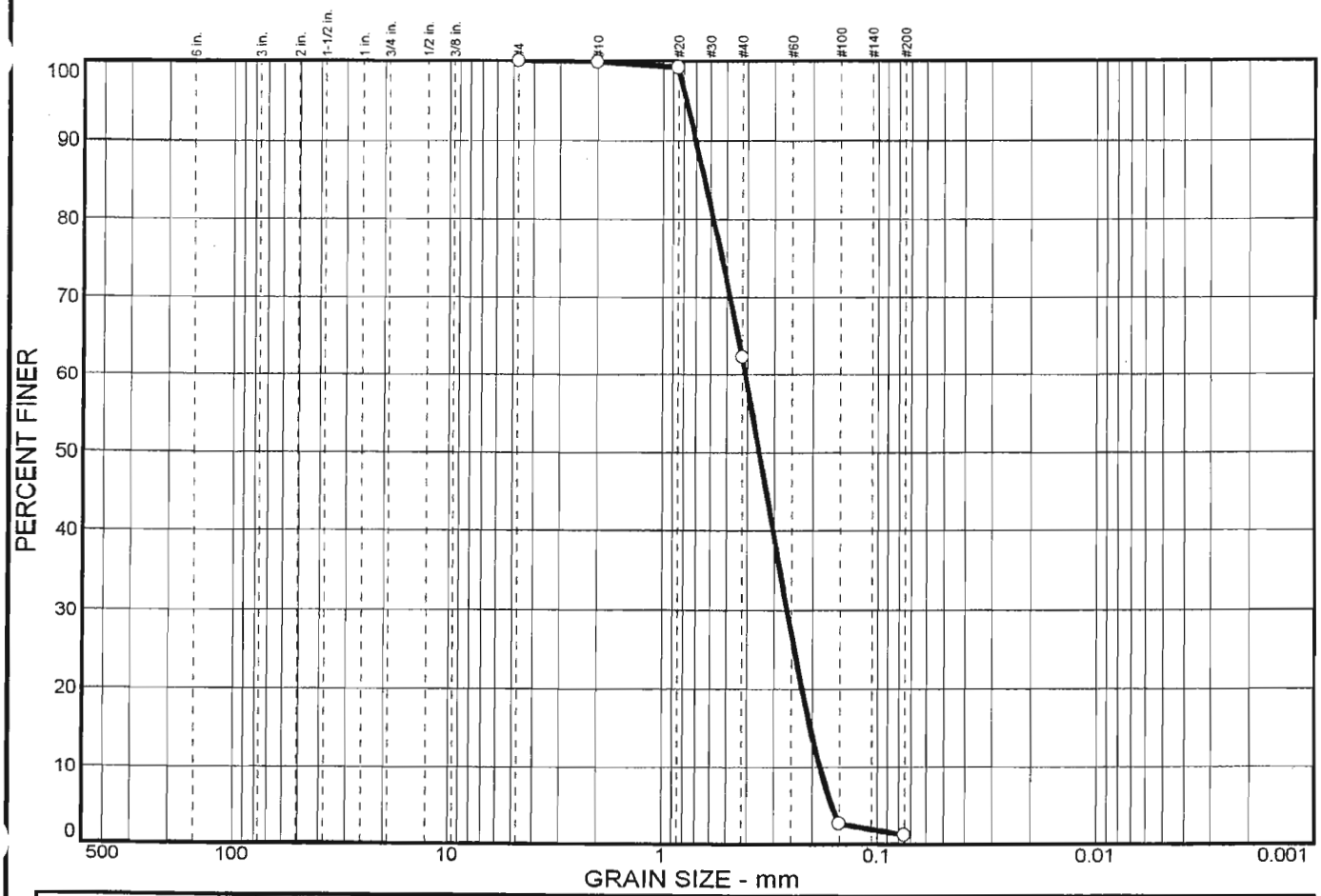
Remarks

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=

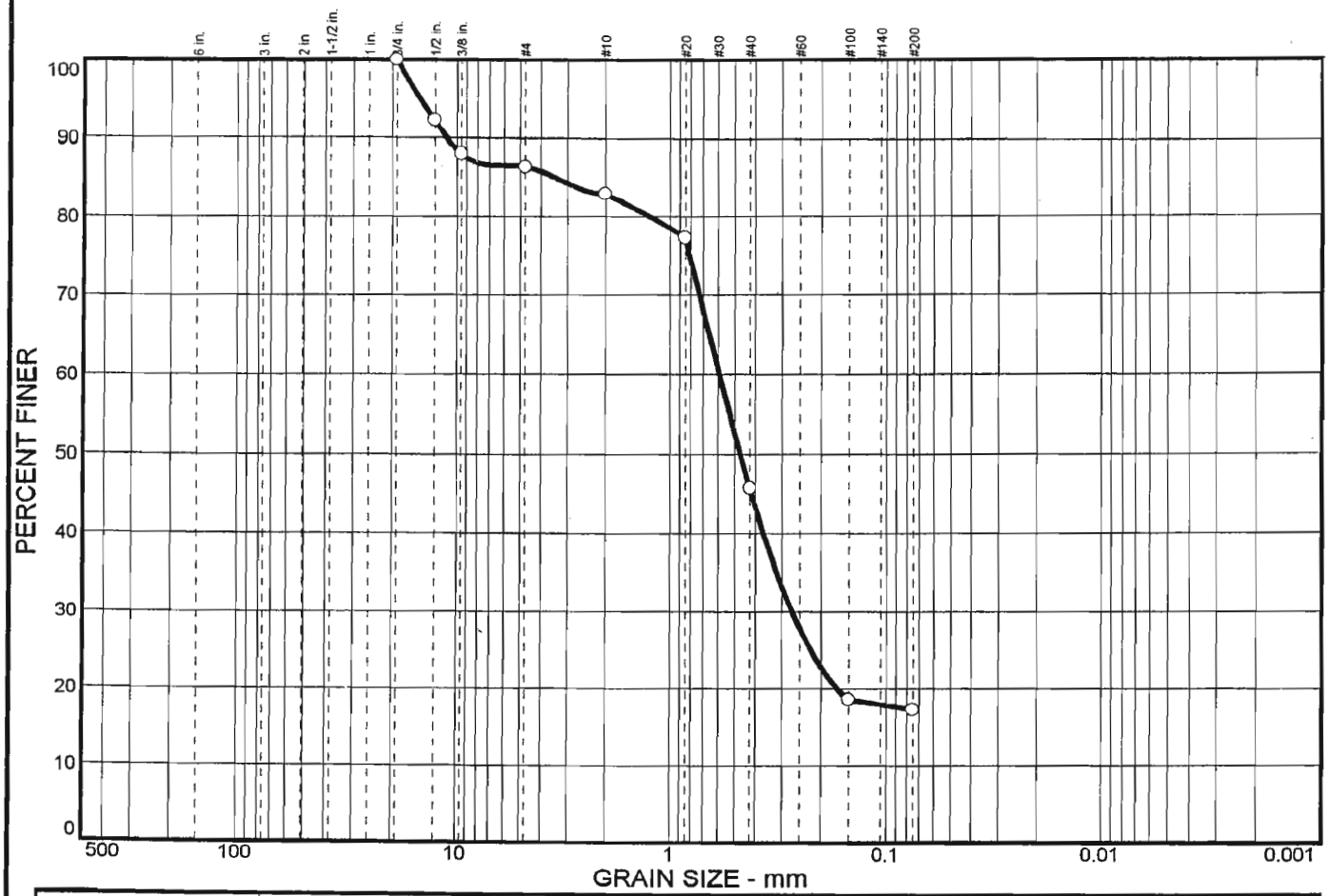
Remarks

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=

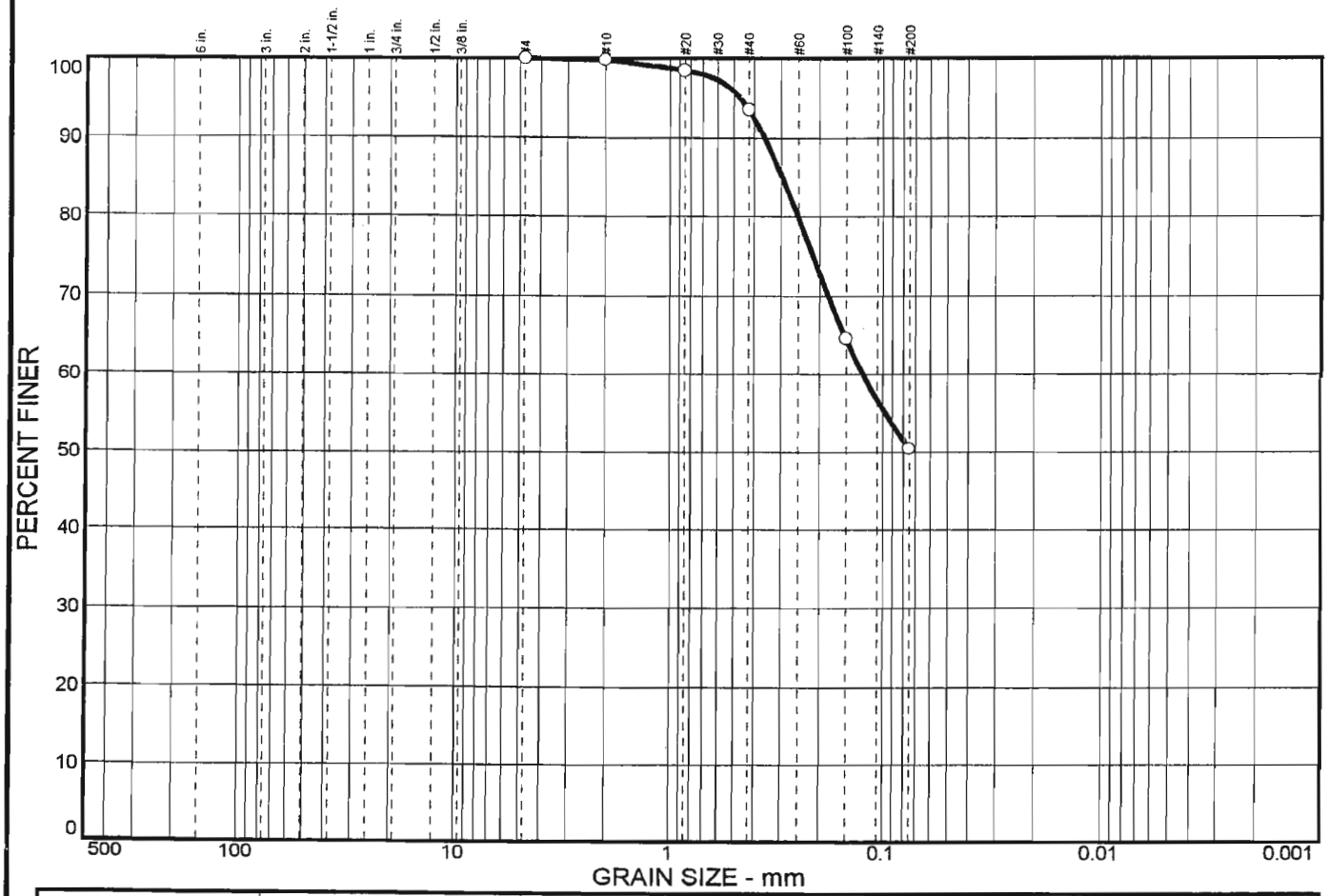
Remarks

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=

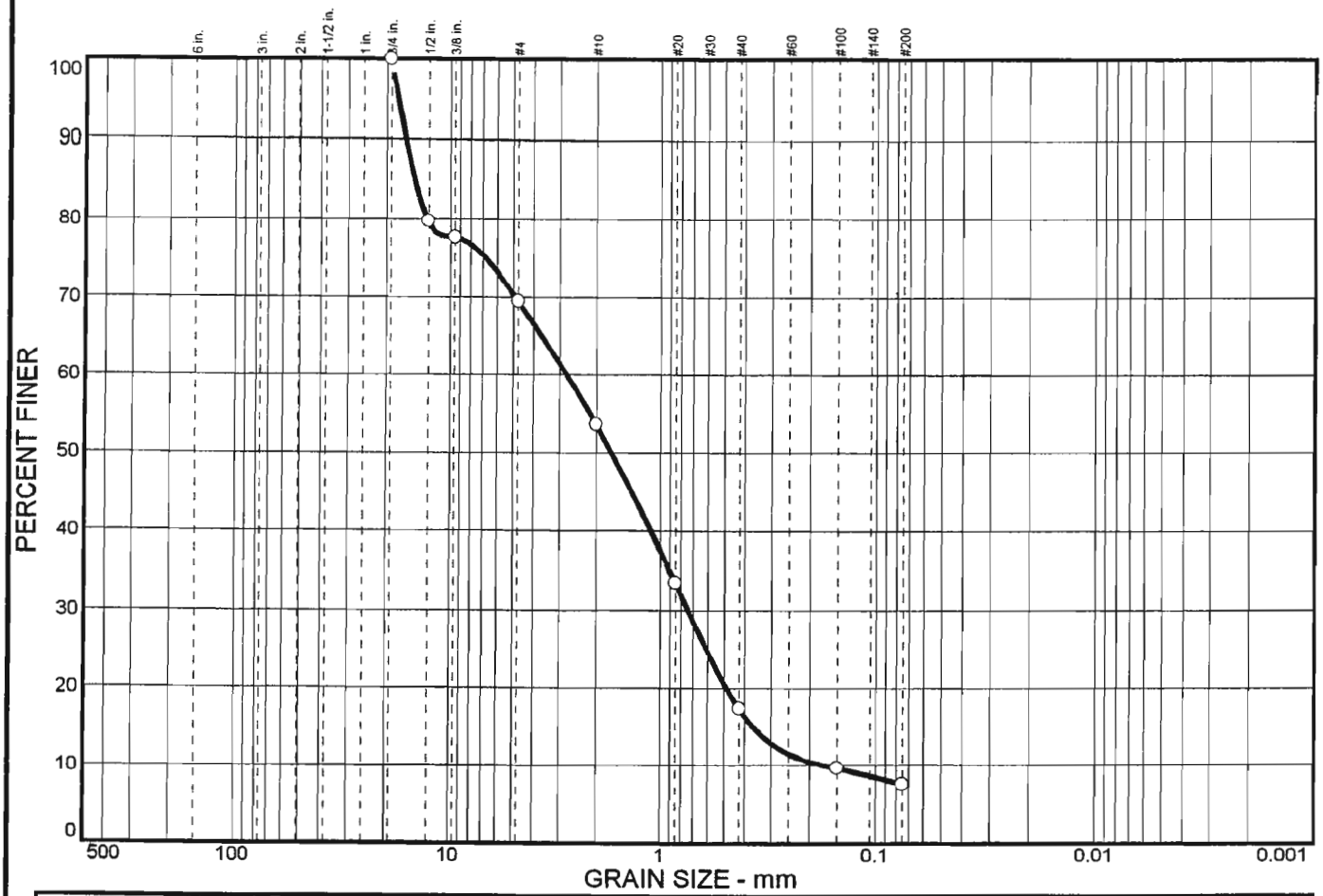
Remarks

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=

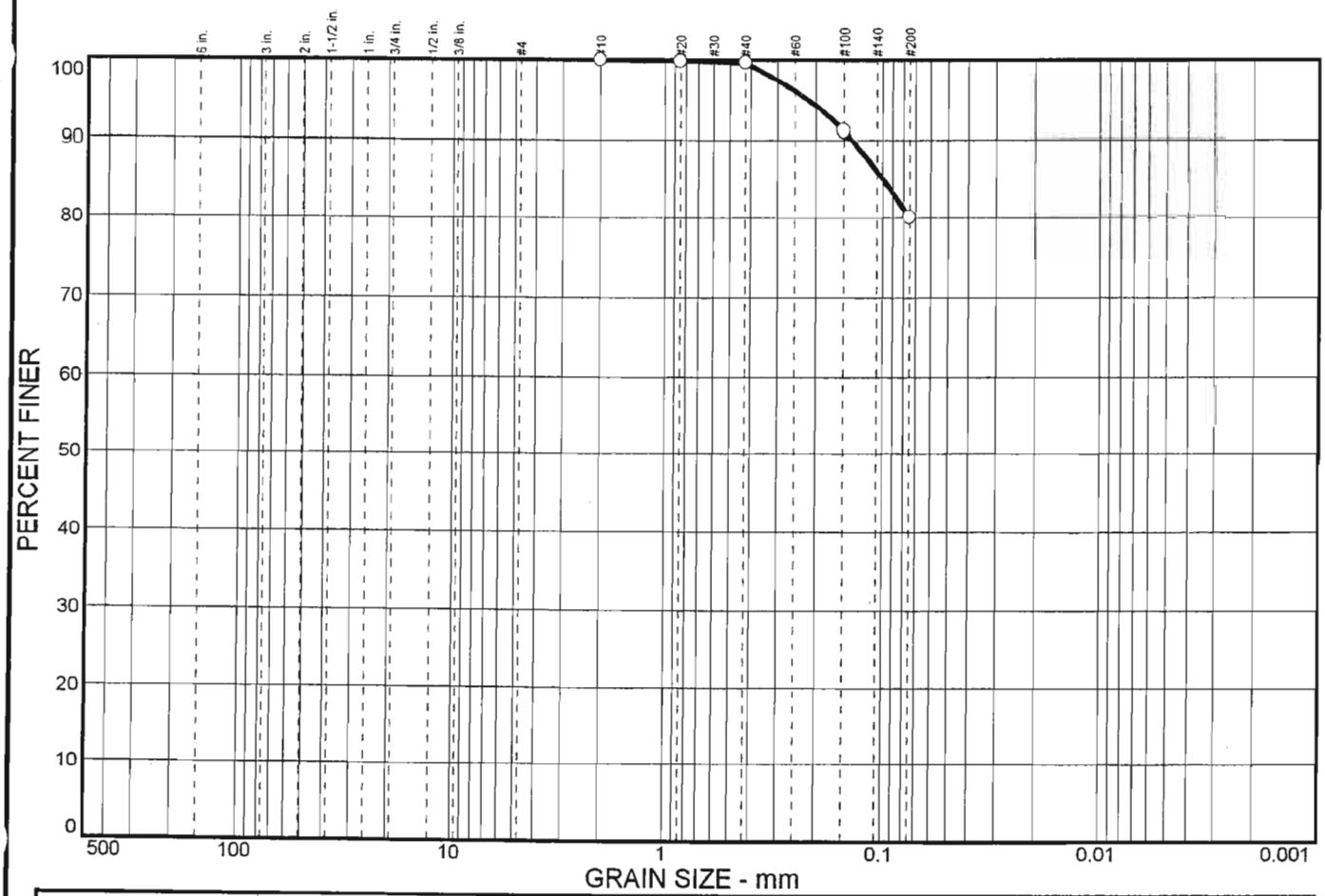
Remarks

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=

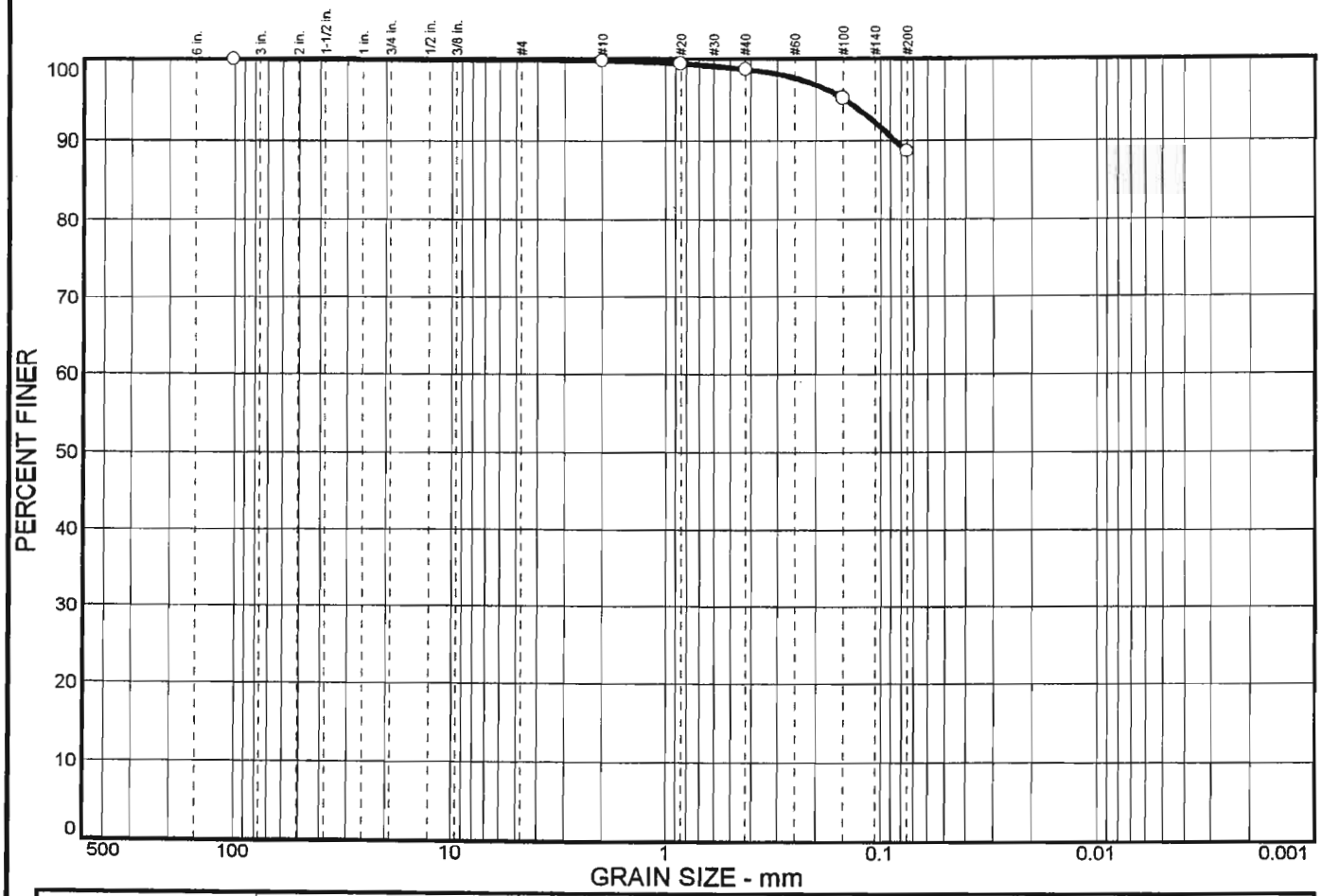
Remarks

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=

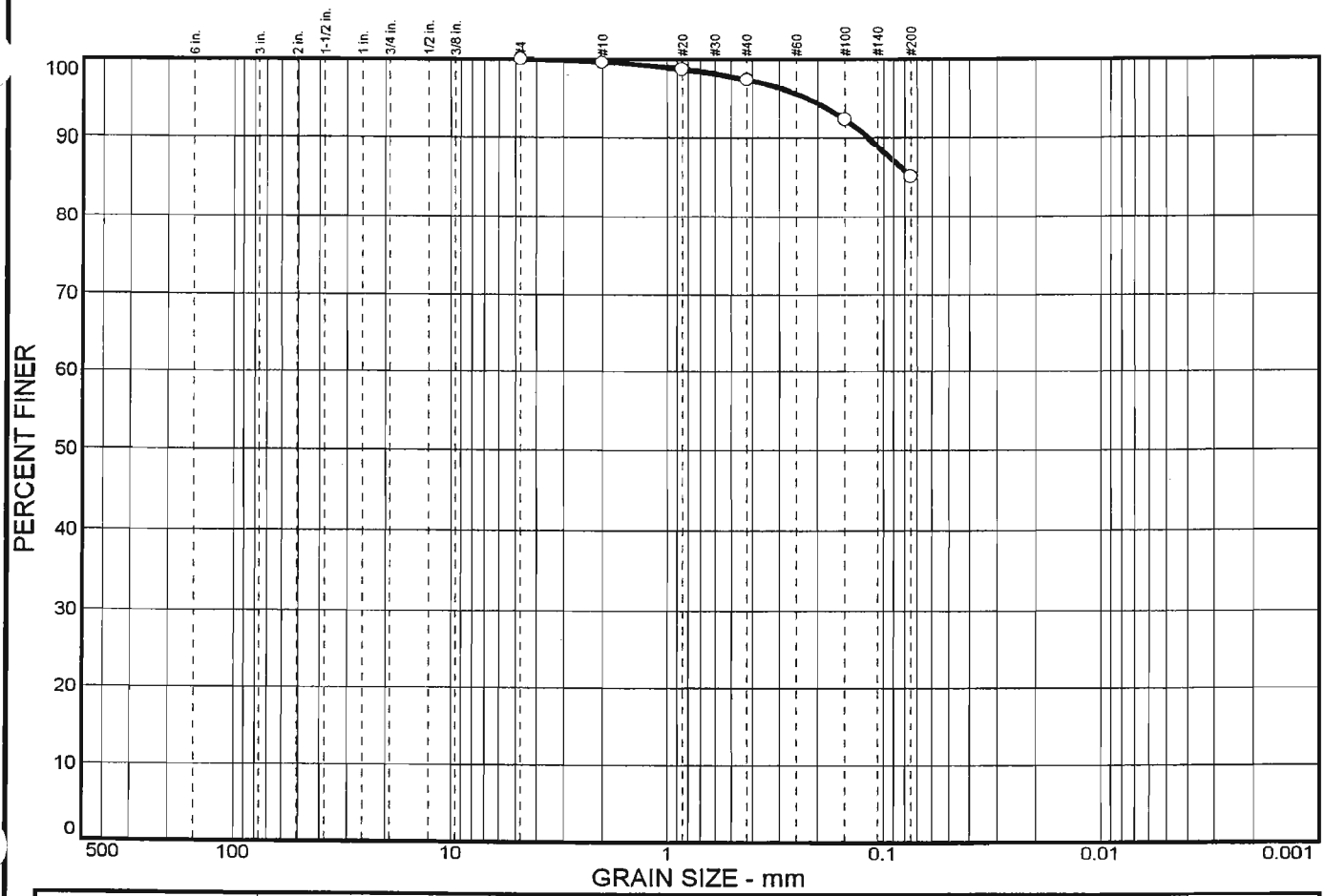
Remarks

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=

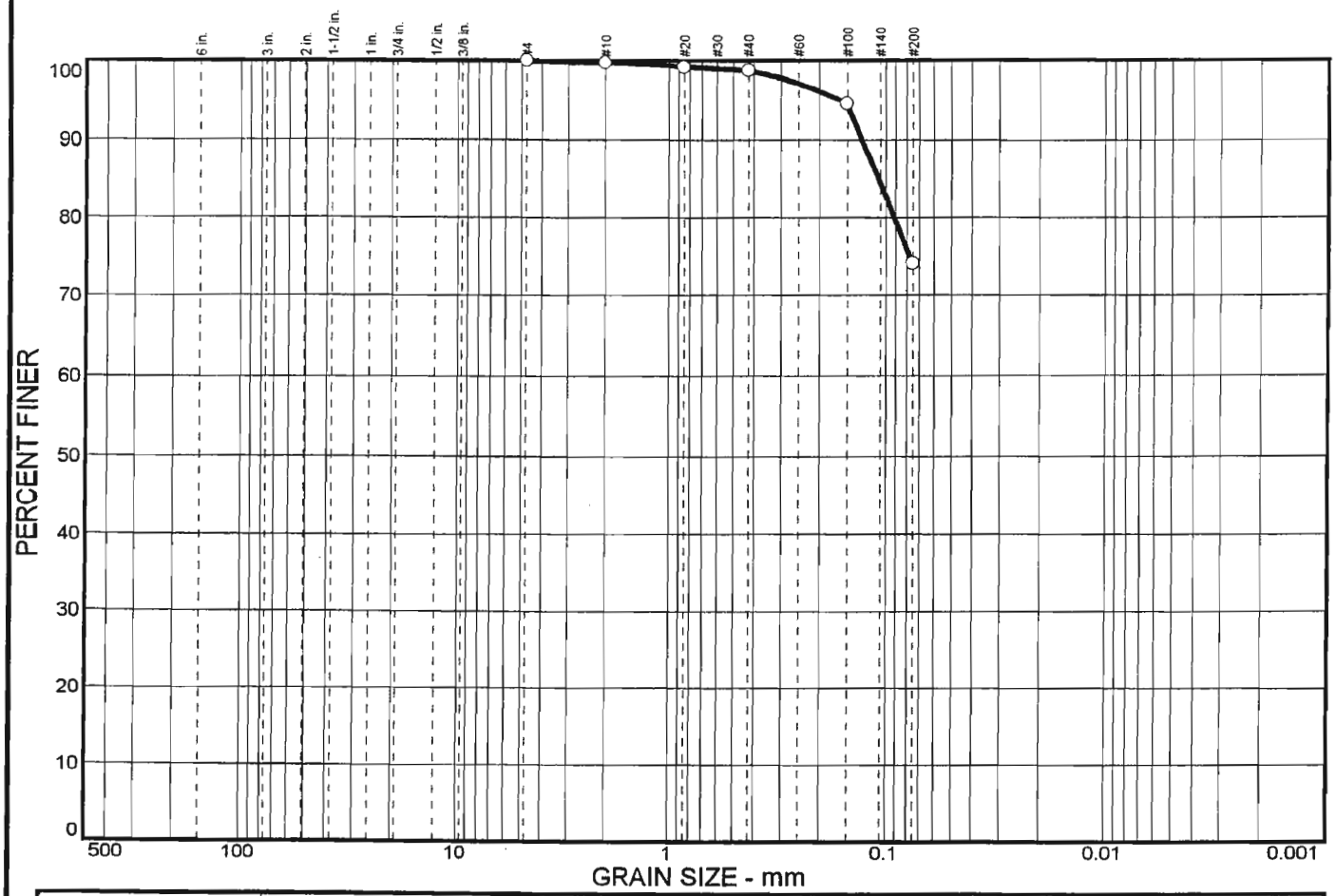
Remarks

