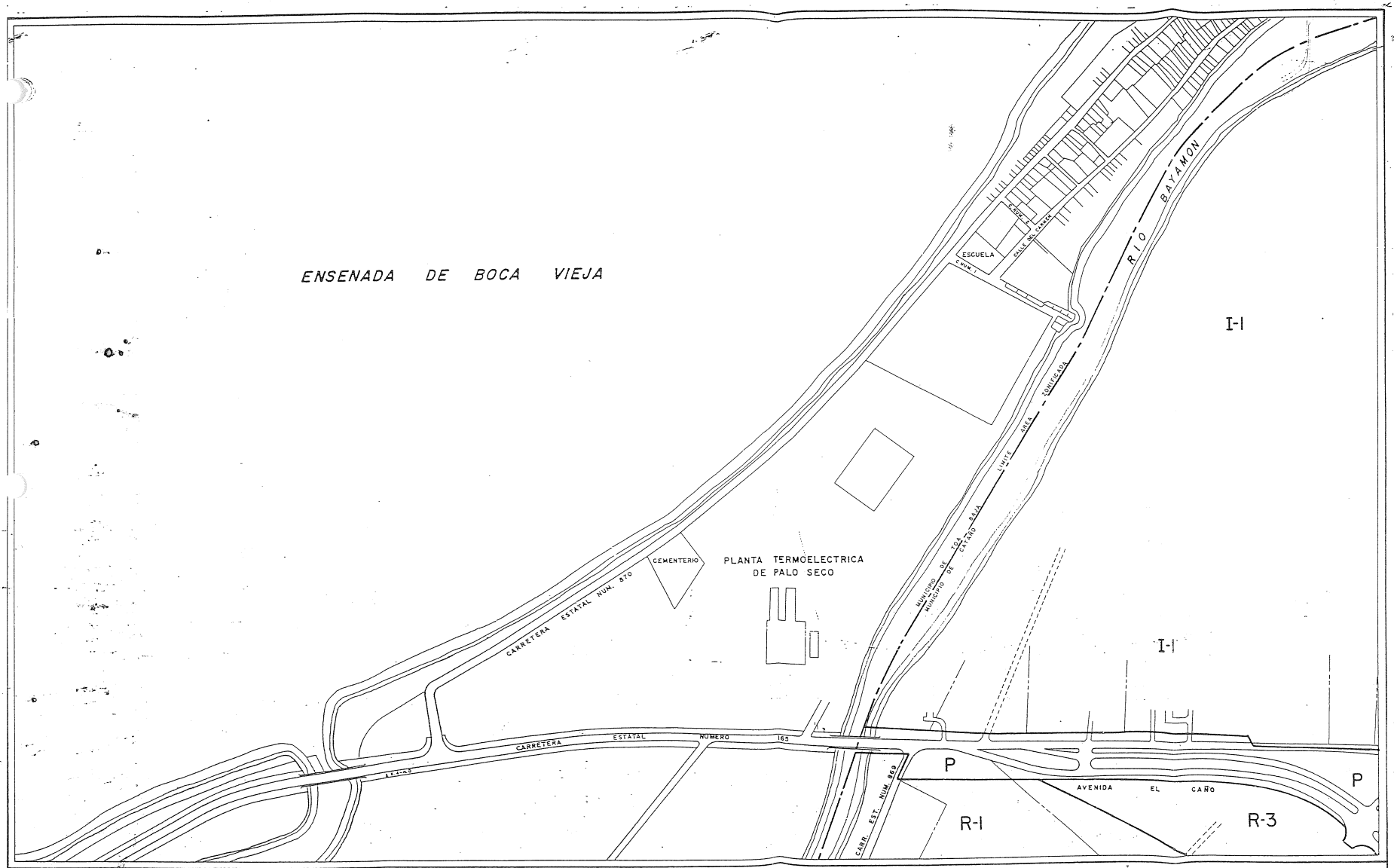
14.7 Mapas de Zonificación de Cataño
Hojas 4, 5, 7 y 8



CERTIFICACION

ADOPTADA POR LA JUNTA DE PLANIFICACION DE PUERTO RICO
RESOLUCION Z-6M 13 DE DICIEMBRE DE 1972

(FIRMADO)
TERESA BIAGGI LUGO
SECRETARIA

NOTA IMPORTANTE: La altura de las estructuras en los proyectos que se propongan abicar en los distritos incluidos en esta hoja, podrán quedar afectada por las zonas de encauzamiento de los componentes internacional de Isla Verde y de Isla Grande. Para determinar su grado de afectacion se debe consultar el Mapa de Zonificacion de Aeropuertos que forma parte de este Mapa de Zonificacion de Cataño como ultima hoja del mismo, segun aprobado por la Junta en 1 de Diciembre de 1976.

MAPA DE ZONIFICACION DE CATAÑO

HOJA NUMERO 4

SEGUN ENMENDADA EN: 13 DE DICIEMBRE DE 1972

VIGENCIA: 26 DE ENERO DE 1973

Certifico que esta es copia fiel y exacta del documento original y para que así conste, firma la presente en San Juan, Puerto Rico a 29 DE JULIO DE 1985

Secretaria

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	4	5
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