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=

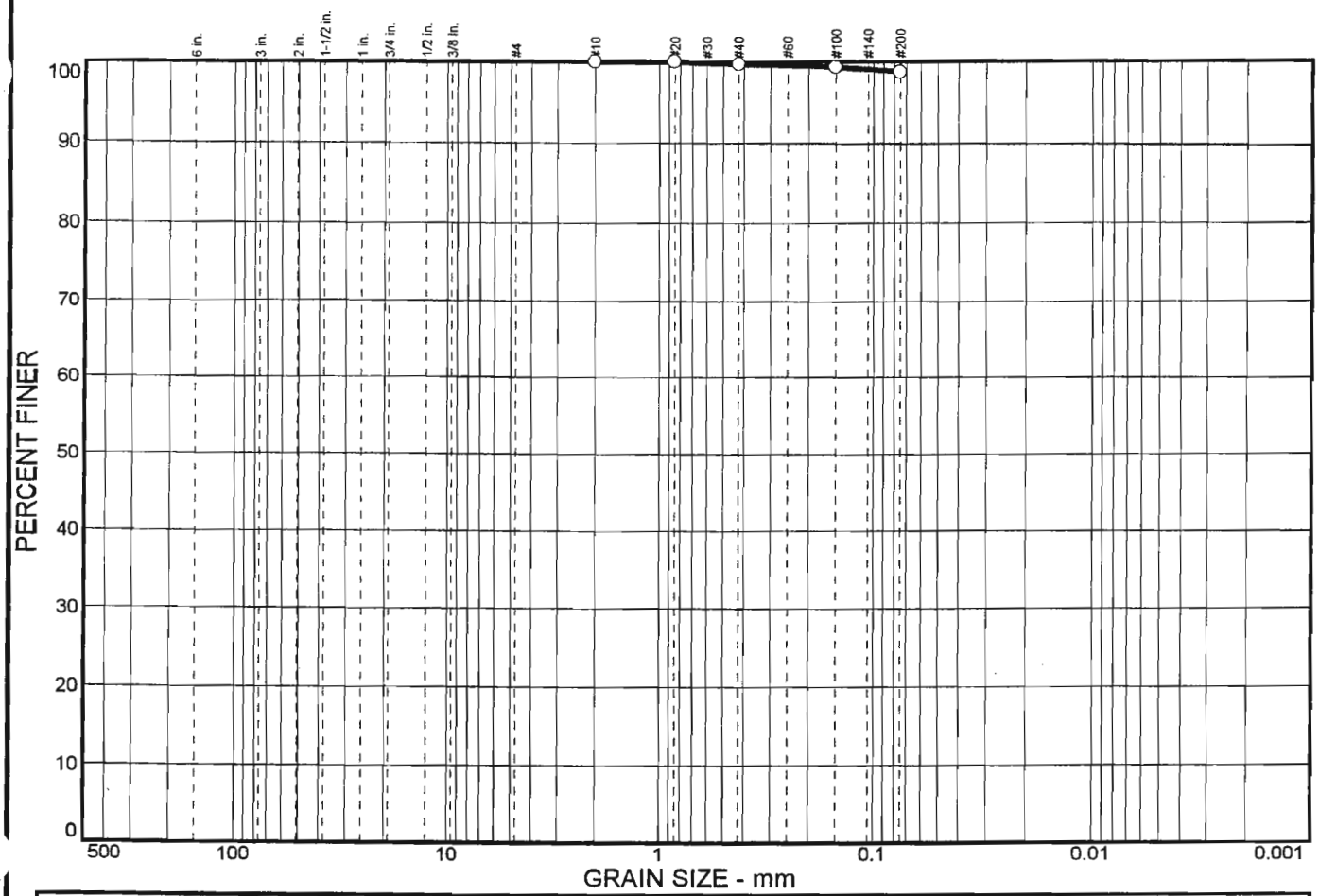
Remarks

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=

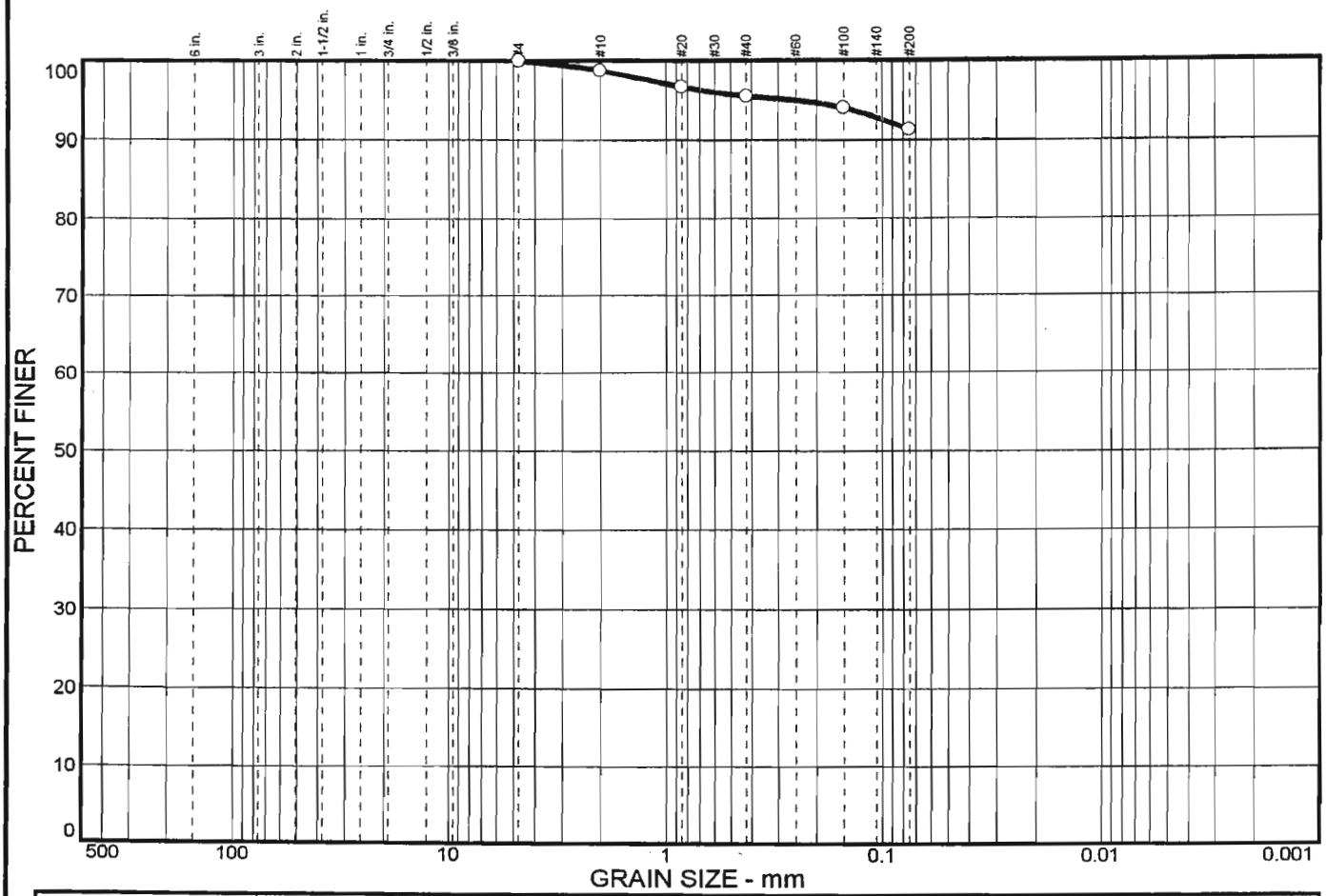
Remarks

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=

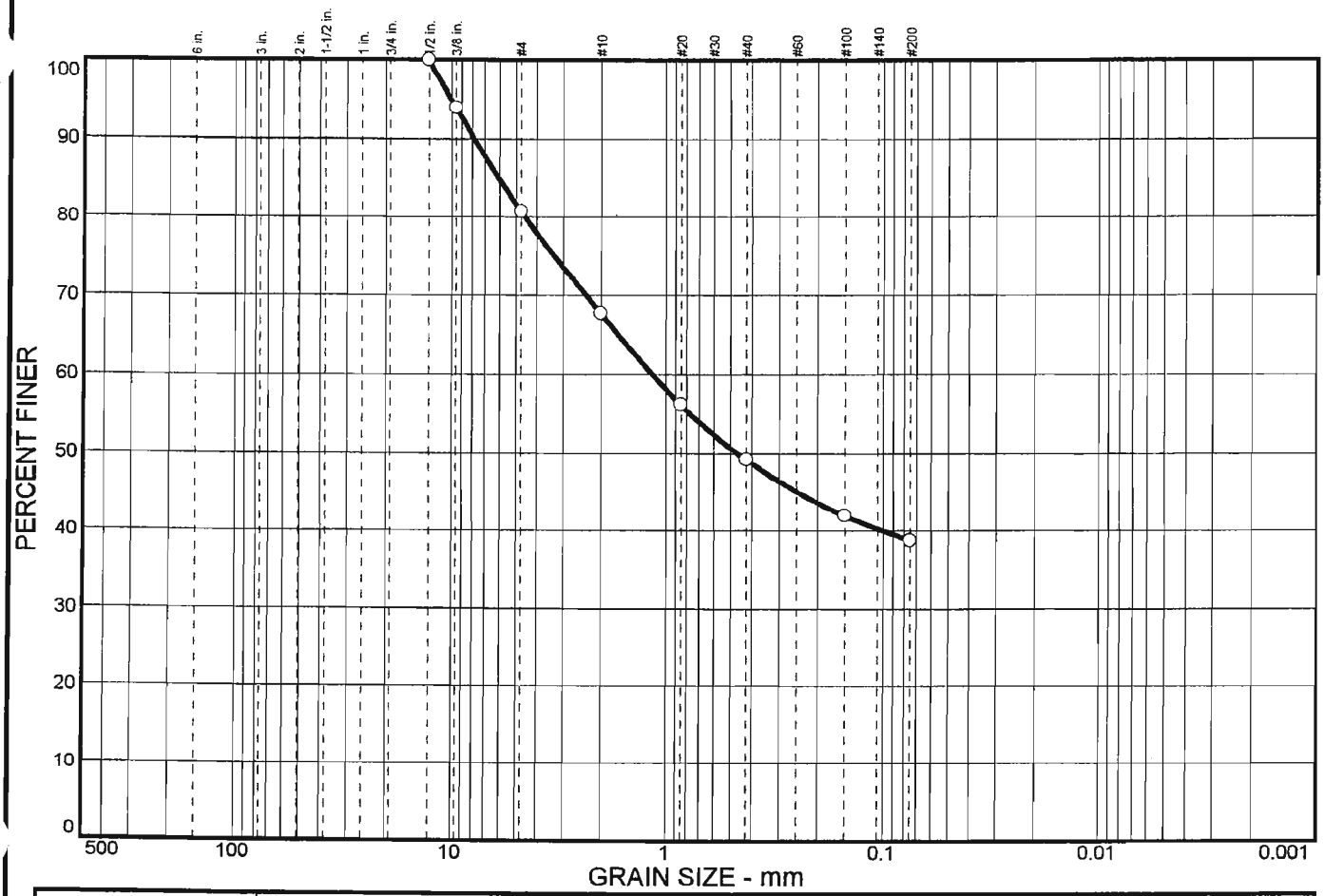
Remarks

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=

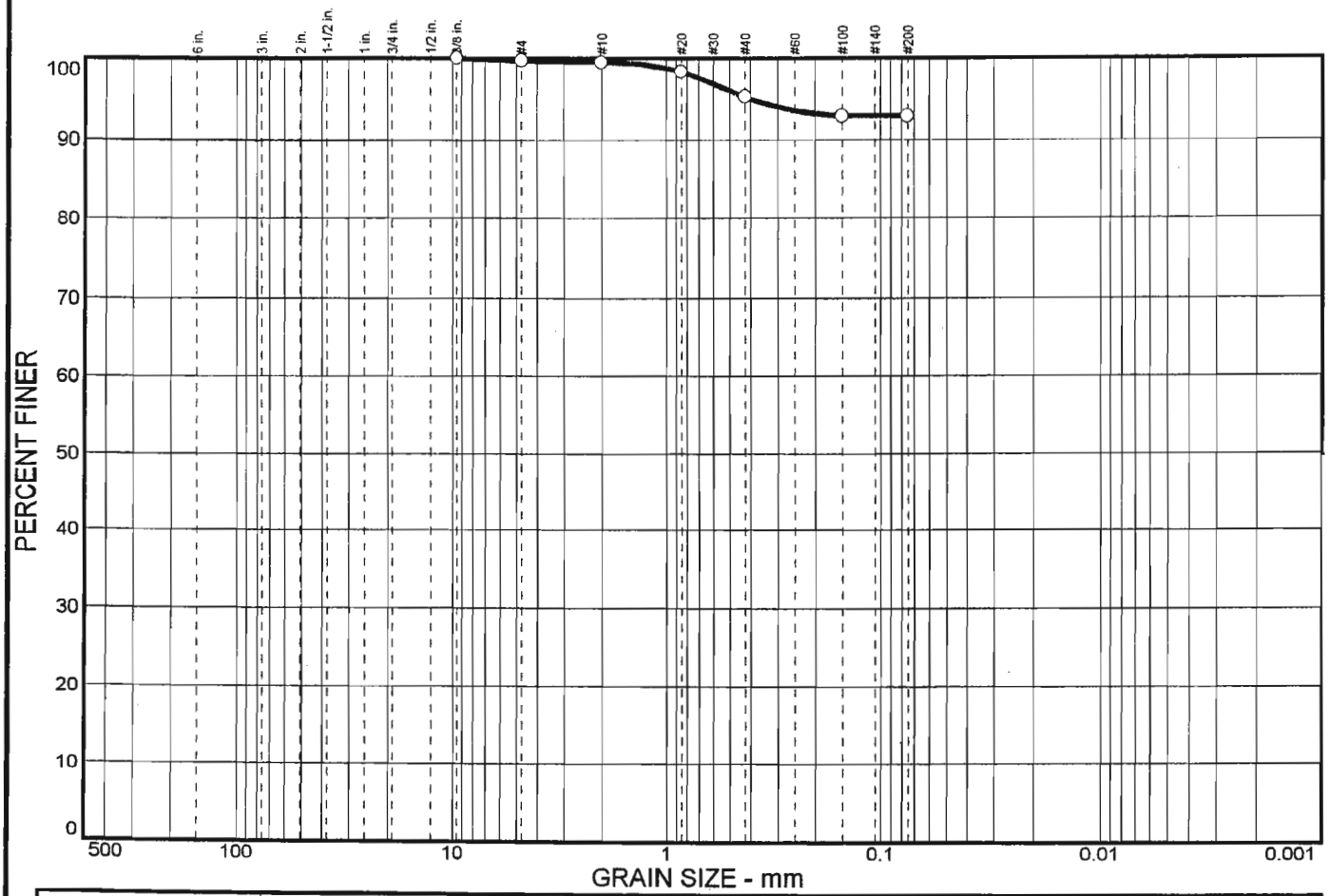
Remarks

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=

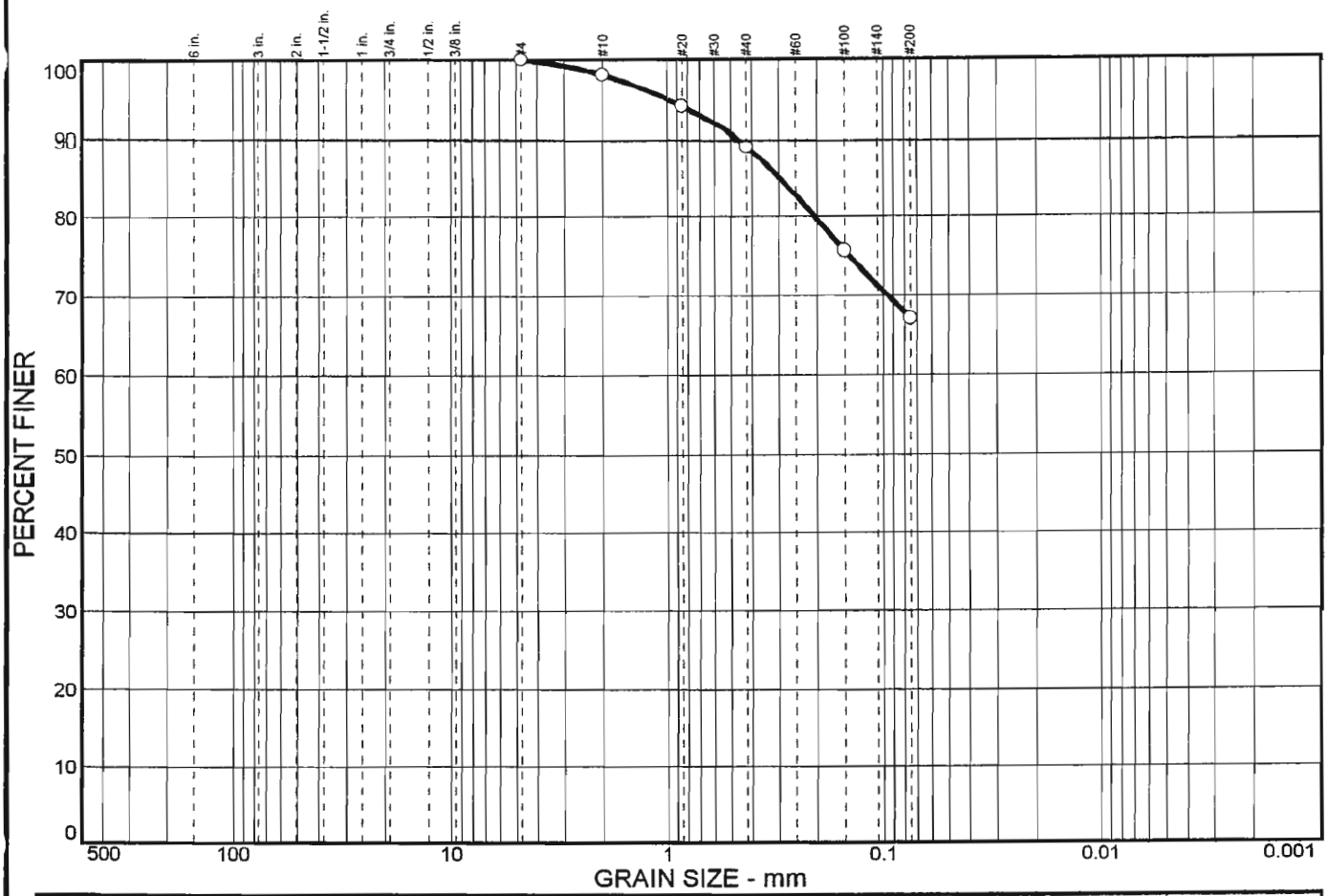
Remarks

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=

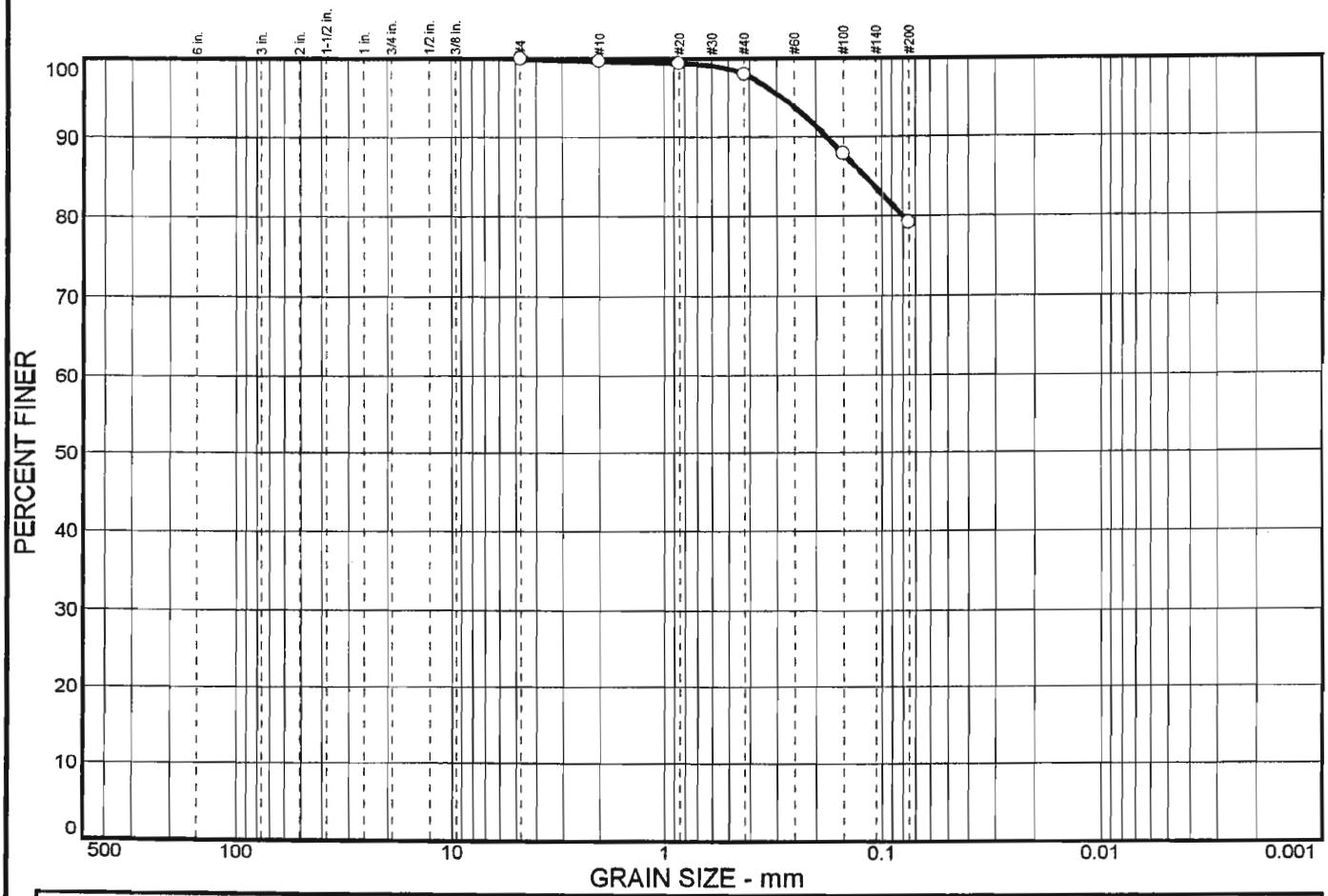
Remarks

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=

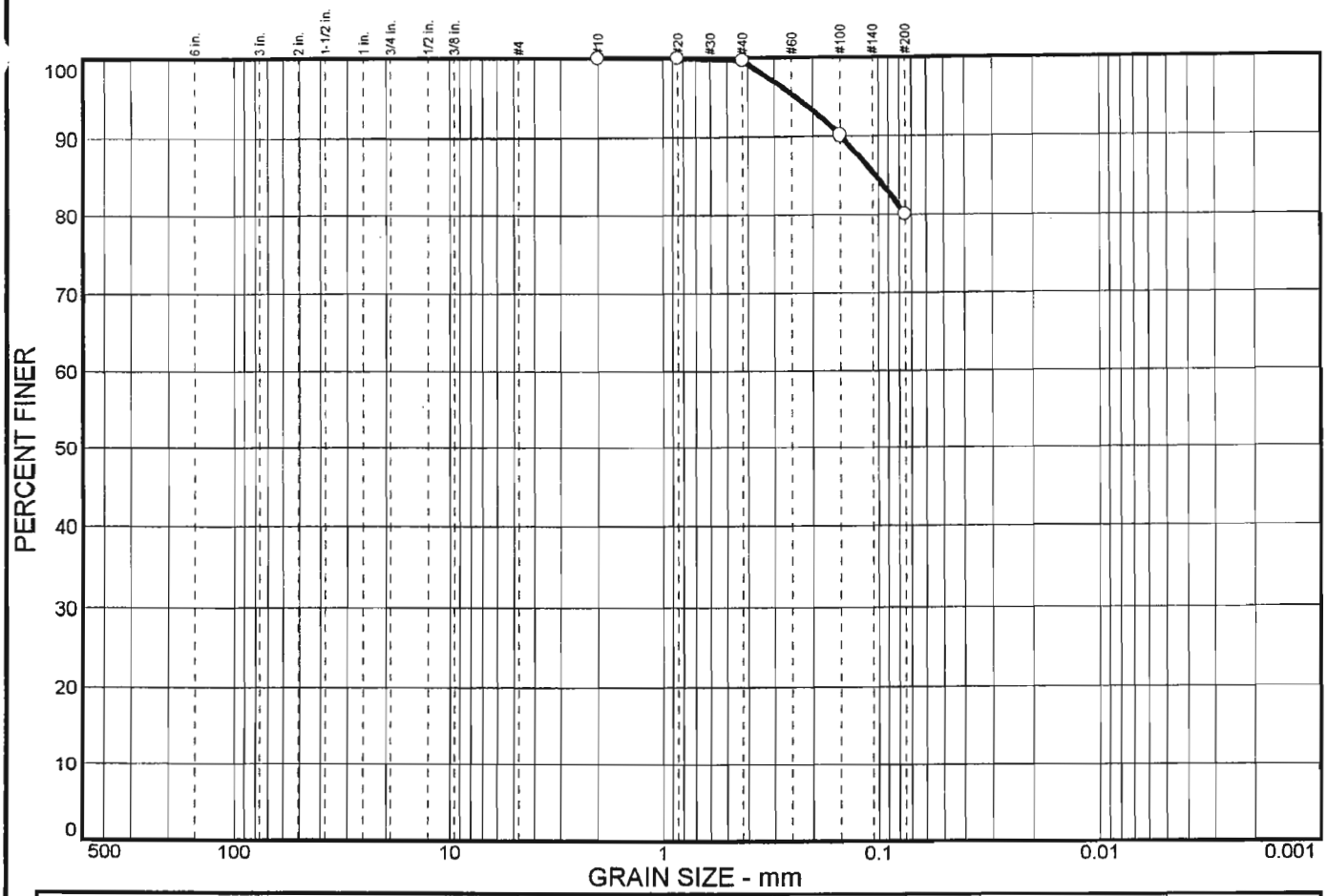
Remarks

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=

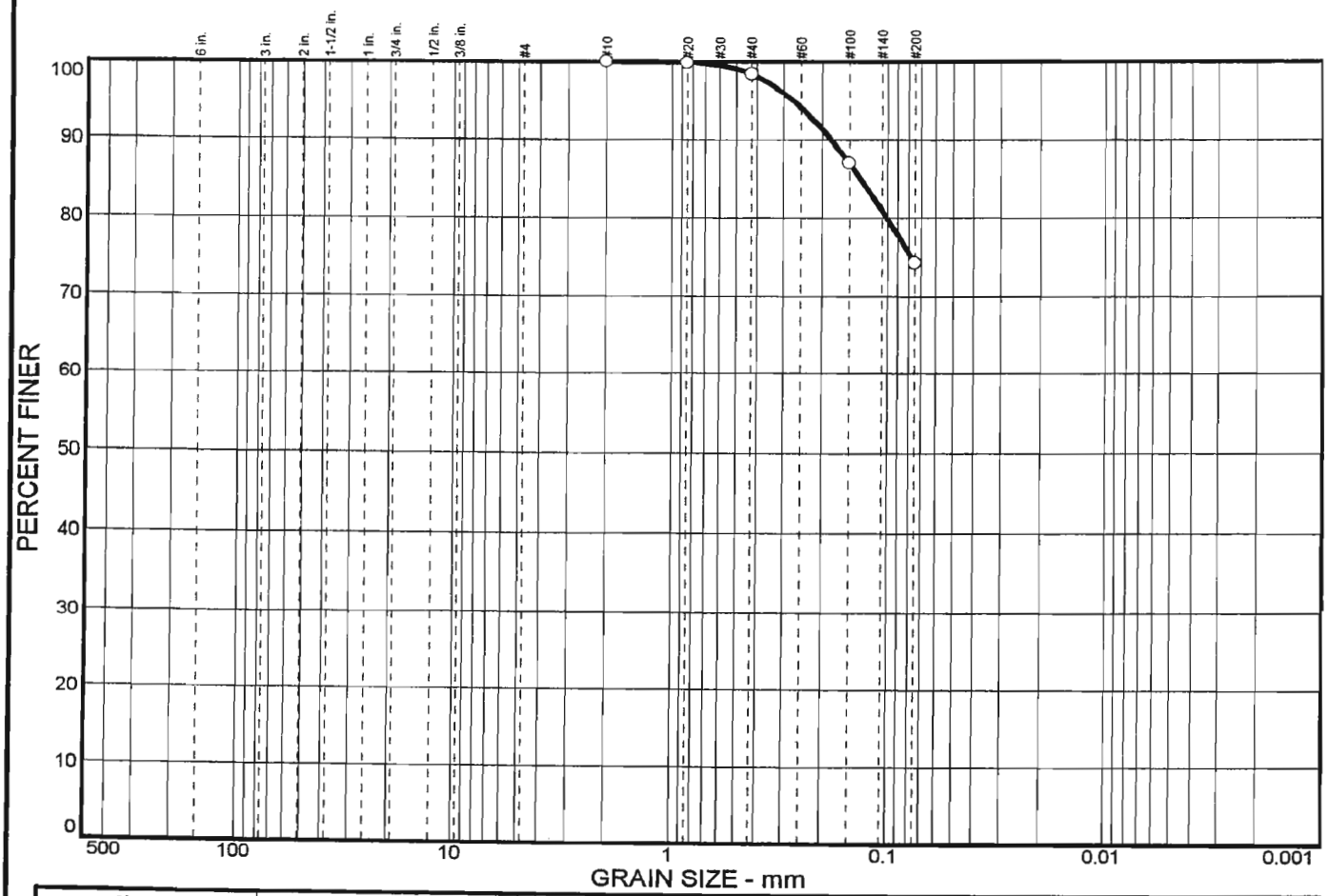
Remarks

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=

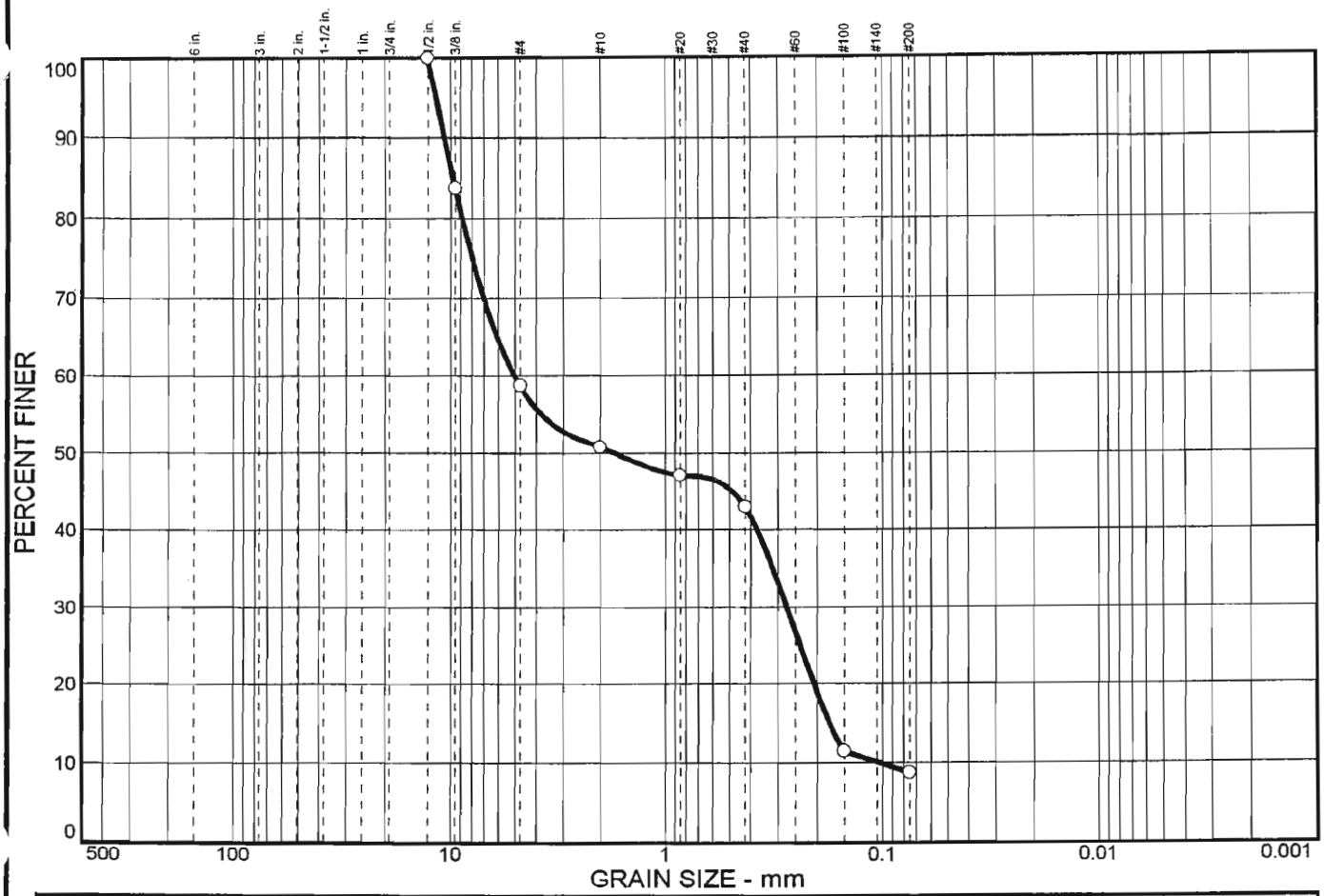
Remarks

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=

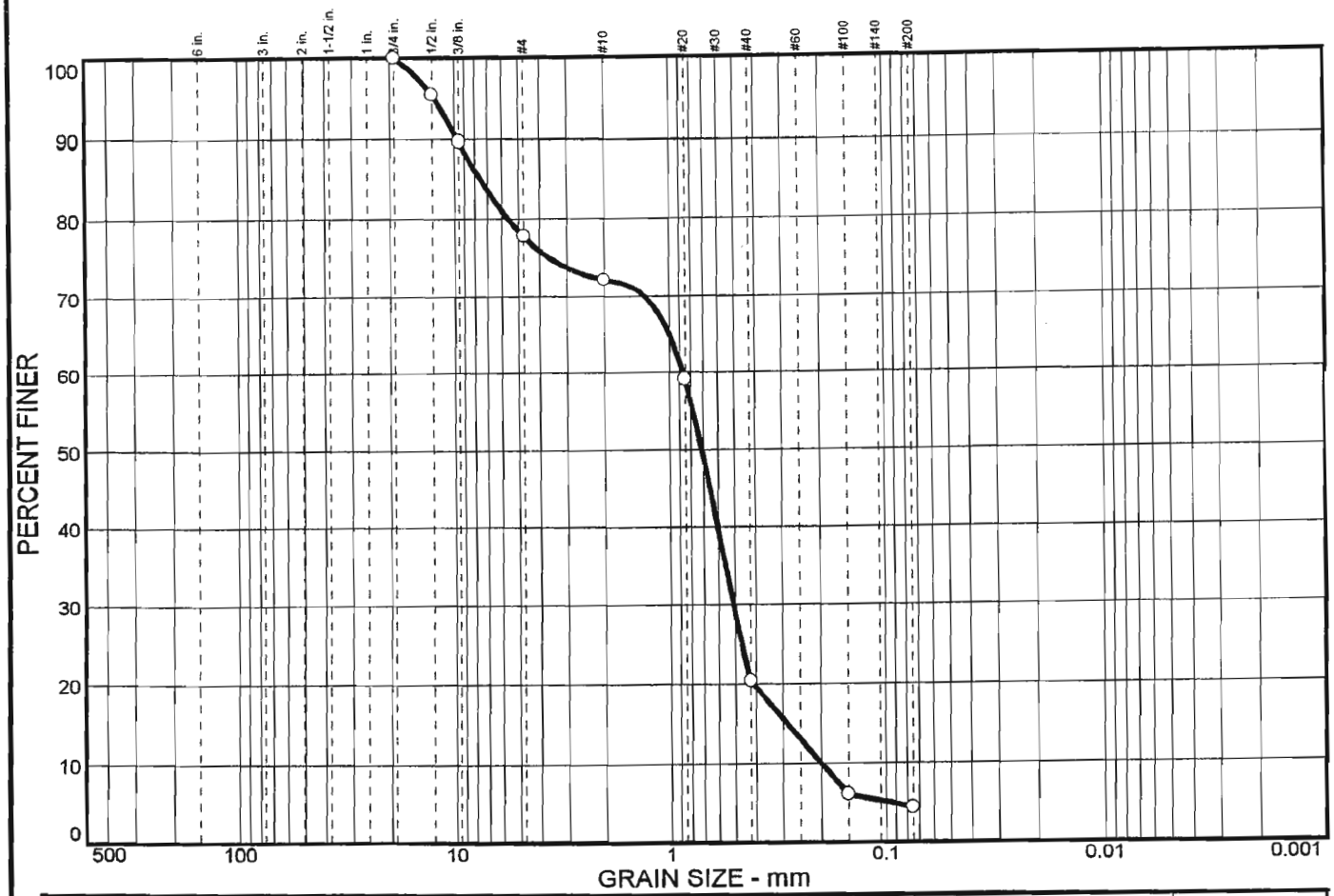
Remarks

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=

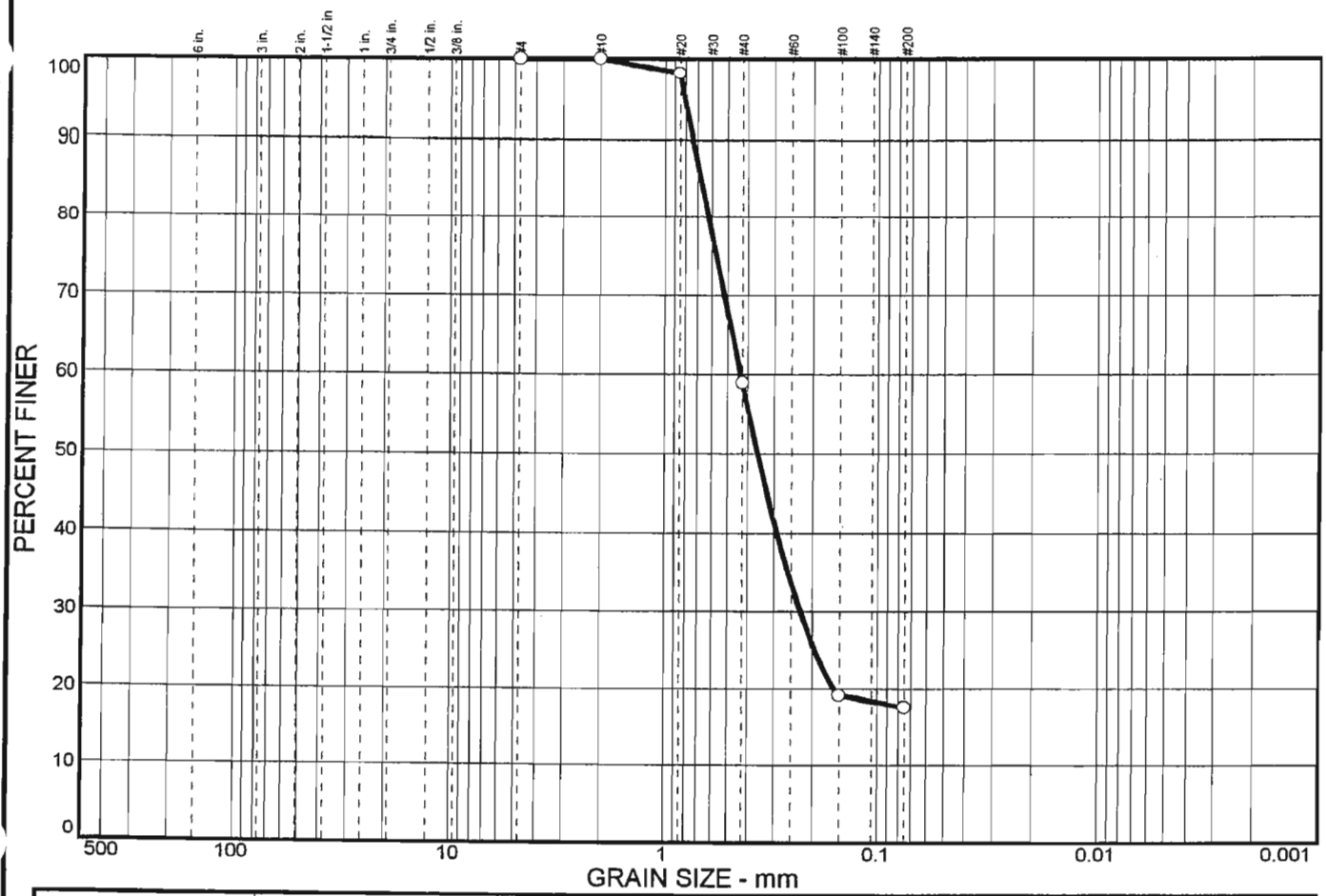
Remarks

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=

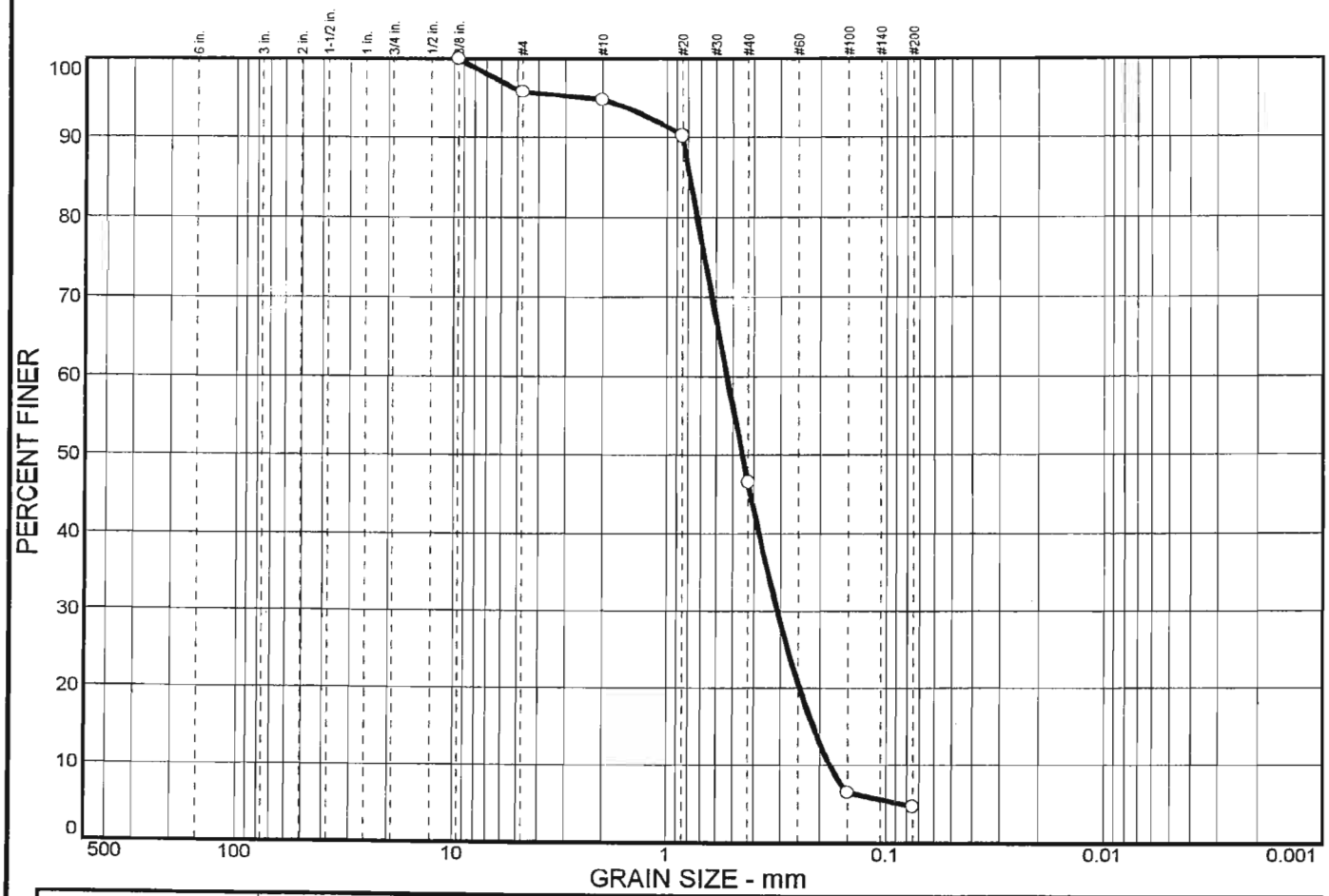
Remarks

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=

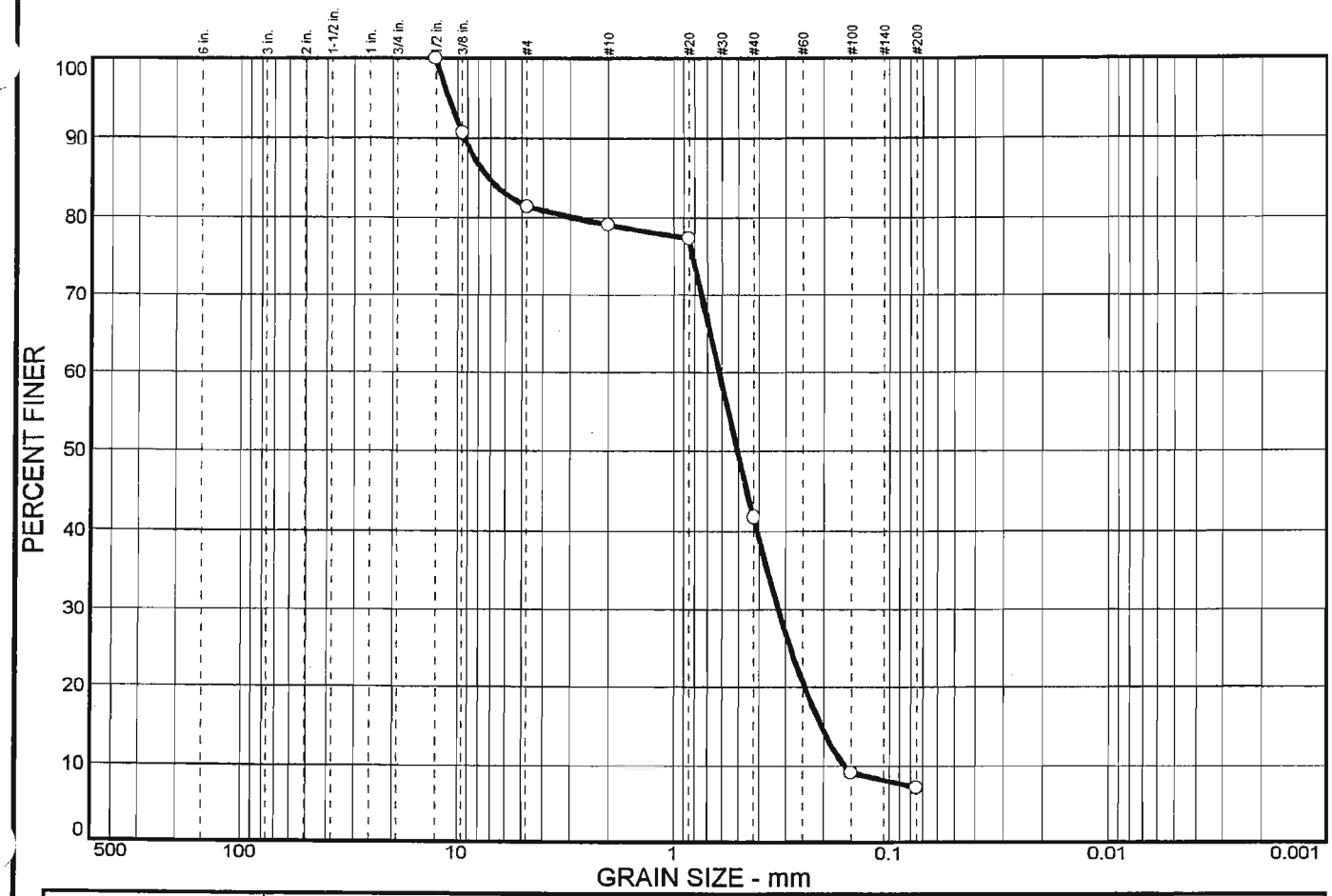
Remarks

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=

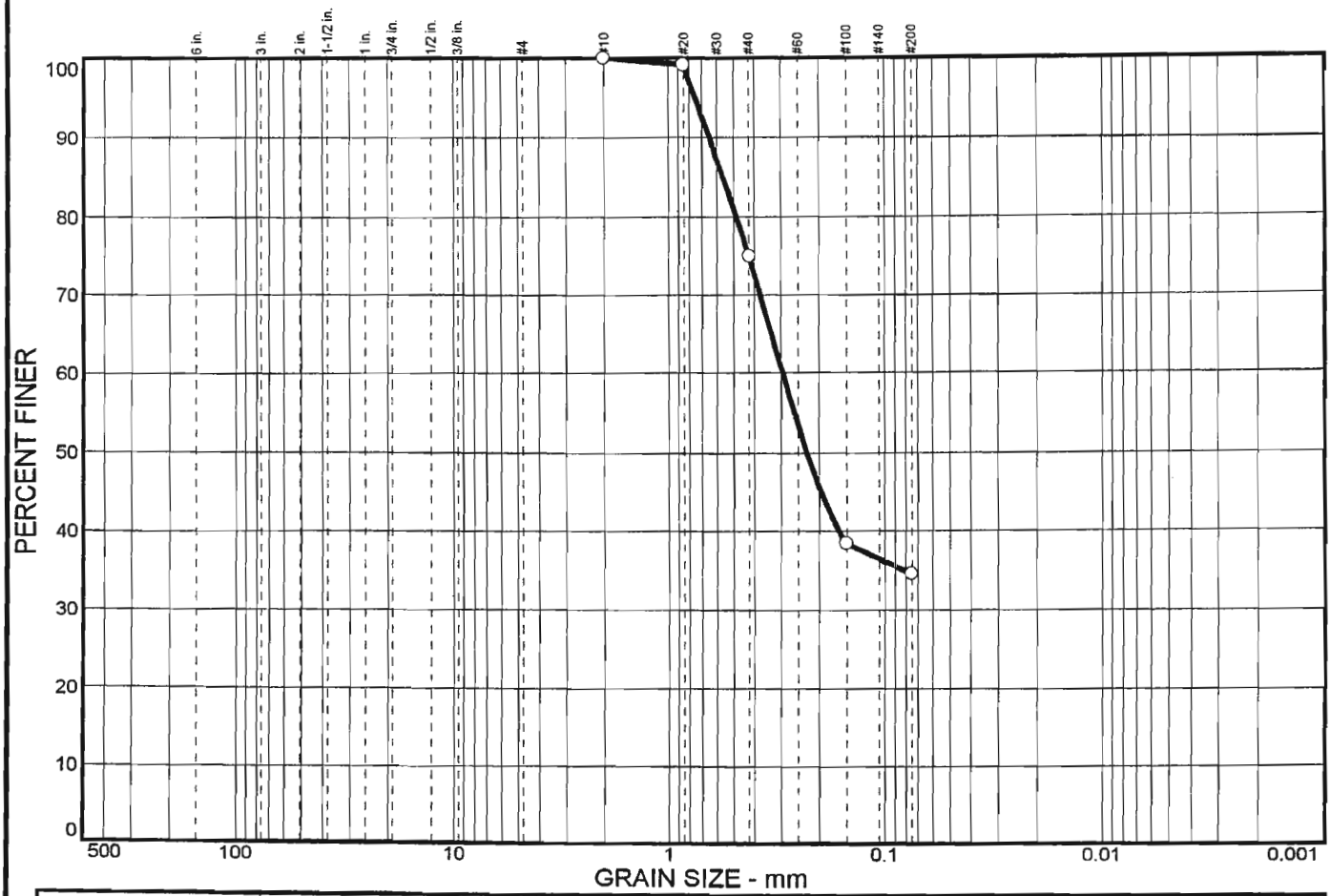
Remarks

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=

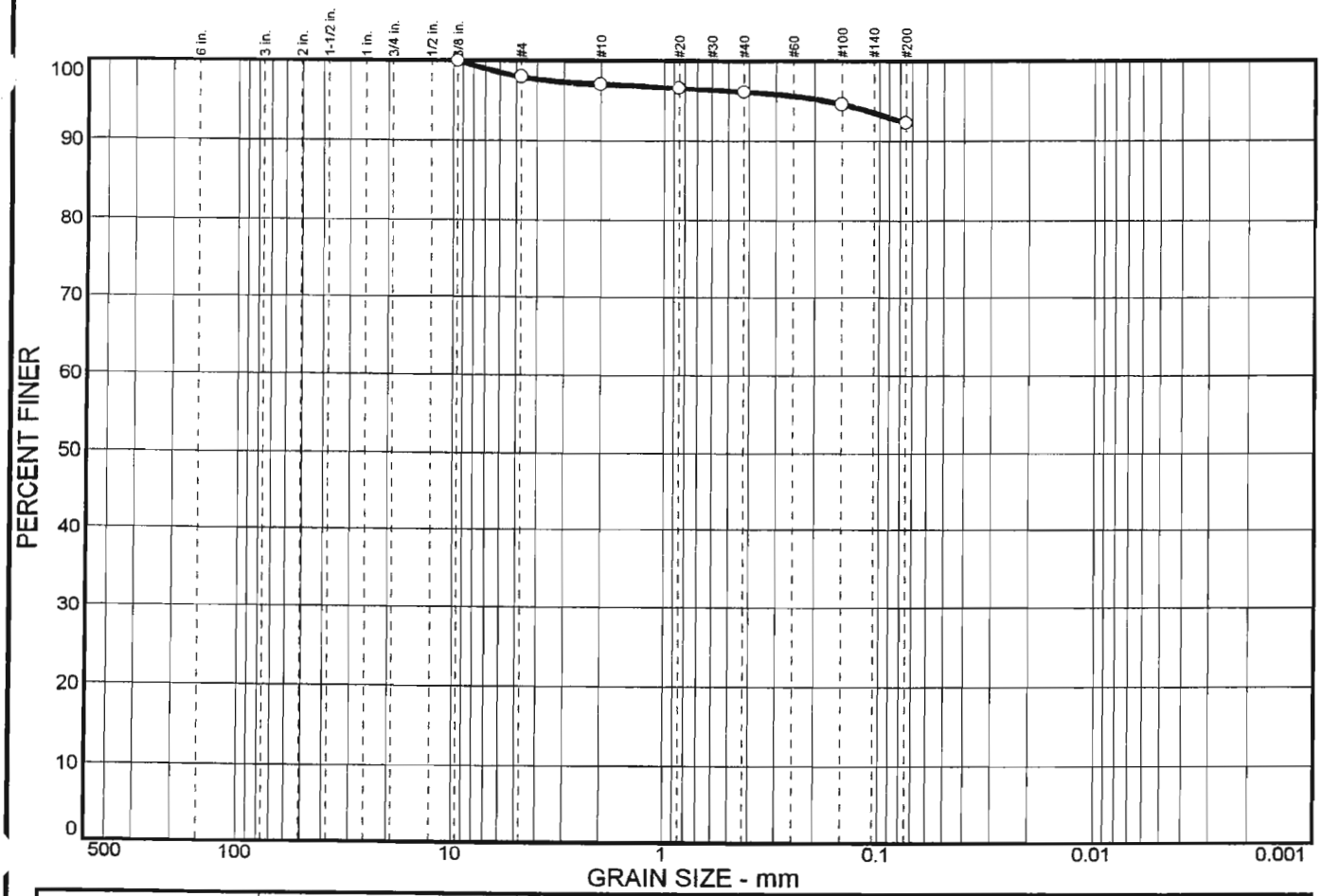
Remarks

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=

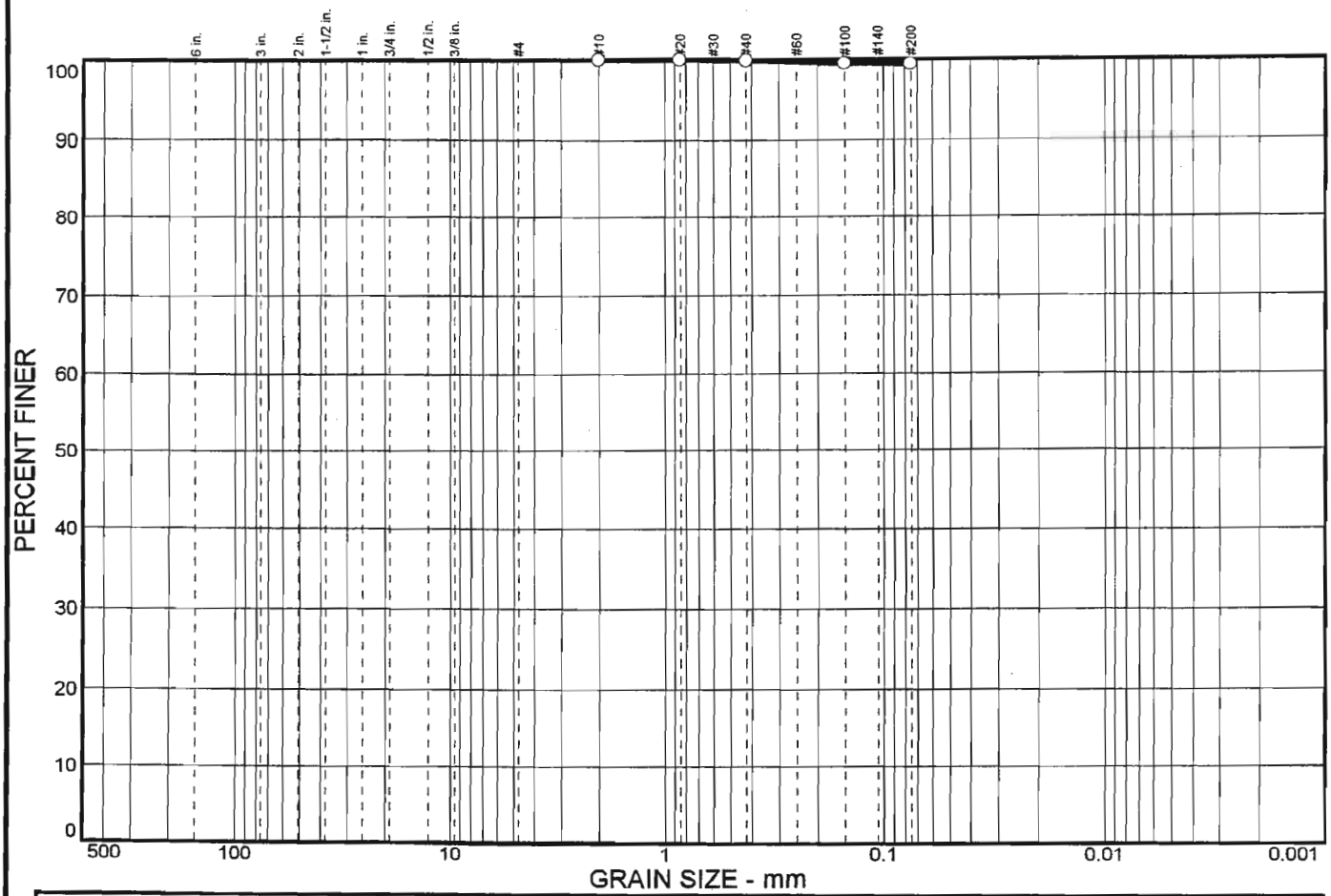
Remarks

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=

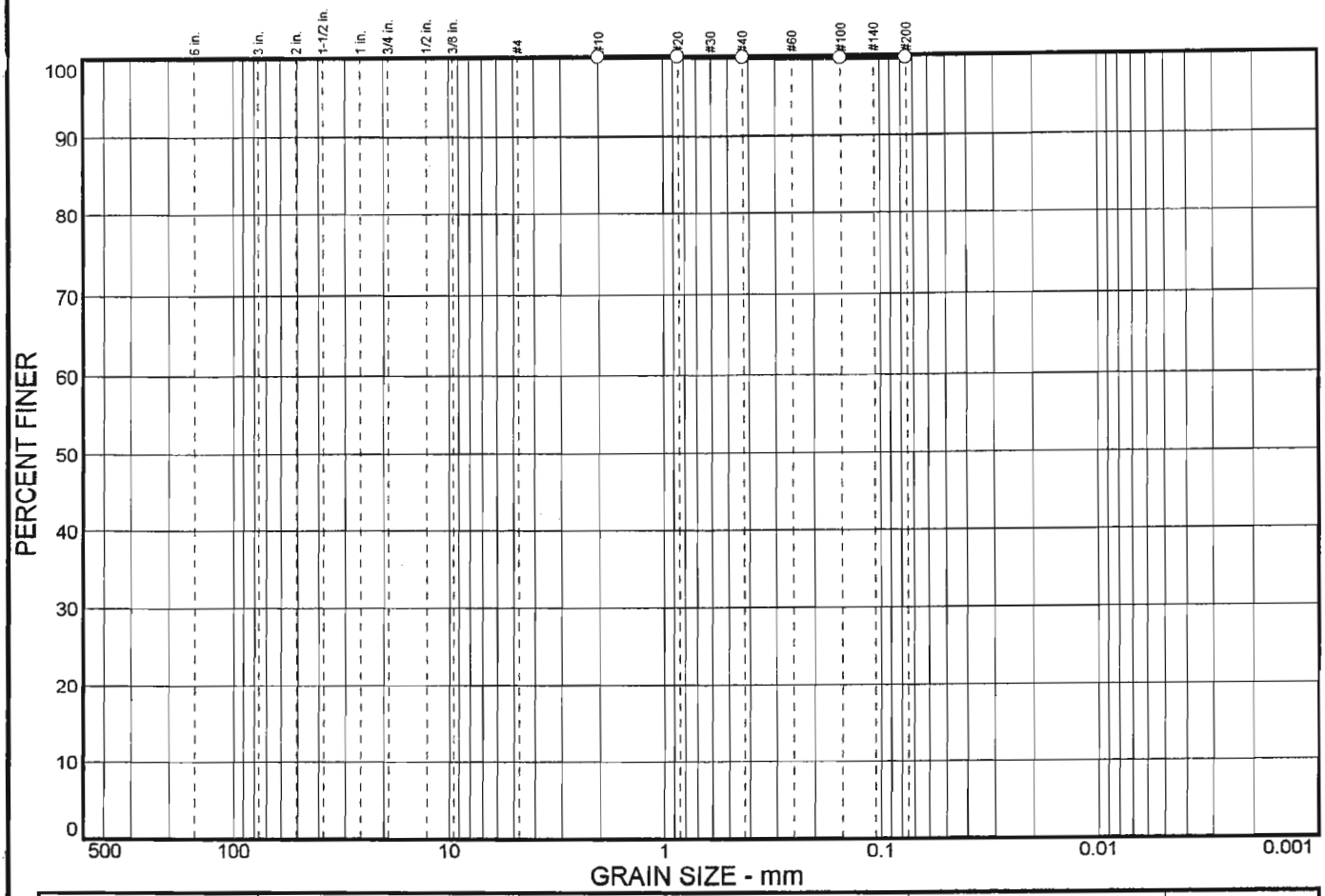
Remarks

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=

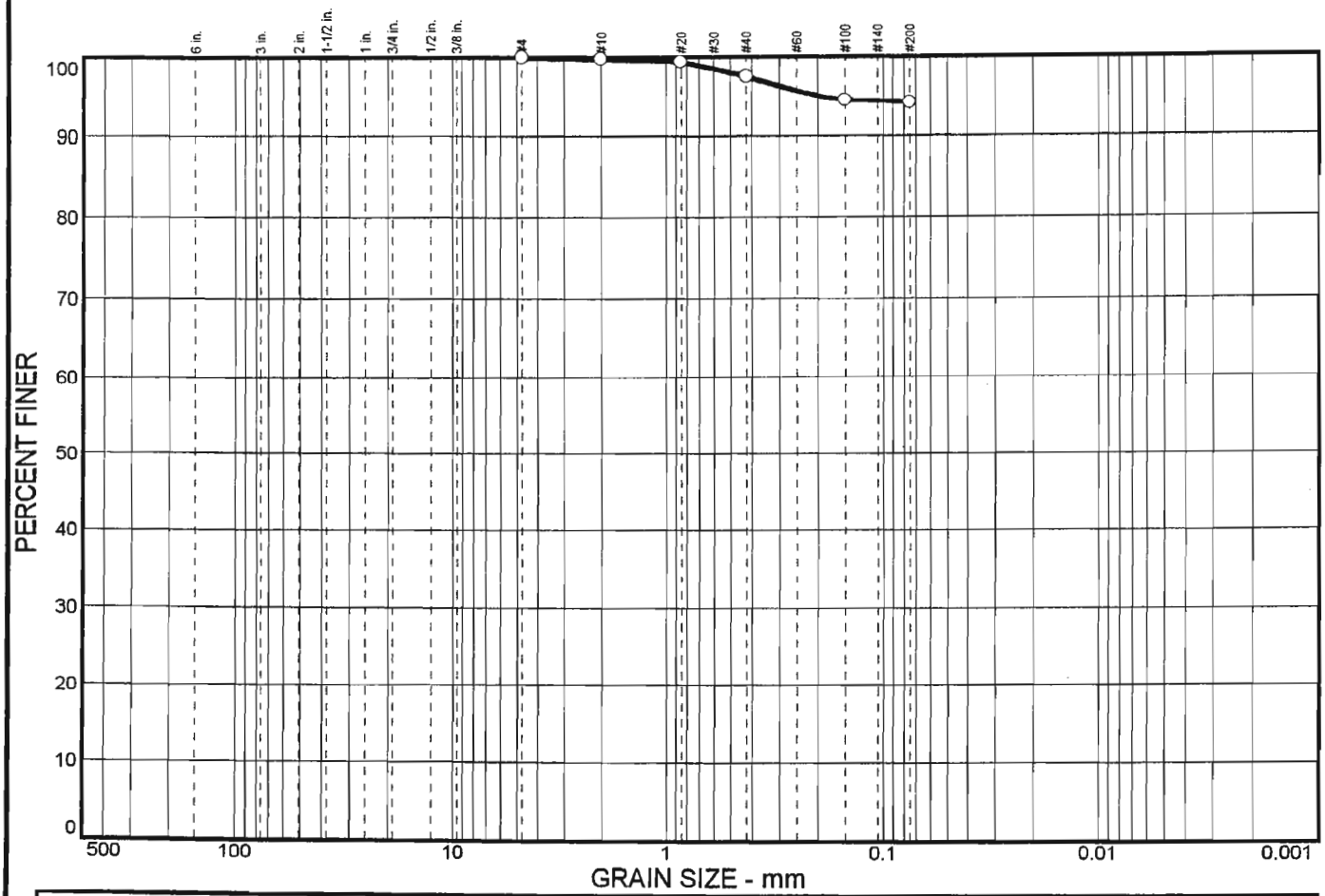
Remarks

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=

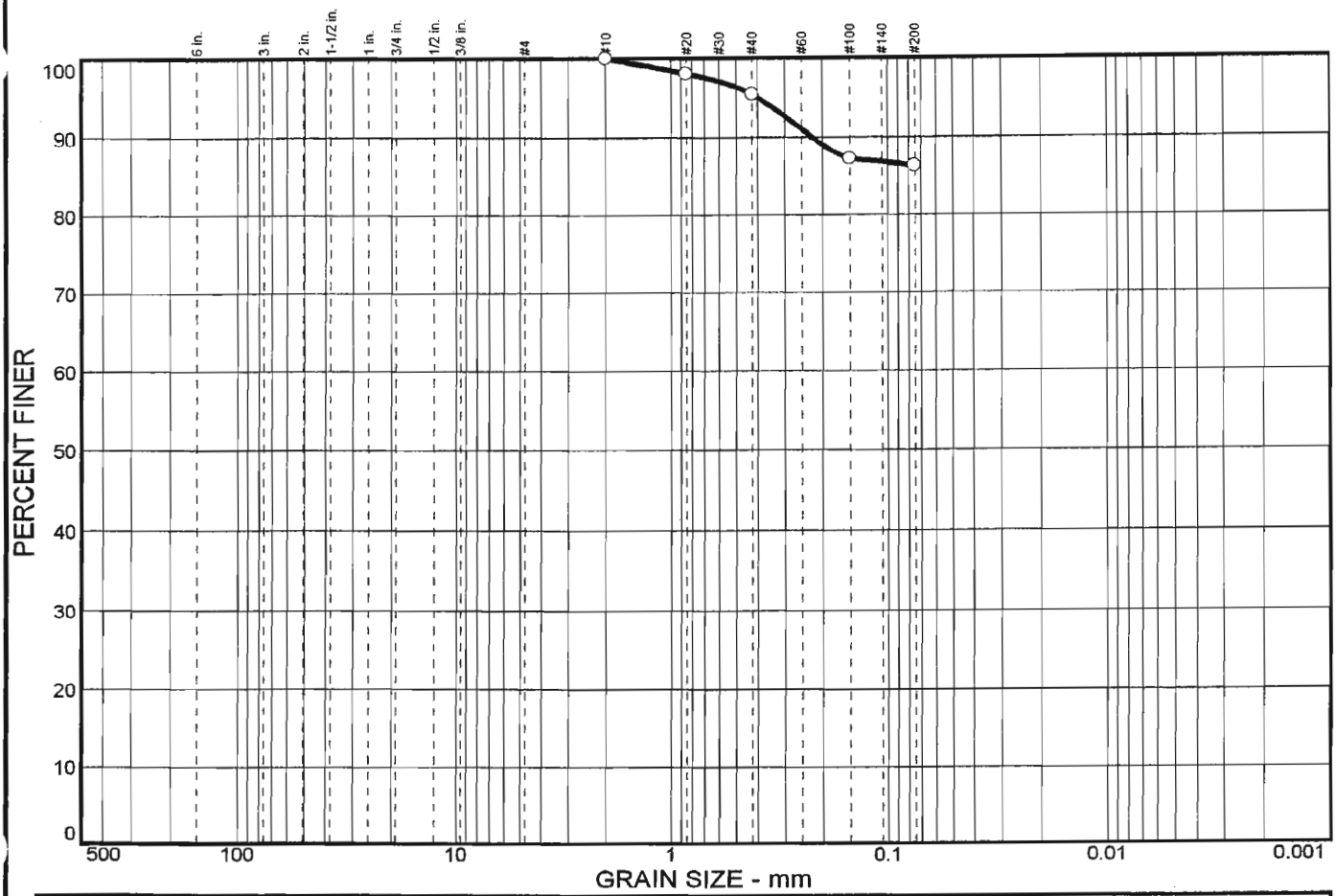
Remarks

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=

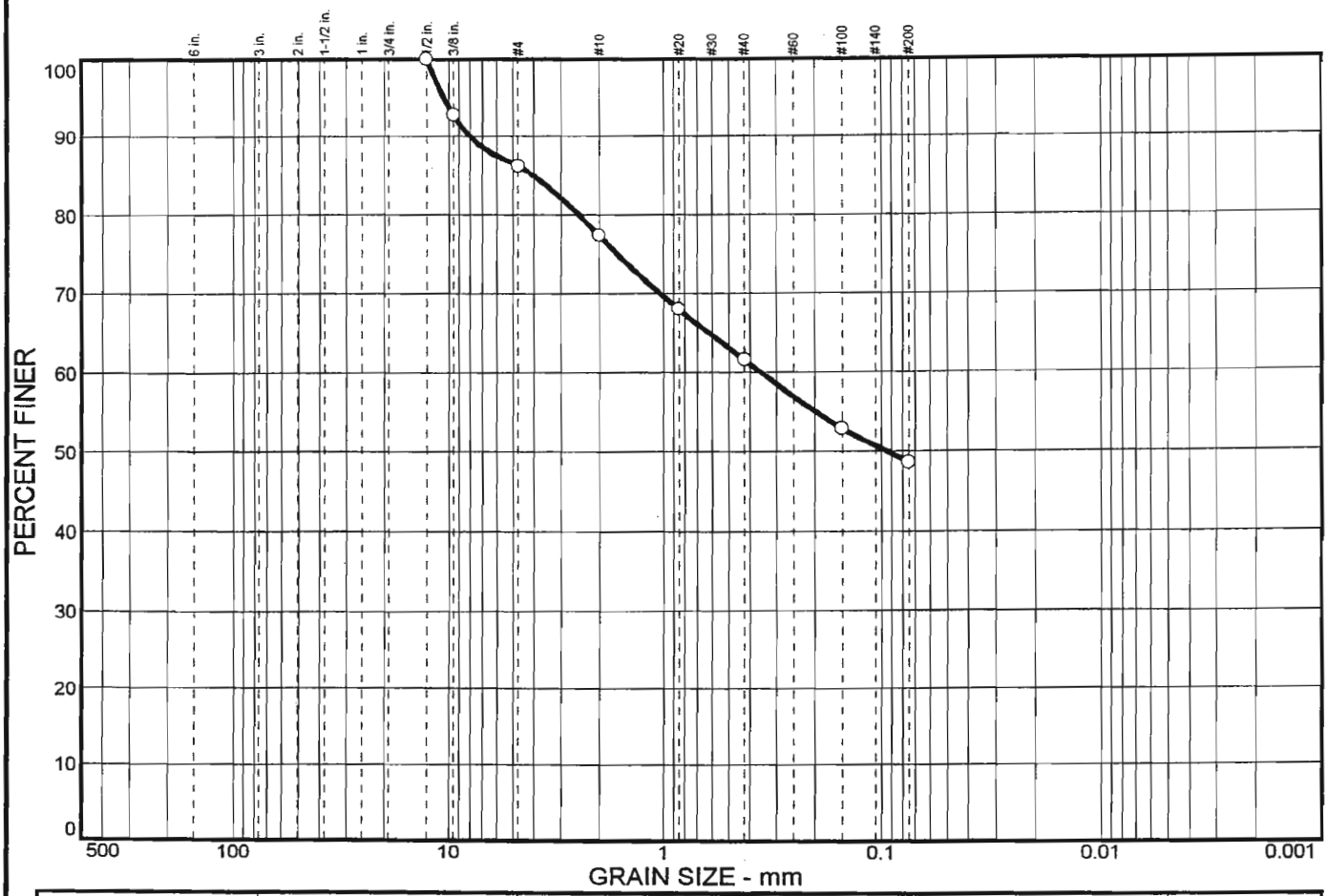
Remarks

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=

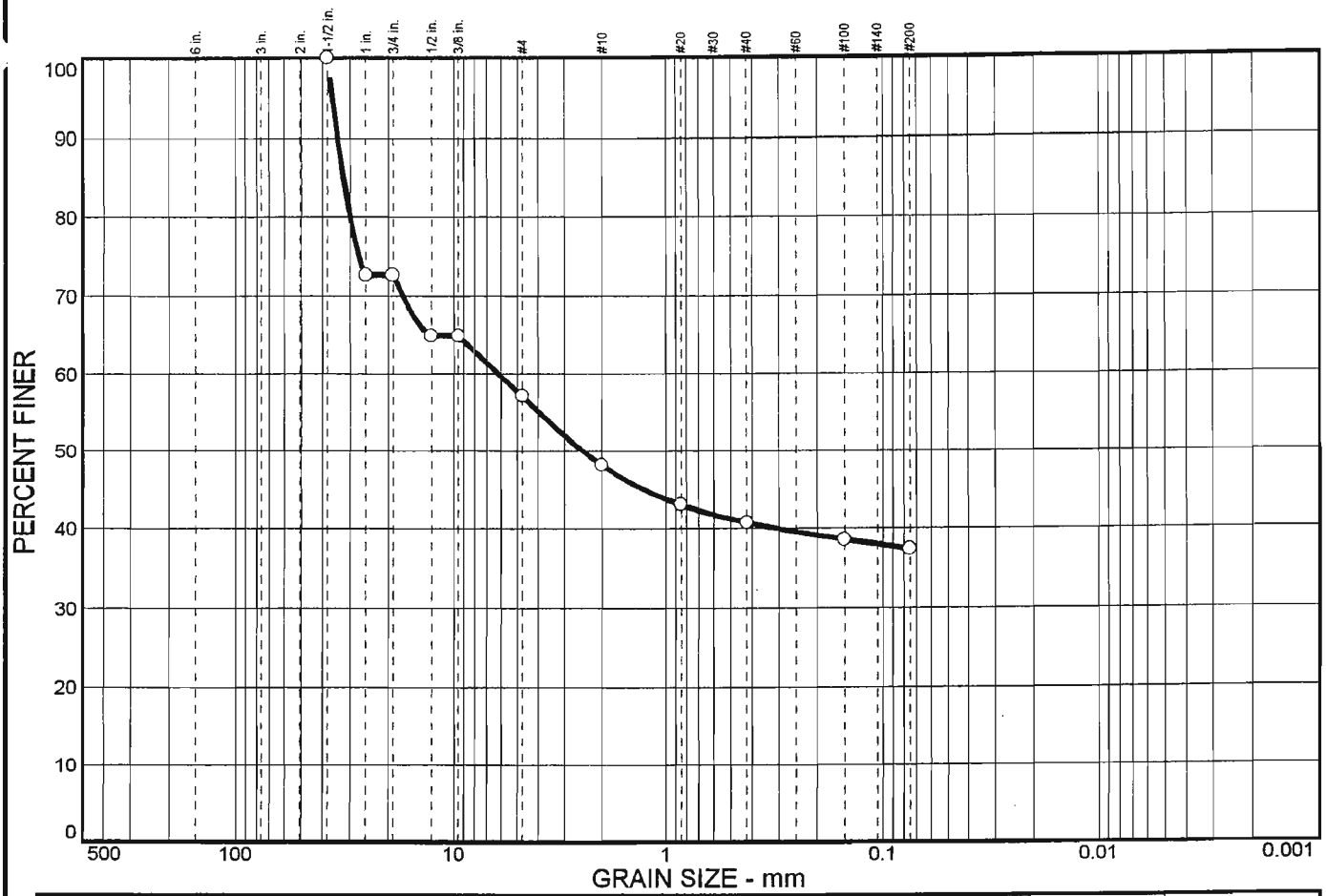
Remarks

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=

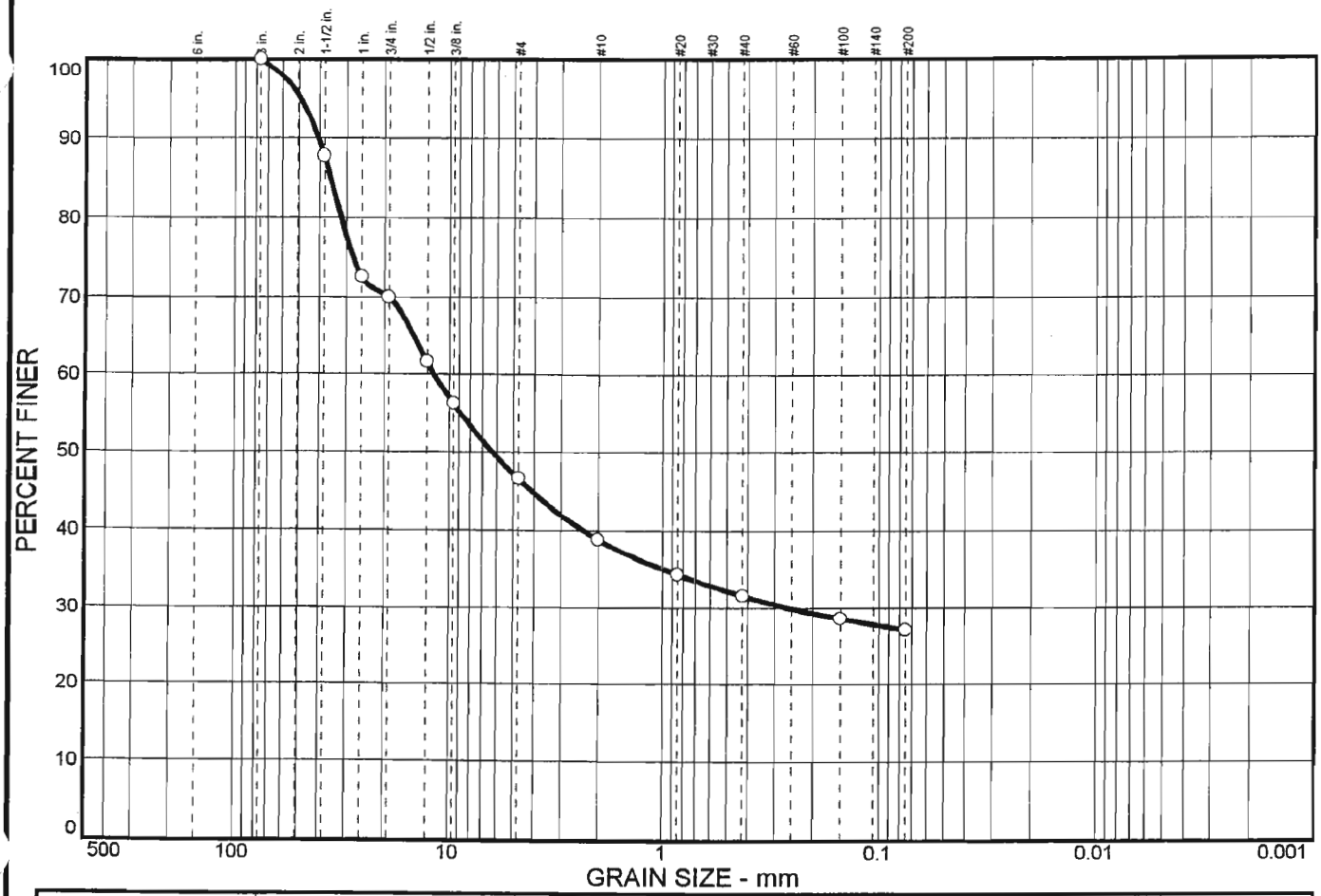
Remarks

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

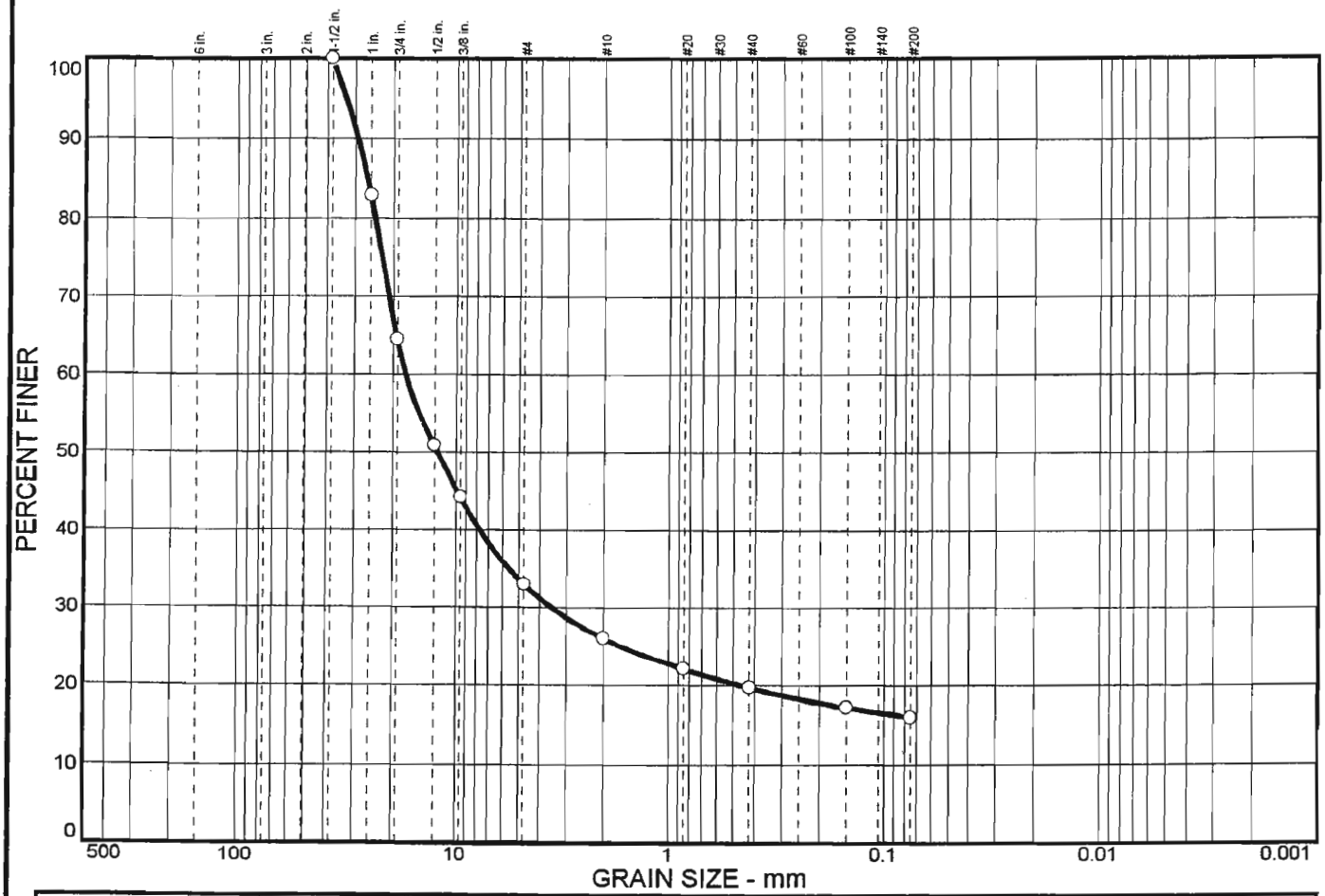
MAx Dry Dens 111.9 pcf @ 15.2% Opt Moisture

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

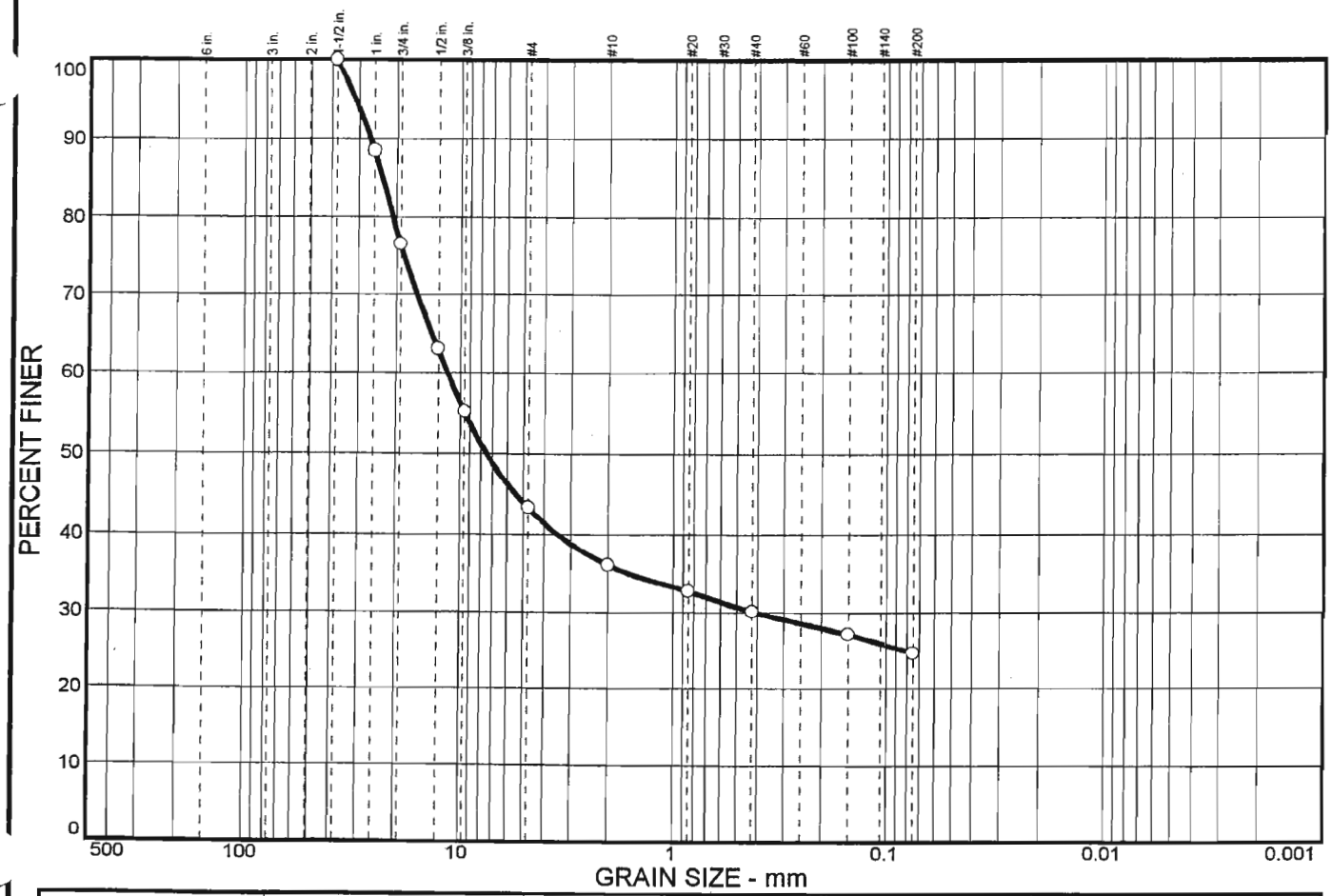
MAx Dry Dens 116.3 pcf @ 11.3% Opt Moisture

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

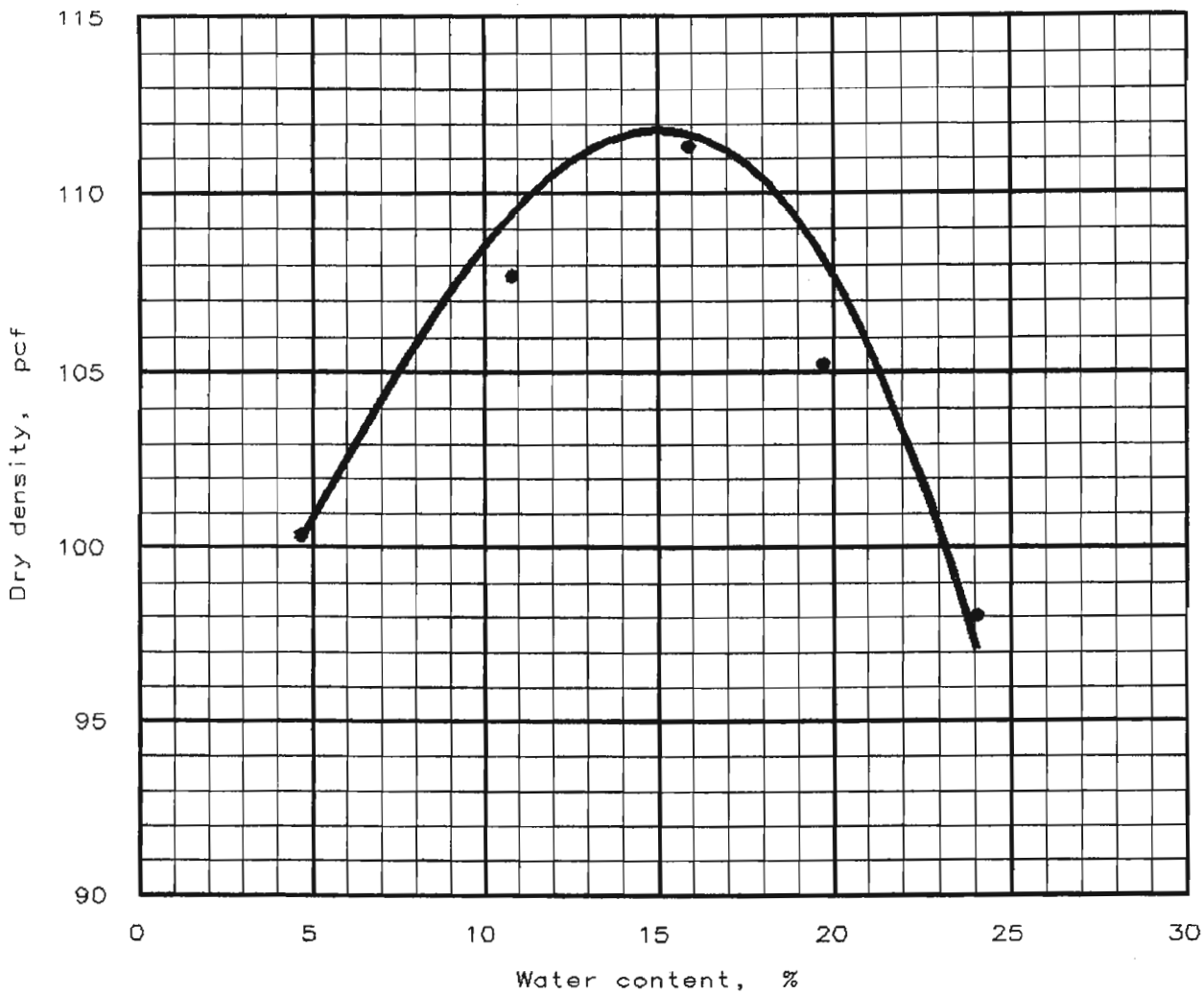
Max Dry Dens 111.7 pcf @ 12.3% Opt Moisture

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**

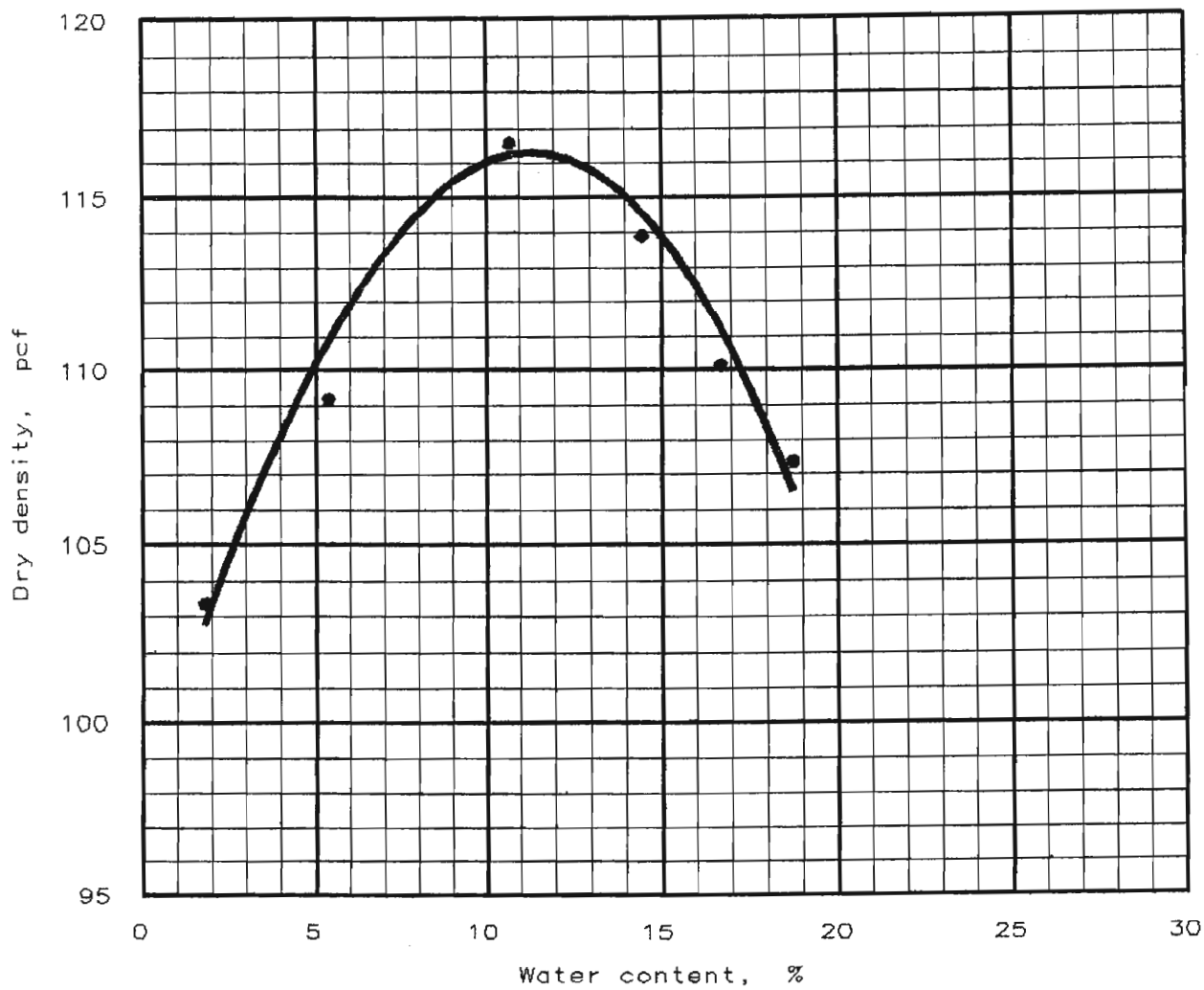
X=243609.03 Y=204369.87

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

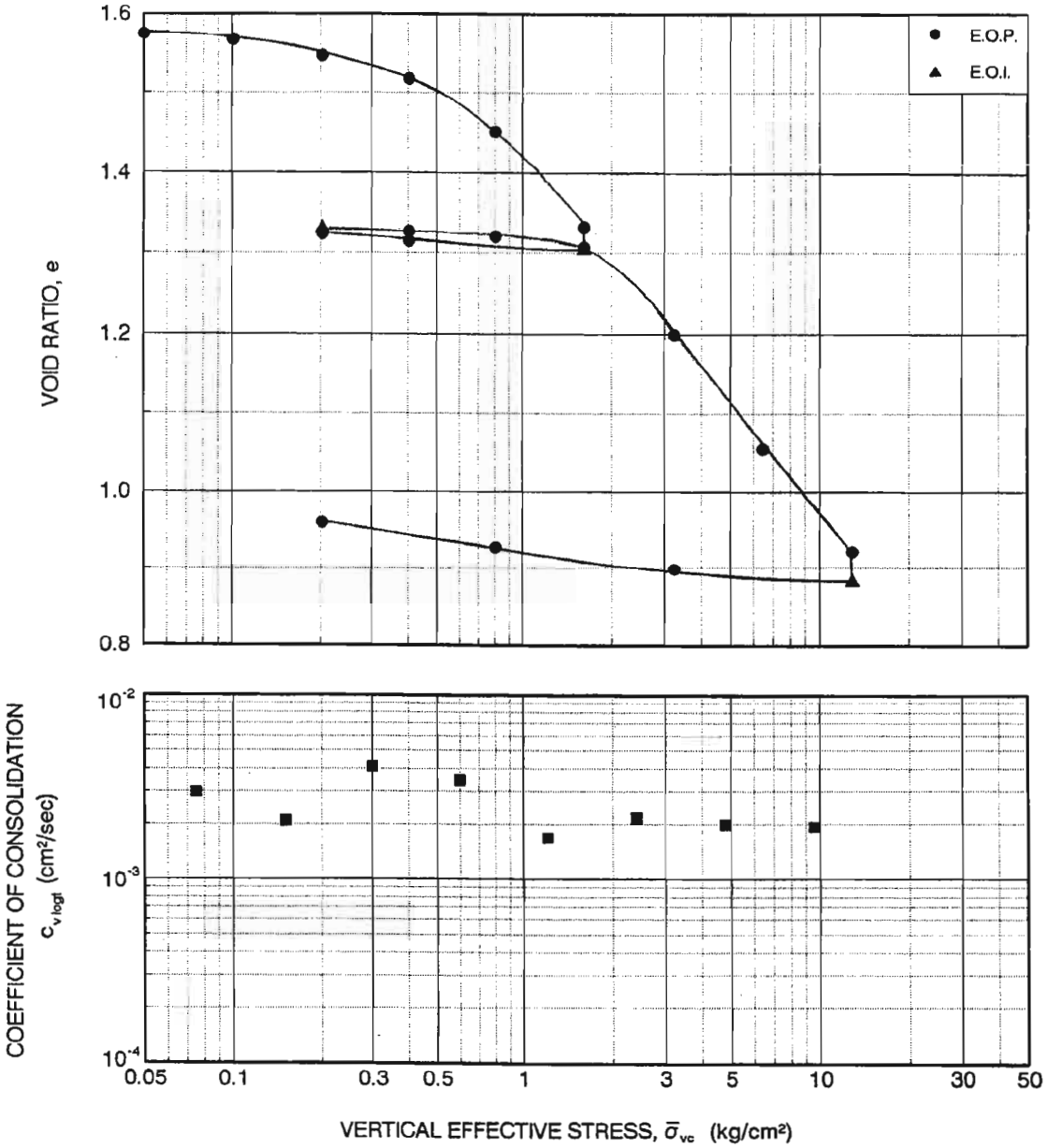
Table 2

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

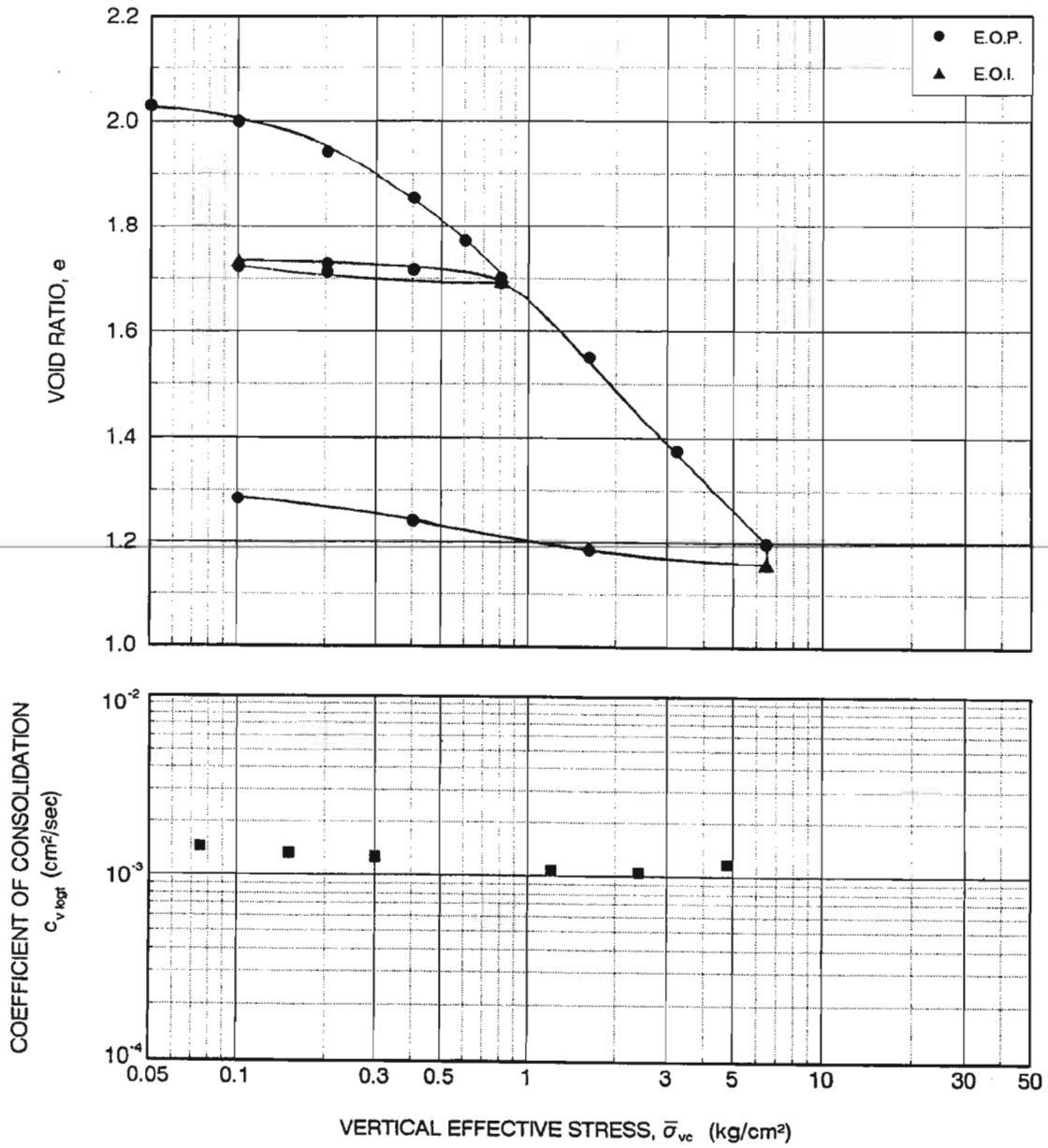
SPECIMEN CONDITIONS	INITIAL	FINAL
MOISTURE CONTENT (%):	57.4	37.1
DRY DENSITY (lb/ft³):	65.0	83.8
VOID RATIO:	1.58	1.00
SATURATION (%):	98	100

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

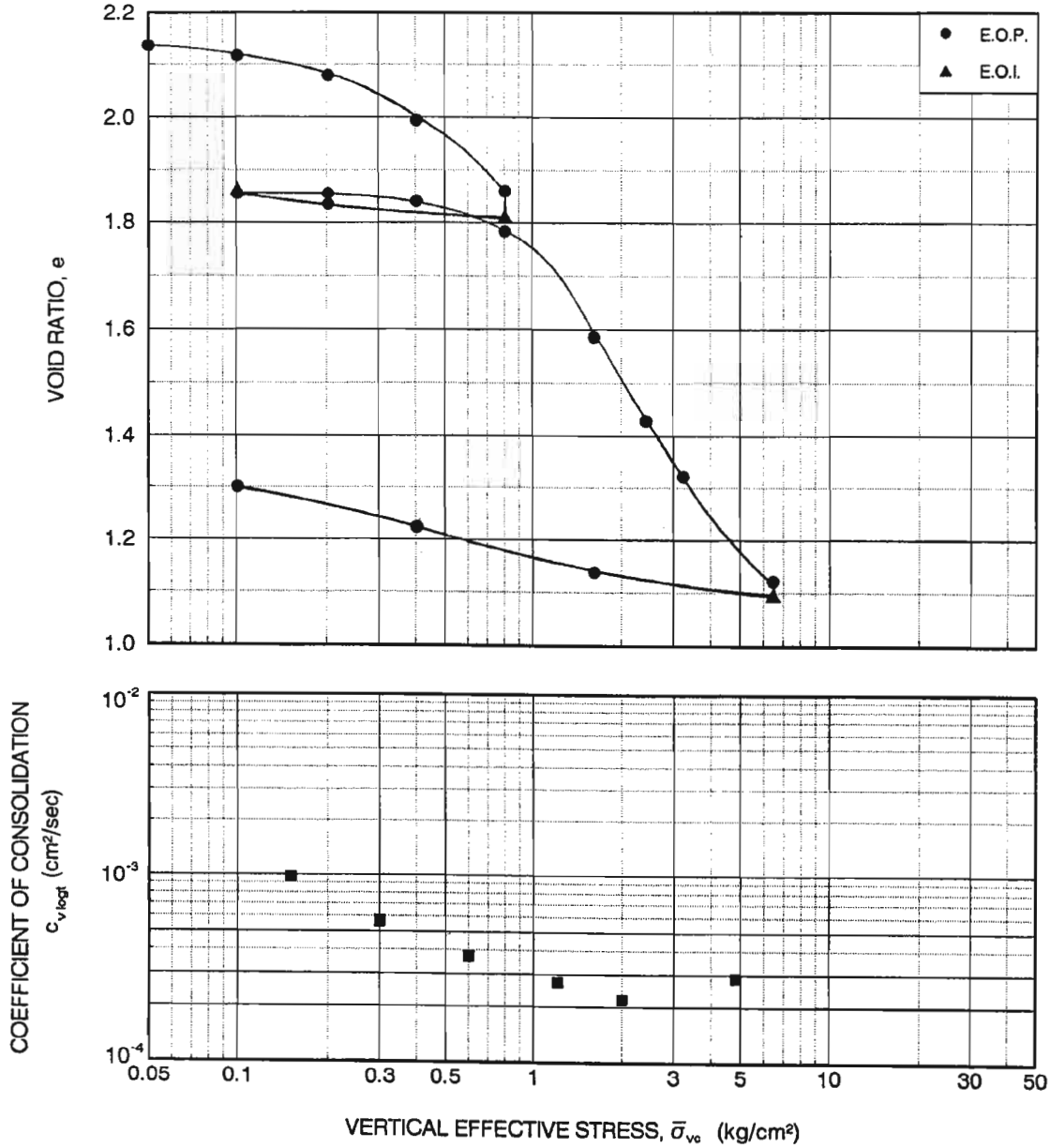
LIQUID LIMIT (%):	74
PLASTIC LIMIT (%):	37
PLASTICITY INDEX (%):	43
% PASSING NO. 200:	99
SPECIFIC GRAVITY:	2.70

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

INDEX PROPERTIES

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

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

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
DRAFT 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

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Bank Protection	6	2
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Subject No.	Paragragh No.	Page
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General	16	4

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Aguadilla / Espinar Control Structure - Typical Section	C-3
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Typical Sections - Espinar Levee	C-6

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 1999.

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

Preparation Date: 04/30/01
Effective Date of Pricing: 10/01/01

Sales Tax: 6.00%

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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 1000's) **

	QUANTY UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
01 CONSTRUCTION COST					
01_02 Relocations		31,000	8,000	39,000	
01_08 08 Roads, Railroads and Bridges		208,000	52,000	259,000	
01_09 09 Channels and Canals		73,000	18,000	91,000	
01_11 11 Levees and Floodwalls		917,000	229,000	1,146,000	
01_15 15 Floodway Control-Divert. Strt		717,000	179,000	896,000	
TOTAL CONSTRUCTION COST		1,945,000	486,000	2,432,000	
02 NON-CONSTRUCTION COST					
02_01 LANDS AND DAMAGES		1,240,000	372,000	1,612,000	
02_30 PLANNING, ENGINEERING & DESIGN		156,000	39,000	195,000	
02_31 CONSTRUCTION MANAGEMENT		195,000	49,000	244,000	
TOTAL NON-CONSTRUCTION COST		1,591,000	460,000	2,051,000	
TOTAL Rio Culebrinas-100 Yr.Flood Plan		3,536,000	946,000	4,482,000	

** PROJECT OWNER SUMMARY - Element (Rounded to 1000'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			31,000	8,000	39,000	
	TOTAL Cemetery, Utilities, & Structure			31,000	8,000	39,000	
	TOTAL Relocations			31,000	8,000	39,000	
01_08	08 Roads, Railroads and Bridges						
01_08_01	Roads						
01_08_01_ 1	Mob, Demob & Preparatory Work			10,000	3,000	13,000	
01_08_01_ 2	Excavate and Haul Ramp #1 Fill	6156.00	LCY	15,000	4,000	18,000	2.95
01_08_01_ 4	Construct Ramp #1	5232.00	CCY	18,000	4,000	22,000	4.24
01_08_01_ 5	Paving Ramp #1			33,000	8,000	42,000	
01_08_01_ 6	Excavate and Haul Ramp #2 Fill	6156.00	LCY	15,000	4,000	18,000	2.9.
01_08_01_ 7	Construct Ramp #2	5232.00	CCY	18,000	4,000	22,000	4.24
01_08_01_ 8	Paving Ramp #2			33,000	8,000	42,000	
01_08_01_ 9	Excavate and Haul Ramp #3 Fill	6156.00	LCY	15,000	4,000	18,000	2.95
01_08_01_10	Construct Ramp #3	5232.00	CCY	18,000	4,000	22,000	4.24
01_08_01_11	Paving Ramp #3			33,000	8,000	42,000	
	TOTAL Roads			208,000	52,000	259,000	
	TOTAL 08 Roads, Railroads and Bridges			208,000	52,000	259,000	
01_09	09 Channels and Canals						
01_09_01	Cutoff Canal						
01_09_01_02	Canal Excavation	10400	CY	24,000	6,000	30,000	2.87
01_09_01_07	Clearing and Grubbing - no haul	1.00	ACR	0	0	0	488.60
	TOTAL Cutoff Canal	225.00	LM	24,000	6,000	30,000	134.60
01_09_02	Interior Drainage Channels						
01_09_02_01	Channel Excavation	21700	LCY	46,000	11,000	57,000	2.64
01_09_02_02	Clearing and Grubbing	7.00	ACR	3,000	1,000	3,000	488.6
	TOTAL Interior Drainage Channels	3456.00	LM	49,000	12,000	61,000	17.60

** PROJECT OWNER SUMMARY - Element (Rounded to 1000's) **

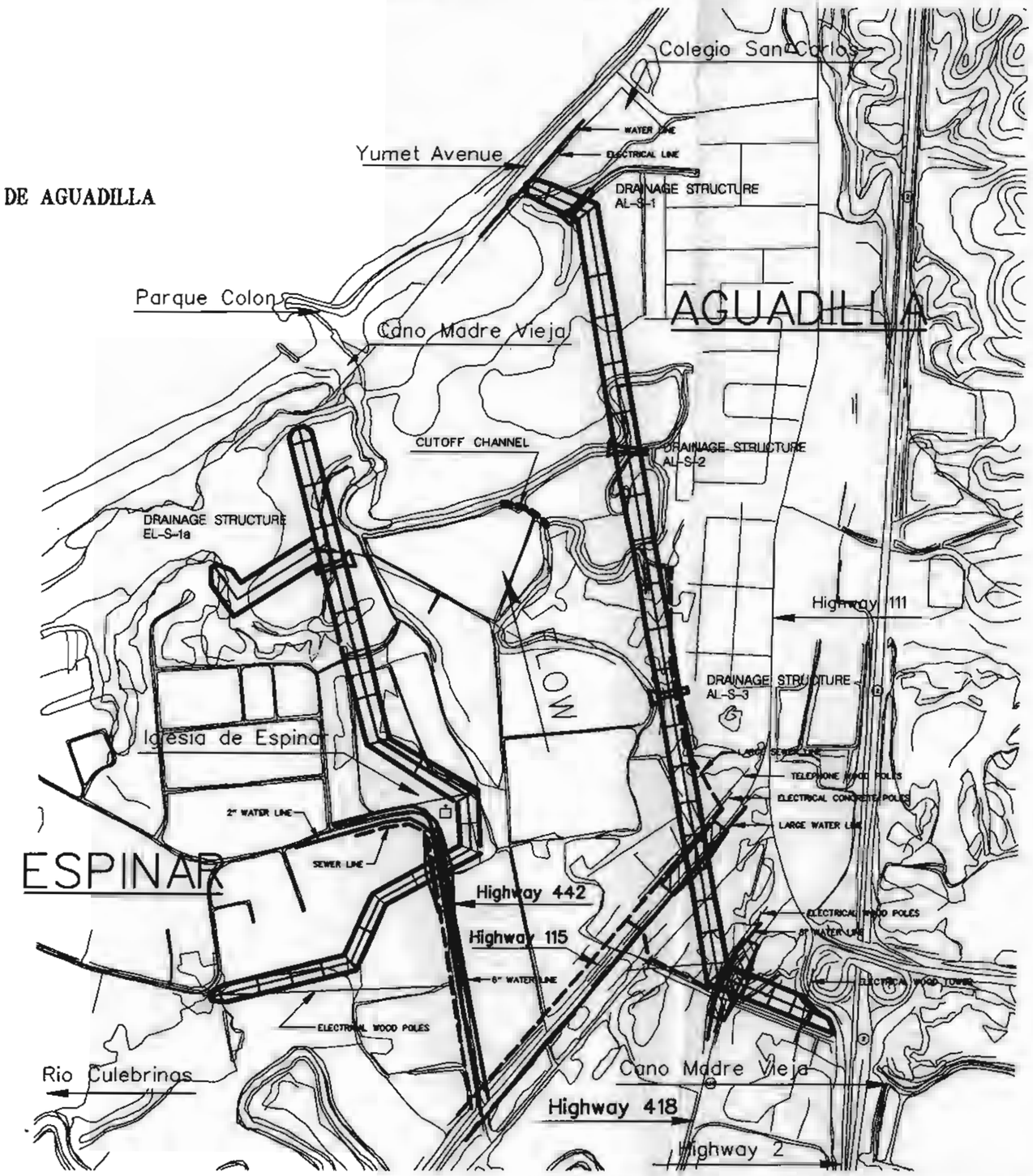
		QUANTY UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
	TOTAL 09 Channels and Canals		73,000	18,000	91,000	
01_11	11 Levees and Floodwalls					
01_11_01	Aguadilla Levee					
01_11_01_ 1	Mob, Demob & Preparatory Work		22,000	6,000	28,000	
01_11_01_ 2	Excavate and Haul Levee Fill	51746 CCM	246,000	62,000	308,000	5.95
01_11_01_ 4	Construct Levee	51746 CCM	212,000	53,000	265,000	5.12
	TOTAL Aguadilla Levee	51746 CCM	480,000	120,000	600,000	11.60
01_11_02	Espinar Levee					
01_11_02_ 1	Mob, Demob & Preparatory Work		18,000	5,000	23,000	
01_11_02_ 2	Excavate and Haul Levee Fill	46800 CCM	225,000	56,000	281,000	6.01
01_11_02_ 4	Construct Levee	46800 CCM	193,000	48,000	242,000	5.17
	TOTAL Espinar Levee	46800 CCM	436,000	109,000	546,000	11.66
	TOTAL 11 Levees and Floodwalls		917,000	229,000	1,146,000	
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	71,000	18,000	88,000	29455
	TOTAL CMP @ Ramps & Internal Channel		71,000	18,000	88,000	
01_15_04	Culvert AL-S-1					
01_15_04_01	3 - 60" CMP w/Flapgate	1.00 EA	118,000	30,000	148,000	147510
	TOTAL Culvert AL-S-1		118,000	30,000	148,000	
01_15_09	Culvert AL-S-2					
01_15_09_01	6 - 60" CMP w/Flapgate	1.00 EA	276,000	69,000	345,000	345401
	TOTAL Culvert AL-S-2		276,000	69,000	345,000	
01_15_10	Culvert AL-S-3					

** PROJECT OWNER SUMMARY - Element (Rounded to 1000's) **

		QUANTY	UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
01_15_10_01	3 - 60" CMP w/Flapgate	1.00	EA	124,000	31,000	155,000	155212
	TOTAL Culvert AL-S-3			124,000	31,000	155,000	
01_15_11	Culvert EL S-1A						
01_15_11_01	2-60" CMP w/gates	1.00	EA	97,000	24,000	121,000	121356
	TOTAL Culvert EL S-1A			97,000	24,000	121,000	
01_15_12	Extend Concrete Box Culvert						
01_15_12_01	Headwall Foundations	9.00	CY	1,000	0	2,000	207.36
01_15_12_02	Bottom Slab	28.00	CY	5,000	1,000	6,000	208.08
01_15_12_03	Cut-off Walls	7.00	CY	3,000	1,000	4,000	574.41
01_15_12_04	Headwalls or Wingwalls	8.00	CY	3,000	1,000	4,000	449.97
01_15_12_05	Box Walls	39.00	CY	9,000	2,000	12,000	302.90
01_15_12_06	Top Slab	28.00	CY	9,000	2,000	11,000	404.61
	TOTAL Extend Concrete Box Culvert	123.00	CY	31,000	8,000	38,000	312.64
	TOTAL 15 Floodway Control-Divert. Strt			717,000	179,000	896,000	
	TOTAL CONSTRUCTION COST			1,945,000	486,000	2,432,000	
02	NON-CONSTRUCTION COST						
02_01	LANDS AND DAMAGES						
02_01_01	Lands and Damages			1,240,000	372,000	1,612,000	
	TOTAL LANDS AND DAMAGES			1,240,000	372,000	1,612,000	
02_30	PLANNING, ENGINEERING & DESIGN						
02_30_30	Planning, Engineering & Design			156,000	39,000	195,000	
	TOTAL PLANNING, ENGINEERING & DESIGN			156,000	39,000	195,000	
02_31	CONSTRUCTION MANAGEMENT						
02_31_31	Construction Management			195,000	49,000	244,000	
	TOTAL CONSTRUCTION MANAGEMENT			195,000	49,000	244,000	

** PROJECT OWNER SUMMARY - Element (Rounded to 1000's) **

	QUANTY UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
TOTAL NON-CONSTRUCTION COST		1,591,000	460,000	2,051,000	
TOTAL Rio Culebrinas-100 Yr.Flood Plan		3,536,000	946,000	4,482,000	



CMP DRAINAGE STRUCTURES

ROAD RAMP ACROSS LEVEE

C:\des\culbrnas\utility.dgn

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

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

PROJECT PLAN

ROAD RAMPS / UTILITIES RELOCATIONS

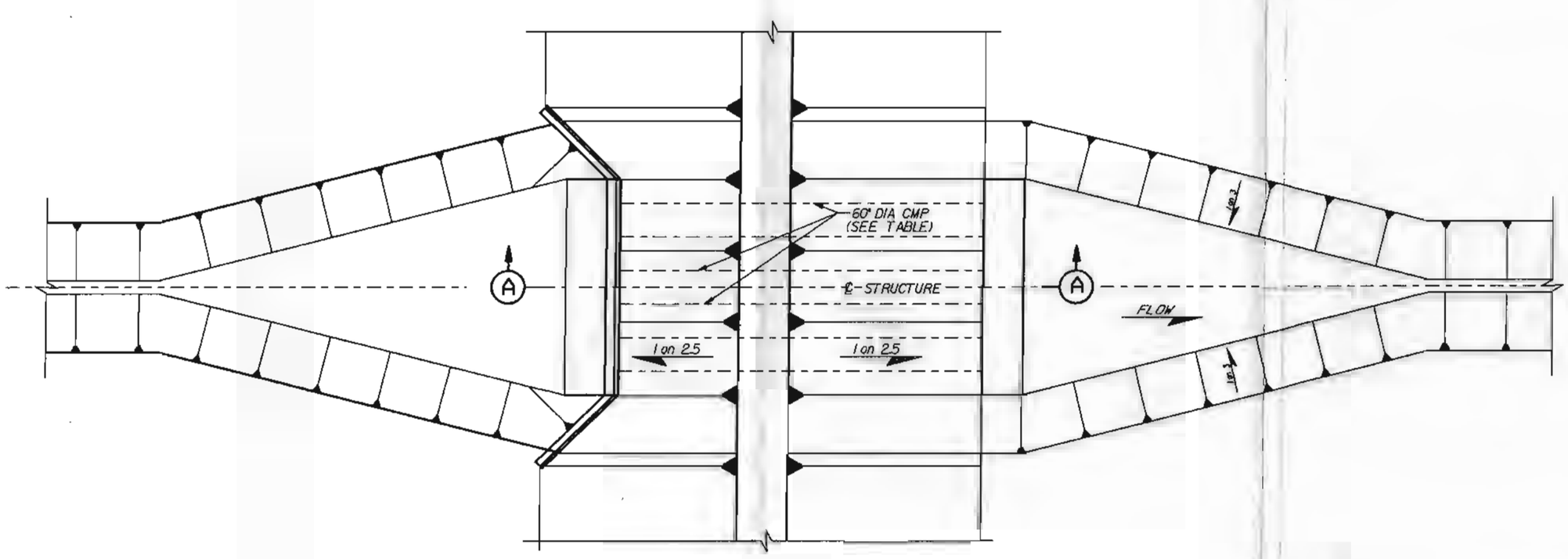
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

NOT TO SCALE

DATE: NOVEMBER 1999

(REVISED: MARCH 2001)

PLATE C-1



SITE PLAN

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

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

AQUADILLIA / ESPINAR CONTROL STRUCTURES

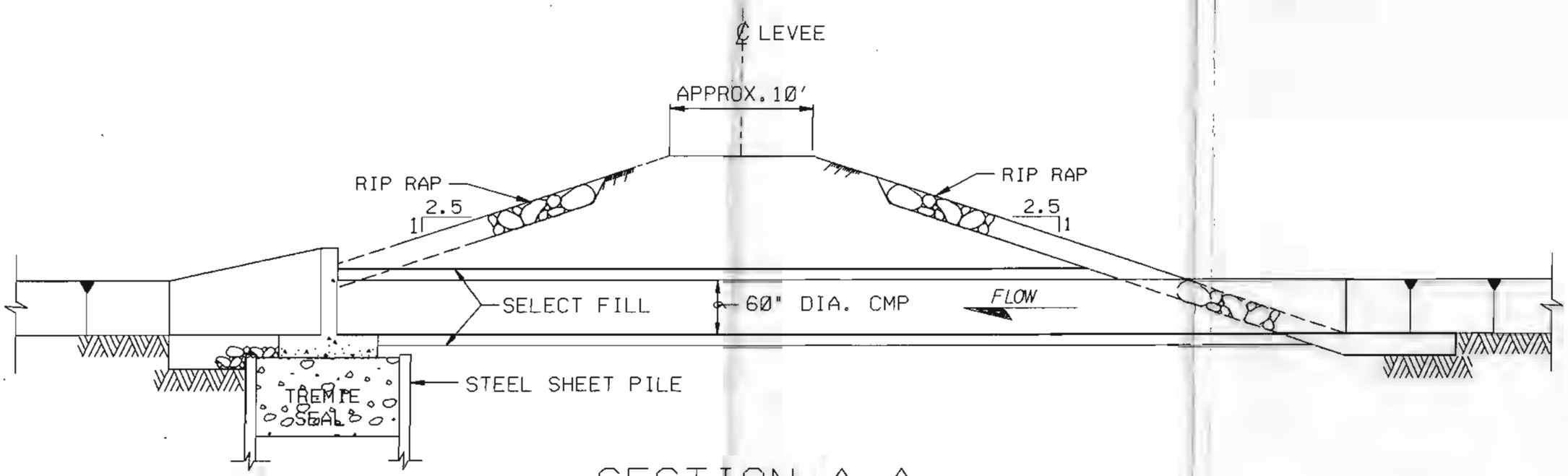
SITE PLAN

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

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

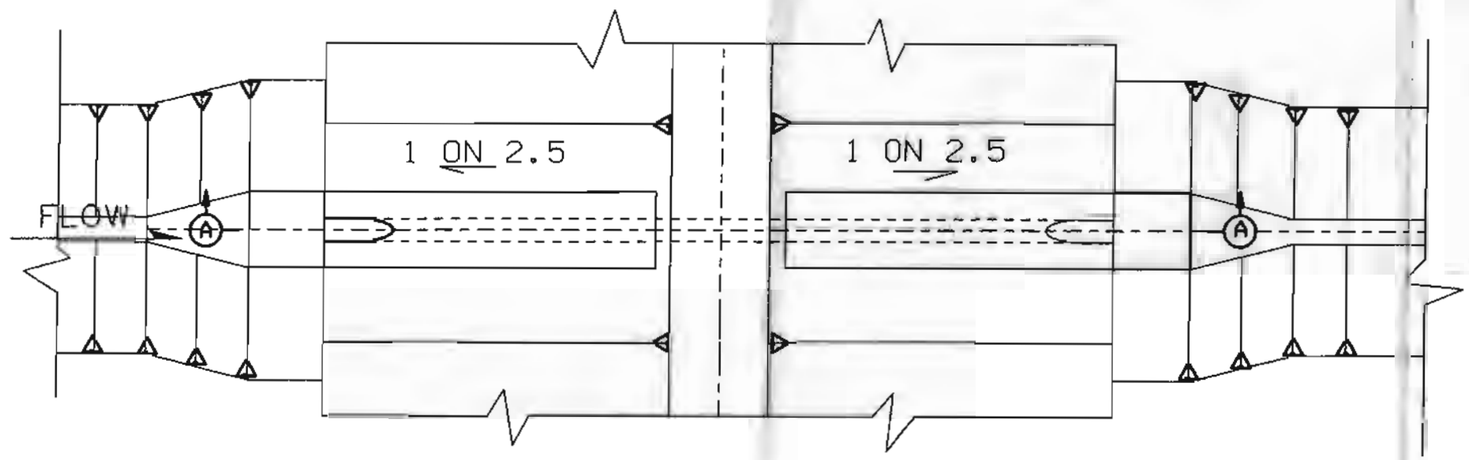
TYPICAL SECTION

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

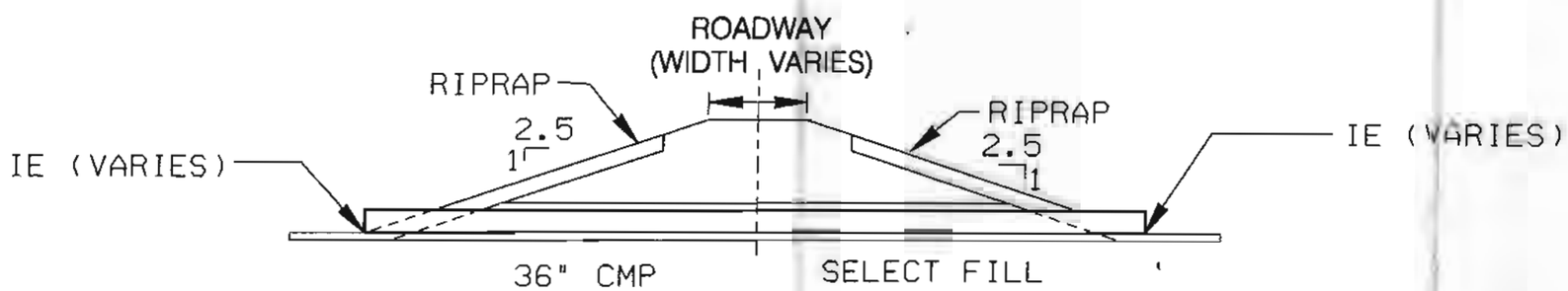
NOVEMBER 1999

(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

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

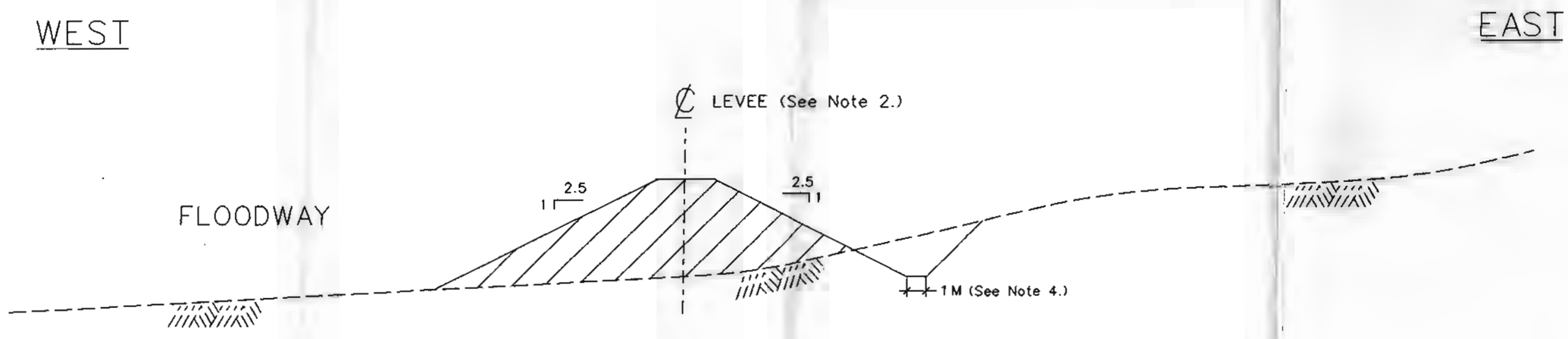
DESIGN ENG.: J.D.H.	
DWN BY:	CKD BY:

NOT TO SCALE

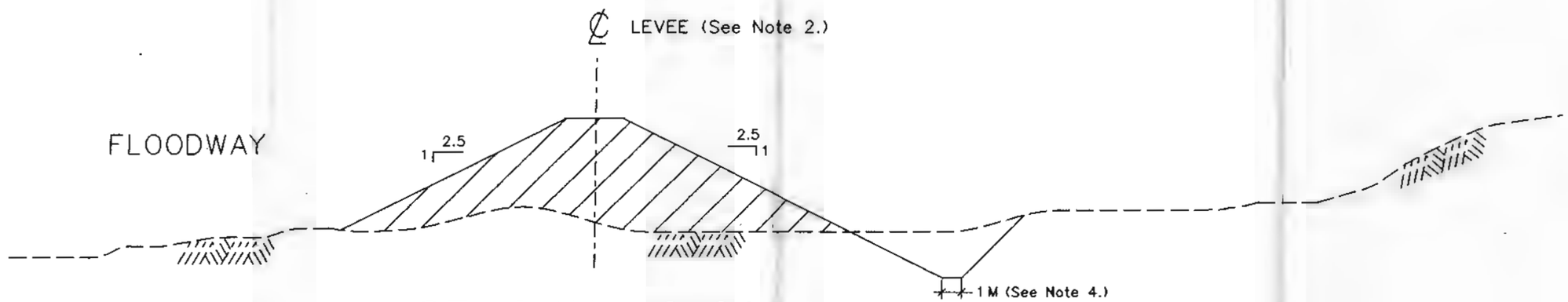
NOVEMBER 1999

(REVISED: MARCH 2001)

PLATE C-4



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.

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

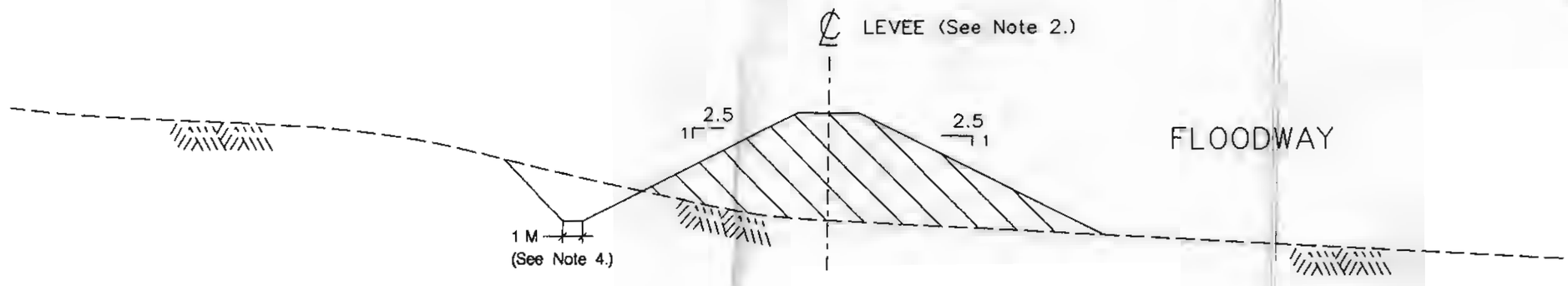
RIO CULEBRINAS @ AGUADA /AGUADILLA, PUERTO RICO
DETAILED PROJECT REPORT

TYPICAL SECTIONS
AGUADILLA LEVEE

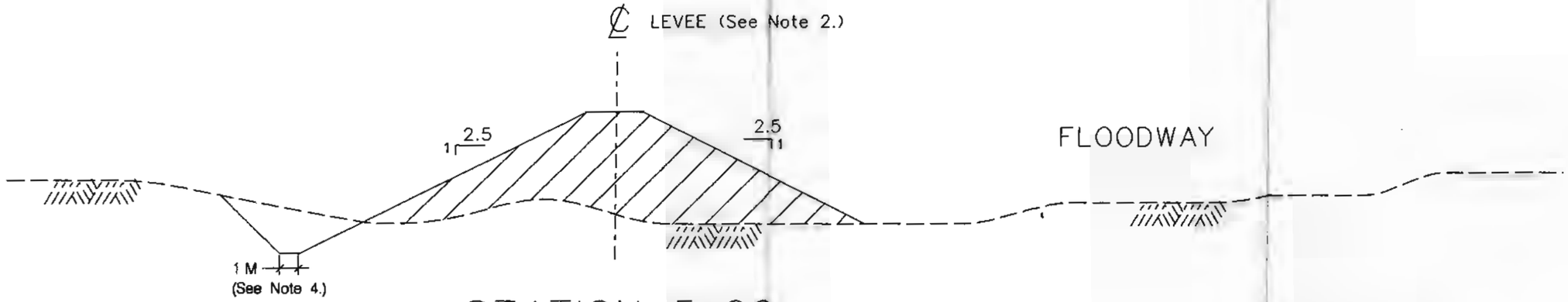
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

NOT TO SCALE NOVEMBER 1999

(REVISED: MARCH 2001) PLATE C-5



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: REH	CKD. BY:

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

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

APPENDIX D
REAL ESTATE PLAN

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2/00 bam
Revised 9/00,12/00,7/01 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 which can 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

Project implementation will not cause greater frequency or duration of flooding as compared to existing conditions. It would still be subject to flooding, 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)	$ 485,000
Aguadilla Levee (24.20 acres)	$ 524,000
Espinar Levee Spur (1.73 acres)	$ 55,680
Channel Improvement Easement (1.30 acres)	$ 5,000
Temporary Work Areas for Roads	$ TBD
Sub-Total	$1,070,000
Total Lands and Damages	$1,070,000

Acquisition/Administrative Costs

Federal:	
Project Planning	$ 20,000
Review of PCA	$ 2,000
Review of Acquisitions	$ 10,000
Review of Appraisals	$ 5,000
Review of Condemnation	$ 12,500
Review of PL 91-646	$ 0
Total Federal Acquisition/ Admin Costs	$ 49,500
Non-Federal:	
Acquisitions	$ 30,000
Appraisals	$ 15,000
Condemnations	$ 75,000
PL 91-646	$ 0
Total Non-Federal Acquisition/ Admin Costs	$ 120,000
Public Law 91-646 Payments	$ 0
Contingency (30%) (RD)	$ 372,000
Total Estimated Real Estate Costs (RD)	$ 1,612,000

*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.

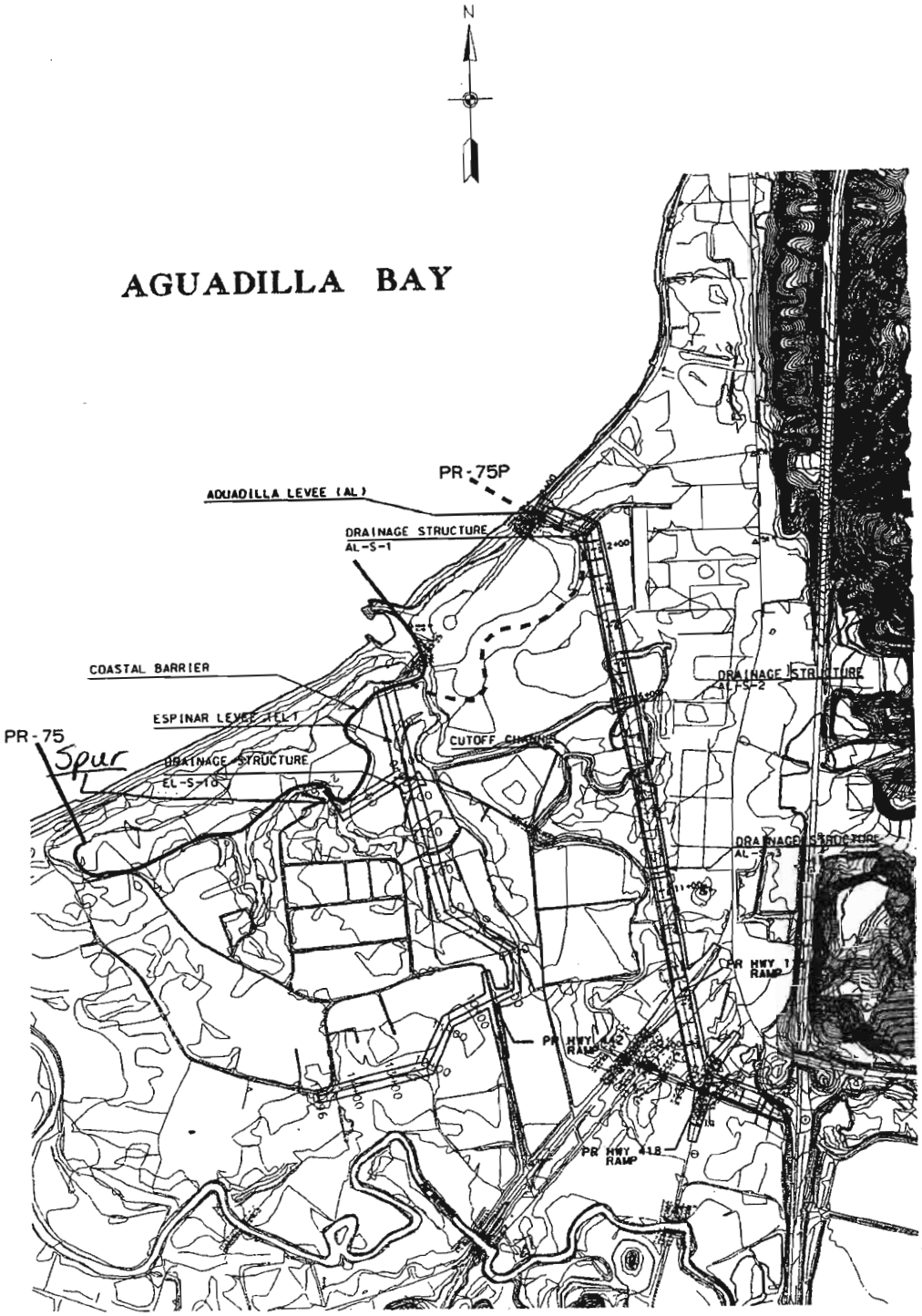
17. ATTITUDE OF LANDOWNERS

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	$20,000	
01B--	ACQUISITIONS		
01B20	BY LOCAL SPONSOR (LS)	$30,000	
01B40	REVIEW OF LS	$10,000	
01C—	CONDEMNATIONS		
01C20	BY LS	$75,000	
01C40	REVIEW OF LS	$12,500	
01E--	APPRAISALS		
01E30	BY LS	$15,000	
01E50	REVIEW OF LS	$ 5,000	
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	$1,070,000	
01R2	PL 91-646 ASSISTANCE PAYMENTS		
01R2B	BY LS	$ 0	
TOTAL REAL ESTATE COST EXCLUDING CONTINGENCY			**$1,240,000**
REAL ESTATE CONTINGENCY (30%) (RD)			**$ 372,000**
TOTAL PROJECT REAL ESTATE COST (RD)			**$1,612,000**



US Army Corps of Engineers
Jacksonville District

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

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Reference files:

RIO CULEBRINAS AT AGUADA/AGUADILLA
PUERTO RICO

DETAILED PROJECT REPORT
RECOMMENDED PLAN

PLATE
D-1

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

APPENDIX E
ECONOMIC ANALYSIS

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E-1 Economic Reaches

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.

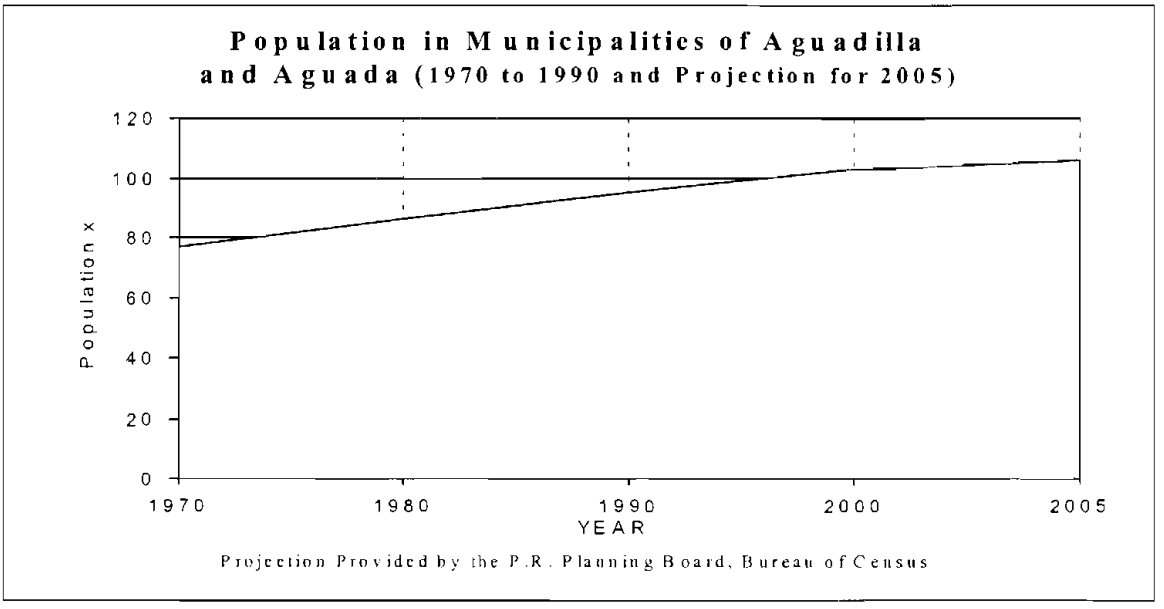


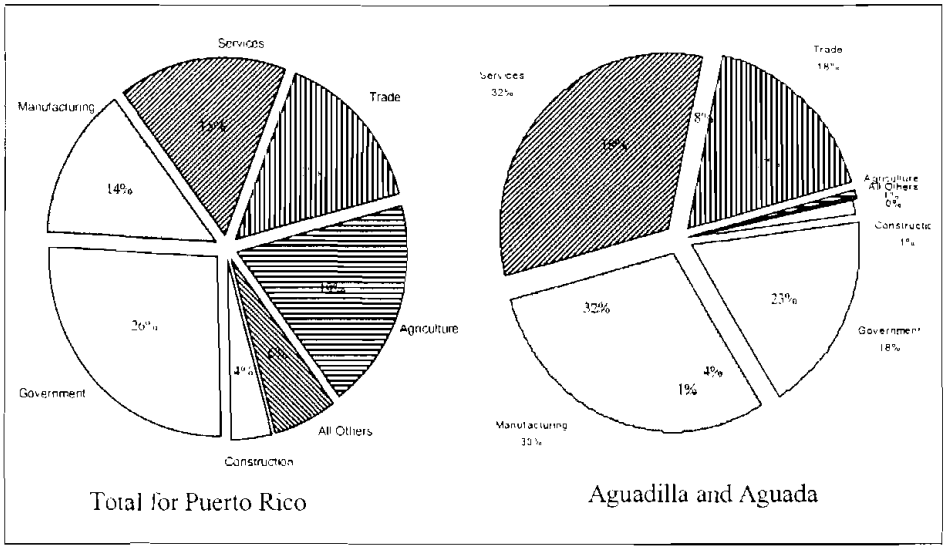
Figure E-1

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 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 REACHES AND NODES FOR ECONOMIC ANALYSIS		
REACH	NODES	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 2 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 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 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 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

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

Average Values of Property Subject to Flooding
Residential Land Use

Reach	Sector	Number of structures	Average values	
			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. For utilities values, these were provided by the PR Aqueduct and Sewer Authority, the 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 Estimated Value of Structures and Contents Commercial Facilities			
Land Use Category	Number of Structures	Total Values ($2001)	
		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 Value of Structures and Contents Public, Nonprofit Utilities			
	Number of Structures	**Total Values ($2001)**	
		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.

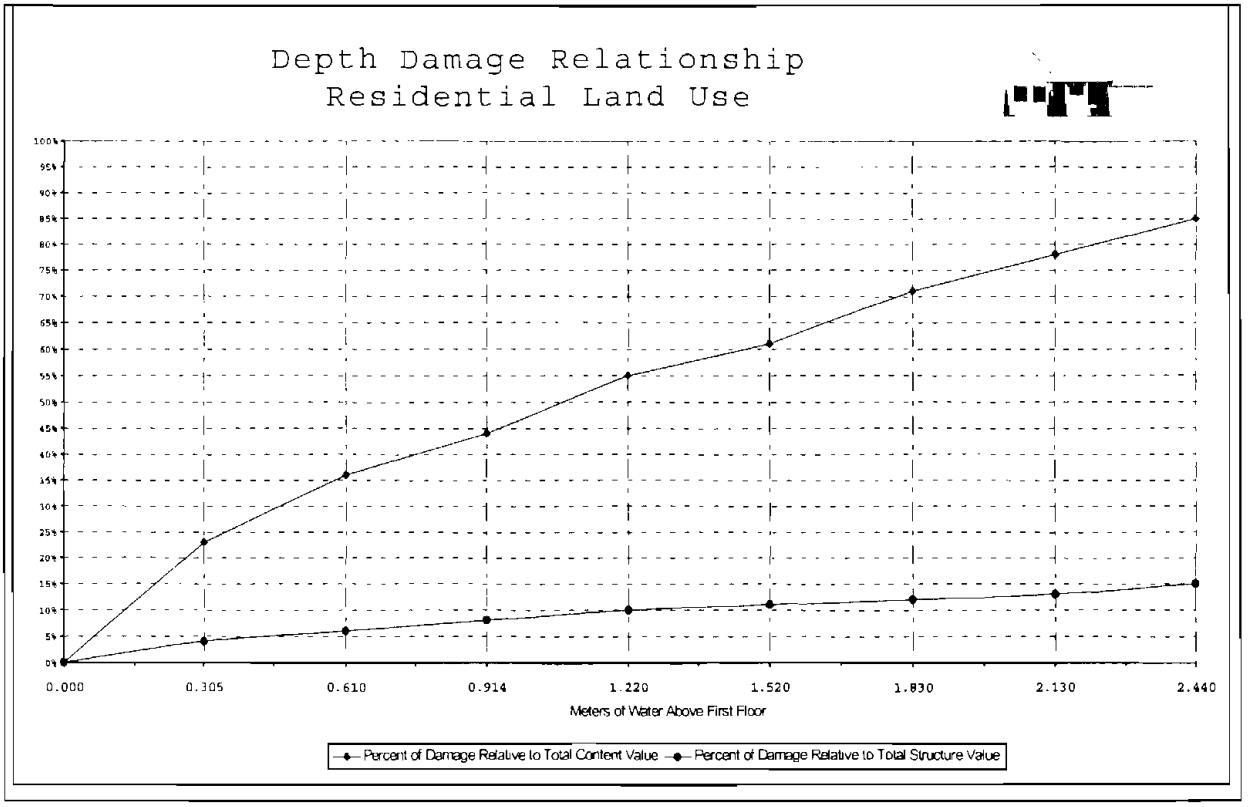


Figure E-3

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.

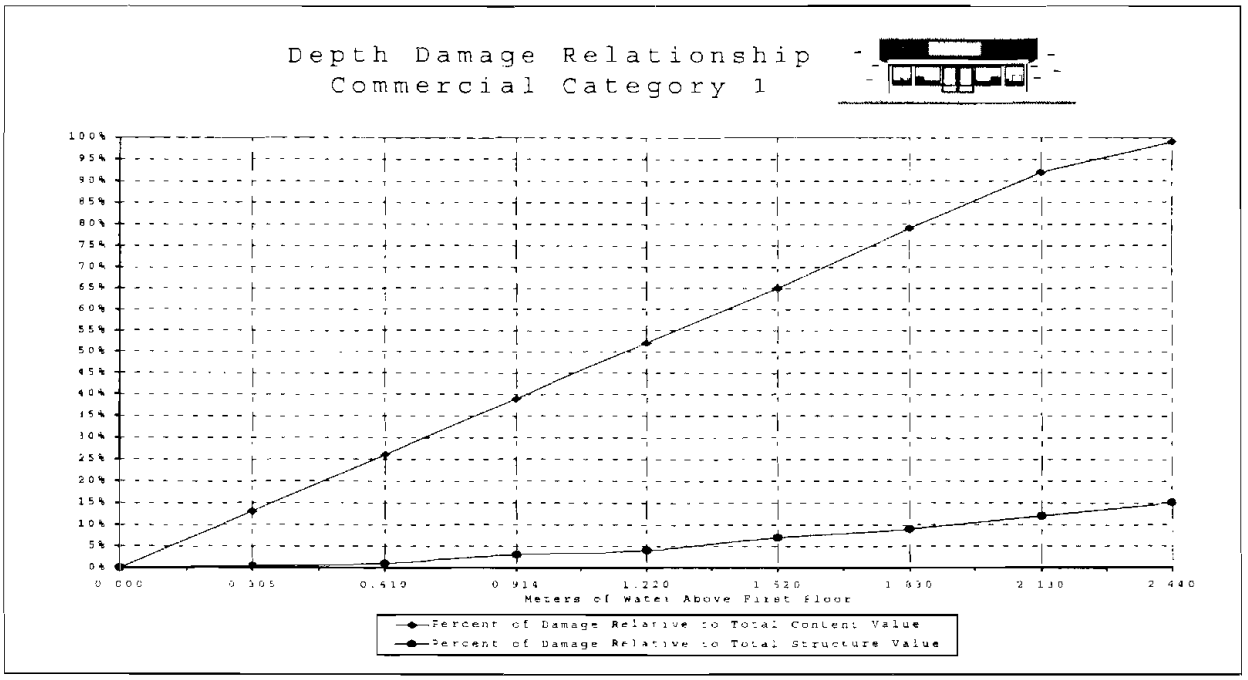


Figure E-4

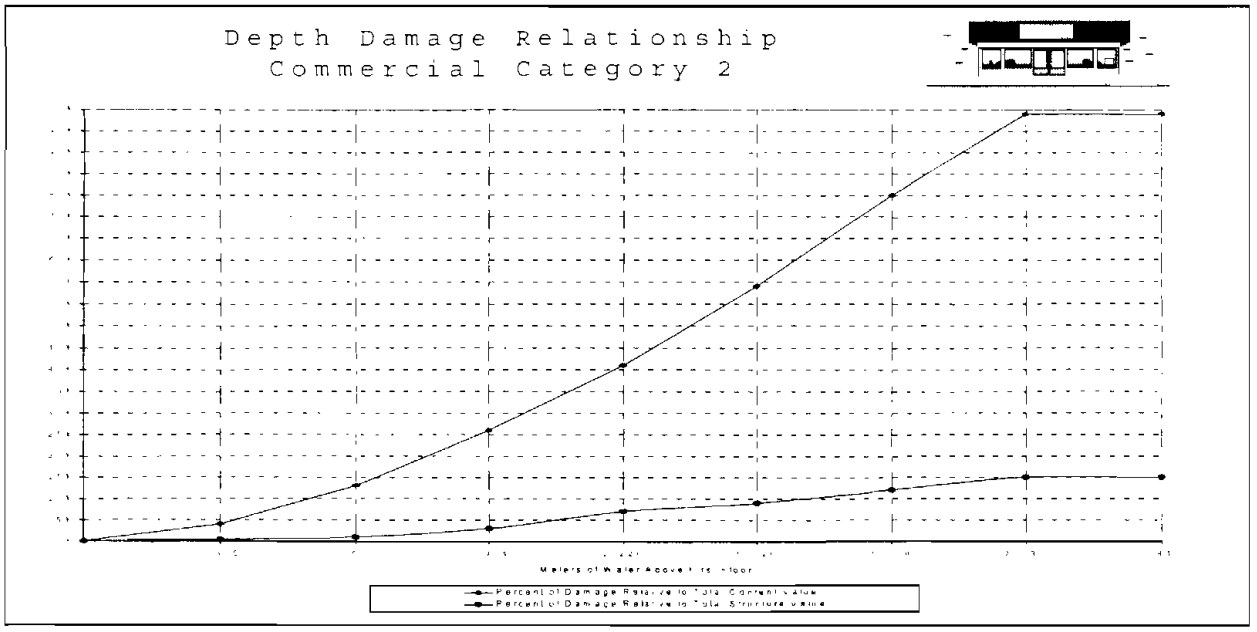


Figure E-5

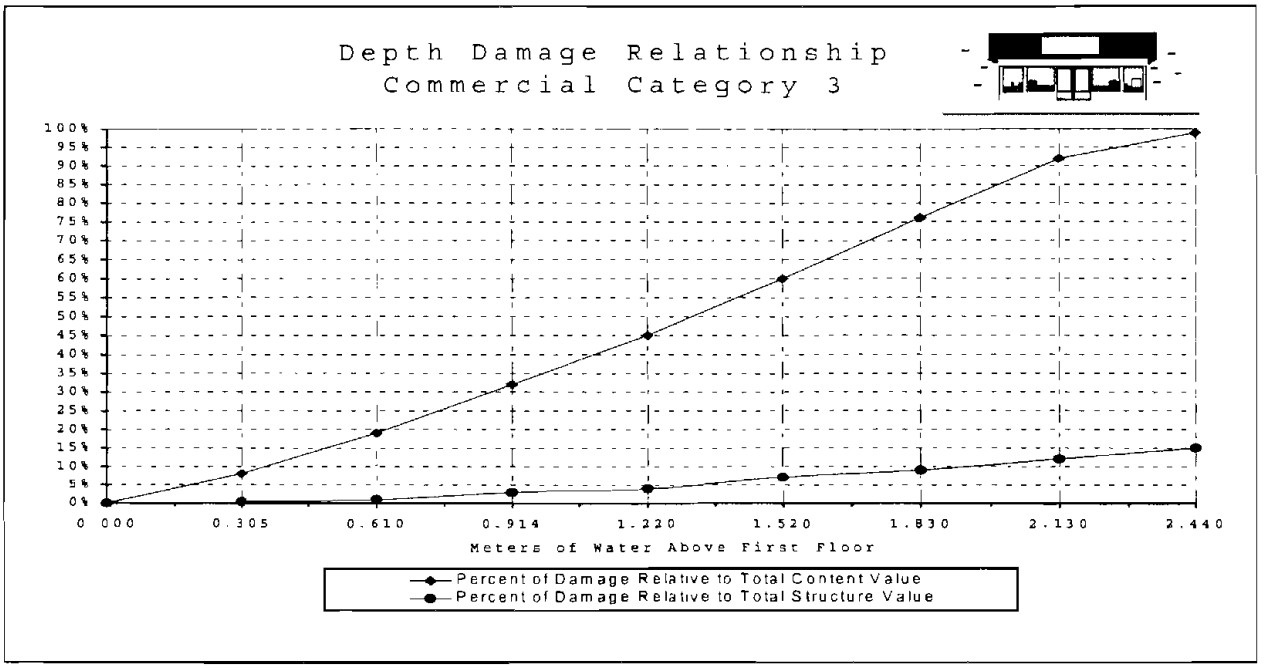


Figure E-6

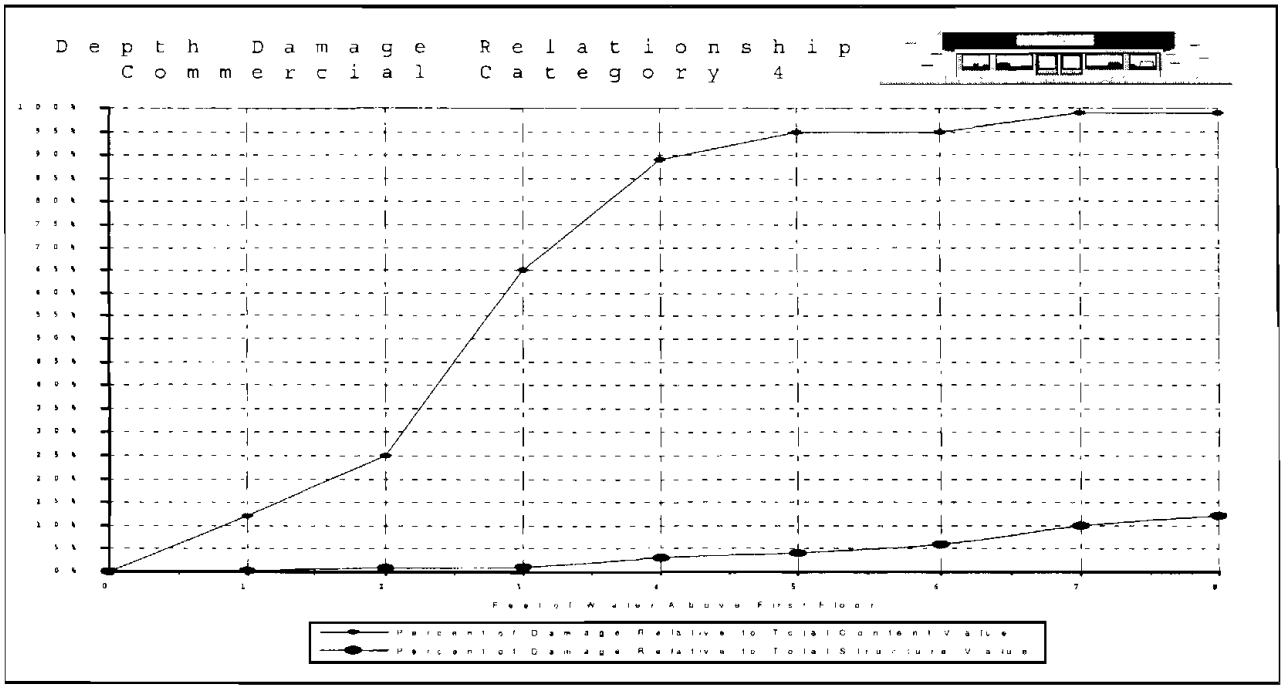


Figure E-7

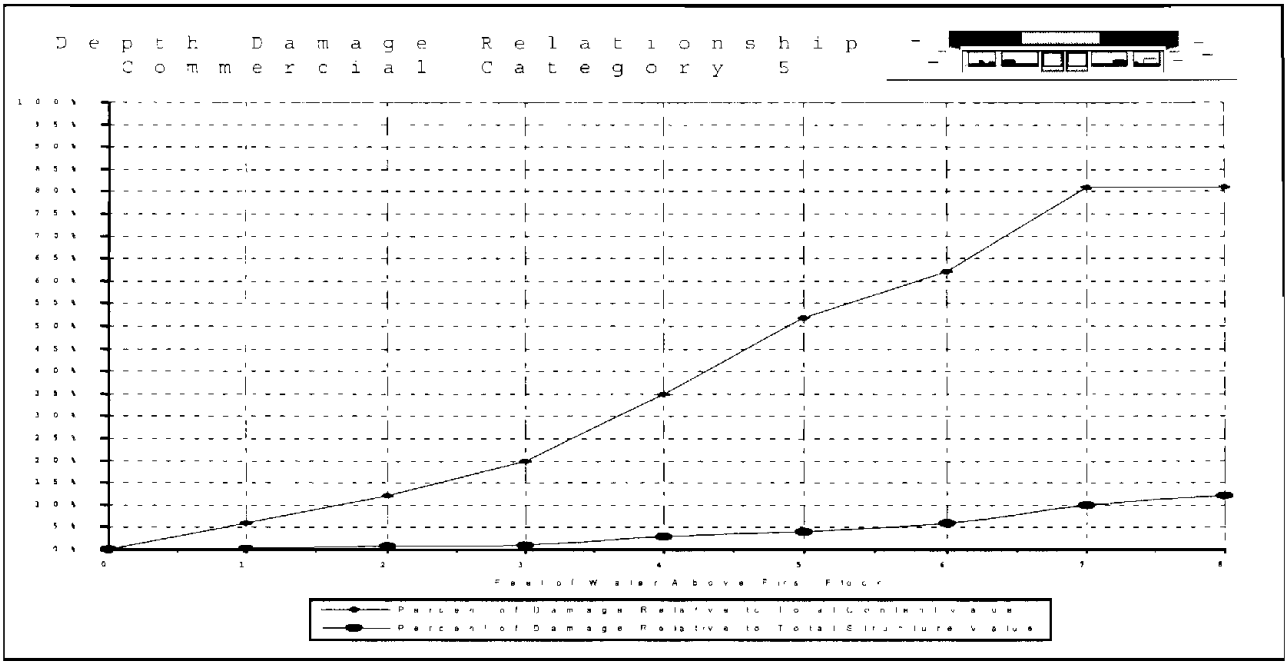


Figure E-8

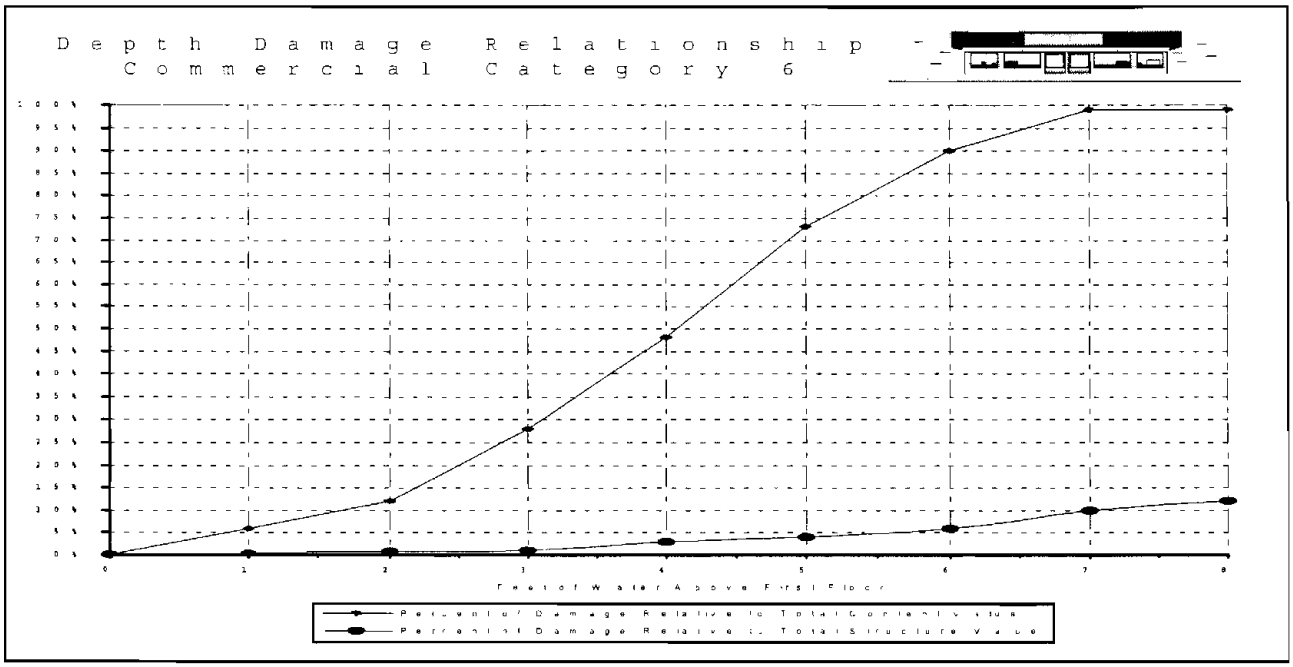


Figure E-9

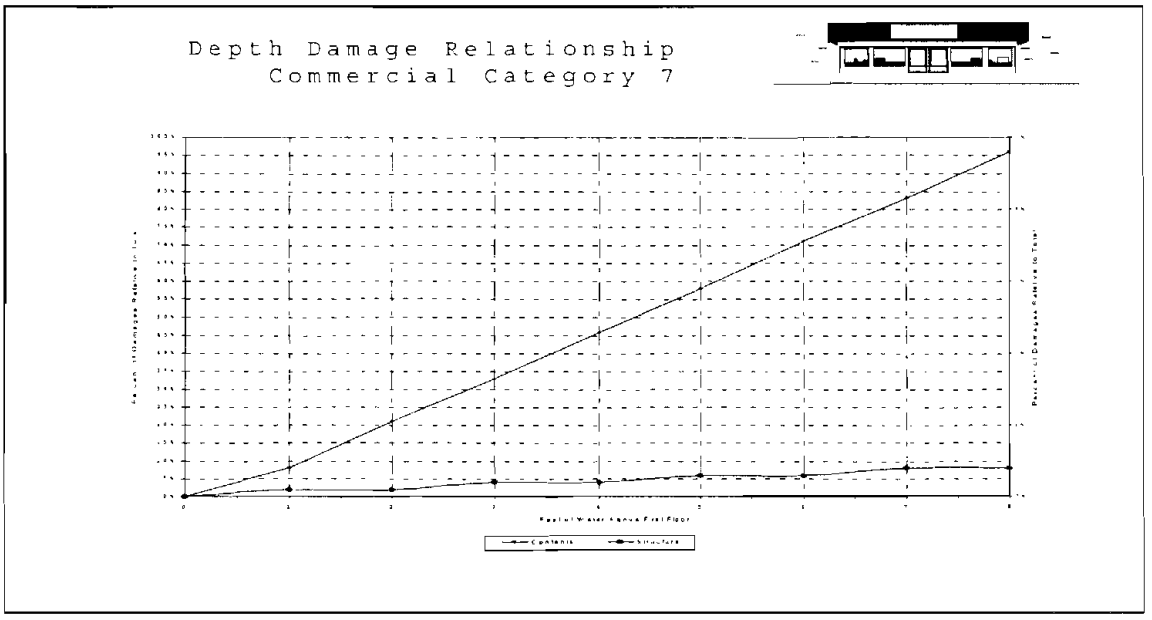


Figure E-10

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.

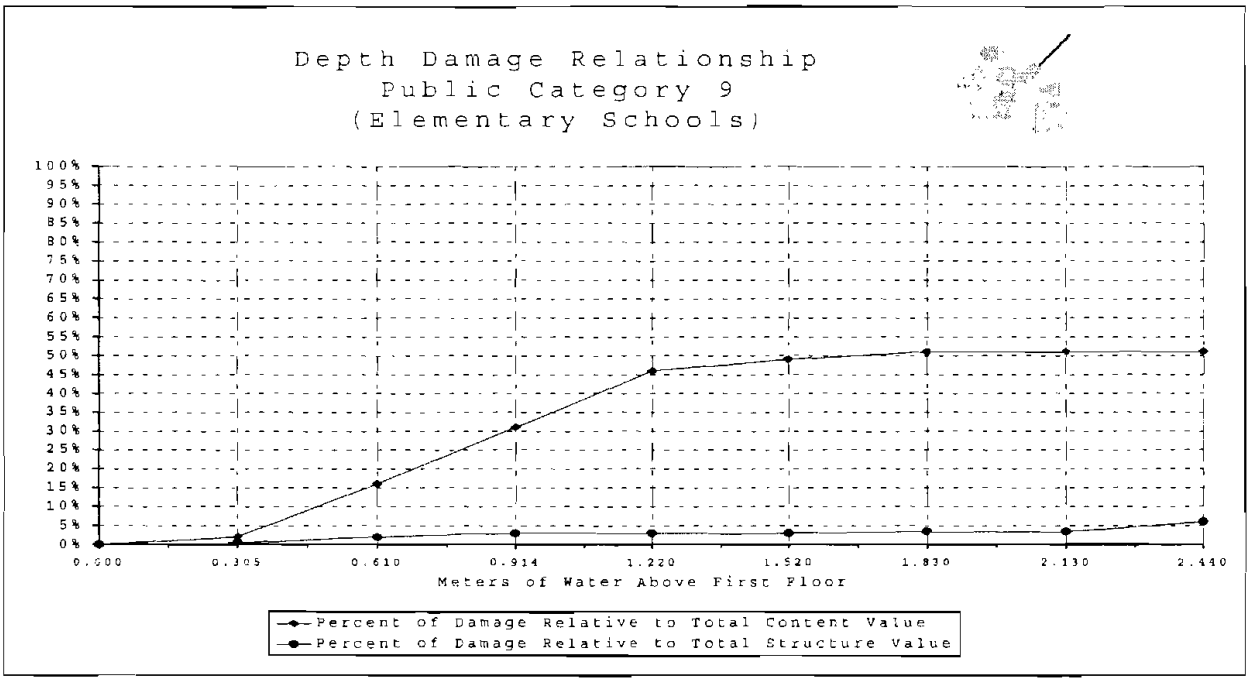


Figure E-11

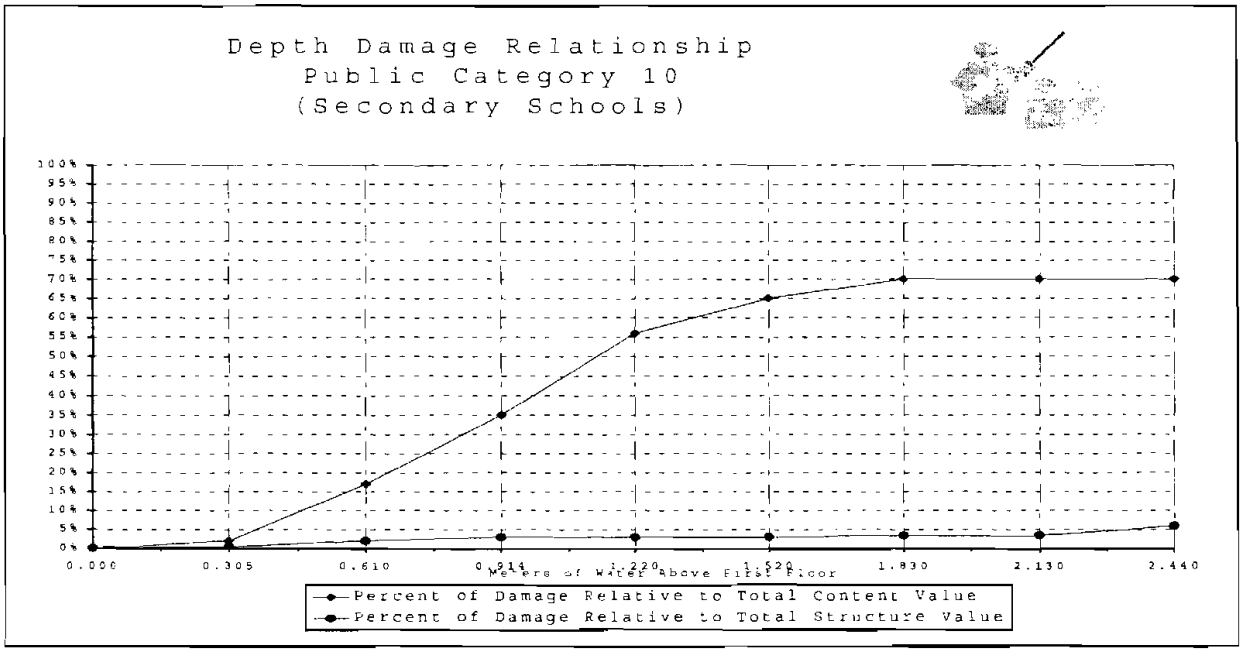


Figure E-12

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.

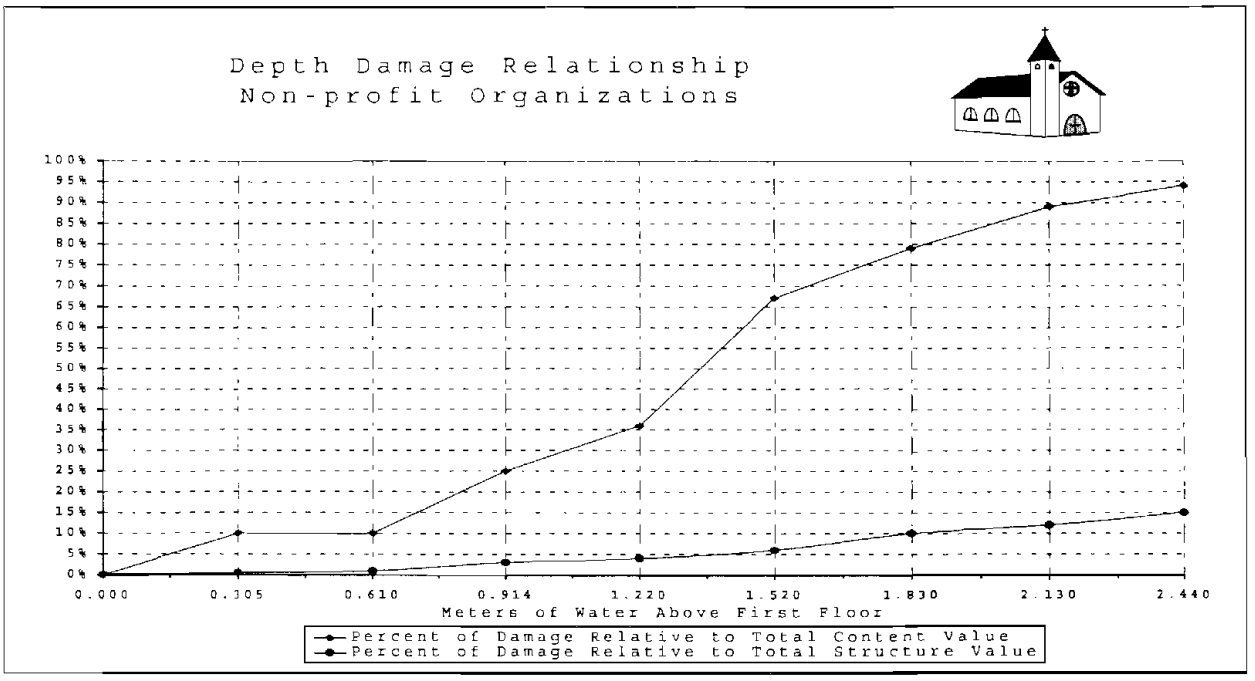


Figure E-13

F. Flood Damages

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 damages. 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 Damages 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 percent interest rate for the first 50 years of the project life. The final analysis for the recommended plan includes FY 2002 price levels discounted at 6 1/8 percent interest rate for the first 50 years of the project life.

a. Existing conditions (1999). 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 $12,245,000 for the 100-year flood.

Table E-10
FLOOD DAMAGES FOR SINGLE FLOOD EVENTS
WITHOUT PROJECT CONDITIONS
($1,000 of 1999)

Damage Category	Frequency (Years)						
	2	5	10	25	50	100	SPF
Residential	177	492	1,206	2,235	4,542	5,135	10,869
Commercial	94	105	239	406	4,040	4,322	4,338
Public	54	54	129	383	396	371	1,248
Nonprofit					3	12	43
Utilities	206	404	656	872	1,467	2,183	2,416
Streets and Highways		7	27	63	213	222	316
TOTAL	**531**	**1,062**	**2,257**	**3,959**	**10,661**	**12,245**	**19,230**

3. Expected annual flood damage. Expected annual damage for existing conditions (2001) 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 EXPECTED ANNUAL FLOOD DAMAGE EXISTING CONDITIONS ($ 1999)			
DAMAGE CATEGORY	**ESPINAR**	**AGUADILLA**	**AMOUNT**
Residential	$191.0	$322.5	$513.5
Commercial	2.0	274.3	276.3
Public	1.5	67.9	69.4
Nonprofit	0.2	0.2	0.4
Utilities	21.0	265.5	286.5
Streets and Highways	3.6	7.9	11.5
TOTAL EXPECTED ANNUAL DAMAGES	**219.3**	**938.3**	**1157.6**

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. 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 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 INUNDATION REDUCTION BENEFITS BY PLAN AND LAND USE ($1,000 of 2002)						
Land Use	SPF Levee		100 Year Levee		50 Year Levee	
	Damage Reduced	Residual Damage	Damage Reduced	Residual Damage	Damage Reduced	Residual Damage
Residential	513.6	0	461.5	52.0	408.2	105
Commercial	276.3	0	202.5	74.0	158.5	118
Public	69.4	0	62.3	7.1	58.2	11
Nonprofit	.4	0	.20	0	.32	0
Utilities	286.3	0	275.6	10.6	254.9	31
Streets & Highways	11.6	0	8.9	2.6	6.7	5
TOTALS	**1157.6**	**0**	**1011**	**146.3**	**886.8**	**270**

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. Between 1994 and 1998 it averaged about 14 percent. In comparison, for the U. S. it averaged less than 5 percent. Even though this average has been reduced to 10.8 for 2001 it continues to be a high rate of unemployment and remains as one of the major socioeconomic 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 2002 interest rate of 6 1/8 percent. The annual benefits over the 50-year life span of the project results in annual equivalent employment benefits of $22,000.

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 ($146) administration cost of each policy for FY 2002. This results in cost saved adding to $25,200 annually for the entire project.

C. Benefits and Costs Analysis

1. Costs. 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. Detailed discussion of items is shown in Appendix C, Design and Costs Estimates.

TABLE E-13

ECONOMIC COSTS OF ALTERNATIVE PLANS
($1,000 of 1999)

Cost Item	Structural Alternatives		
	SPF	100 Year	50 Year
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

2. Evaluation of final plans. The evaluation of final plans was performed following ER-1105-2-100 (Principles and Guidelines) procedures. 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. These plans were evaluated at 6 7/8, the prevailing interest rate at the time of analysis during FY 1999. The 100-year plan came out as the NED plan with a total first cost of $4,365,000, total net benefits of $453,600 and a B/C ratio of 2.0/1.0

3. The recommended plan. 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 6 1/8 percent, the prevailing interest rate for FY 2002. The economics of the recommended plan is shown in Table E-14. The total first cost of the plan is $4,365,000, net benefits are 453,600 and its B/C ratio is 2.4/1.0.

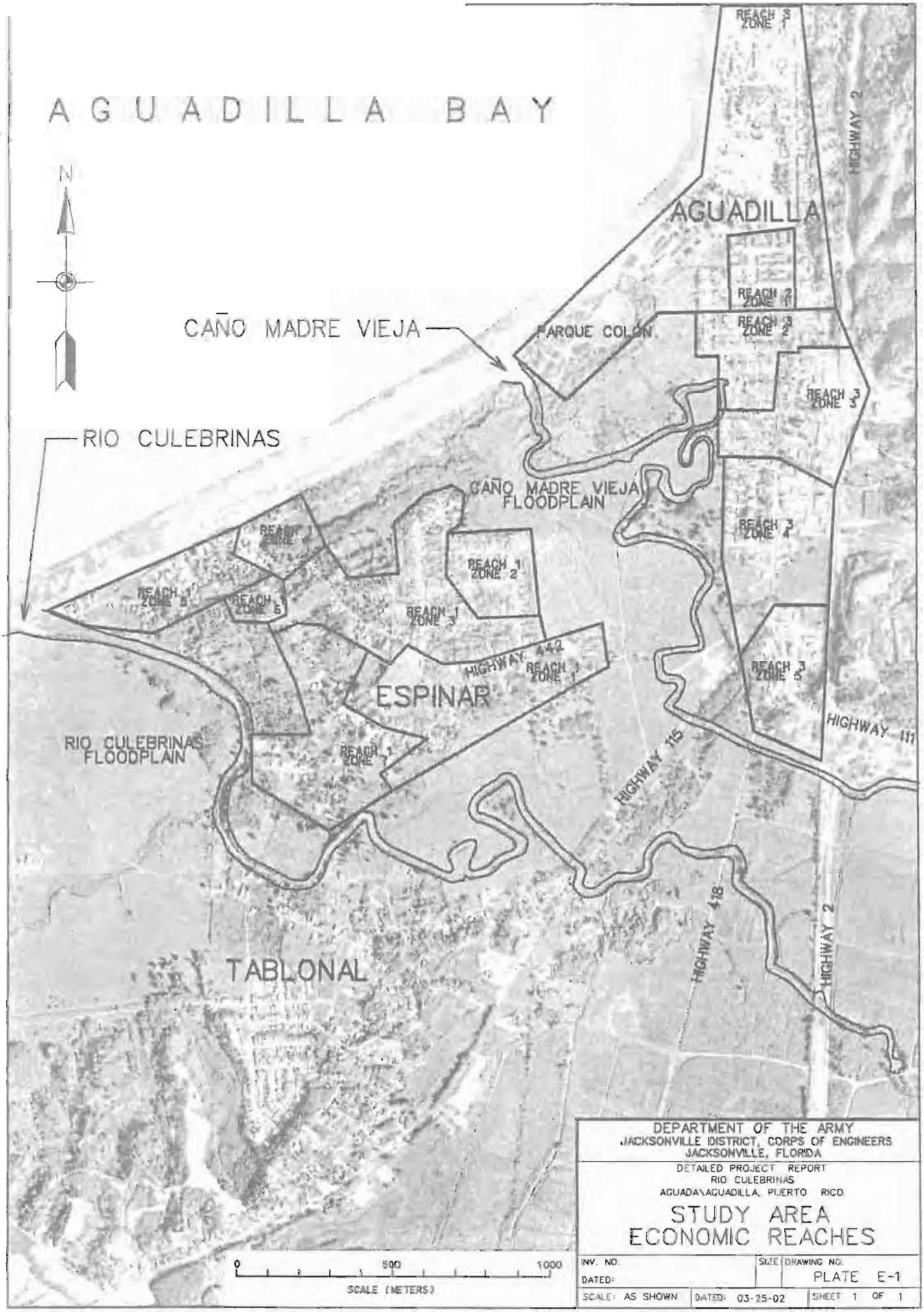
TABLE E-14

ECONOMICS OF THE RECOMMENDED PLAN

($1,000 of October 1999 for Project Costs and March 2002 for Benefits)

	ESPINAR LEVEE	AGUADILLA LEVEE	ENTIRE PROJECT
TOTAL FIRST COST[2]	1,734	2,749.0	4,483.0
Interest During Construction	35	74.4	109.4
TOTAL INVESTMENT COST	1,769	2,823.4	4,592.4
Interest and Amortization	114	182.3	296.5
Annual Operations & Maintenance	5.0	10.0	15.0
TOTAL ANNUAL COST	119	192.3	311.5
Annualized Benefits			
Inundation Reduction	219.1	938.4	1157.5
Employment	7.0	15.0	22.0
Flood Insurance Cost Savings	8.5	10.0	18.5
TOTAL ANNUAL BENEFITS	234.6	963.4	1198.0
Net NED Benefits	115.4	711.1	886.5
BENEFIT TO COST RATIO	2.0/1.0	5.0/1.0	3.9/1.0

[2] Do not include Cultural Resources Preservation.



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: 03-25-02		SHEET 1 OF 1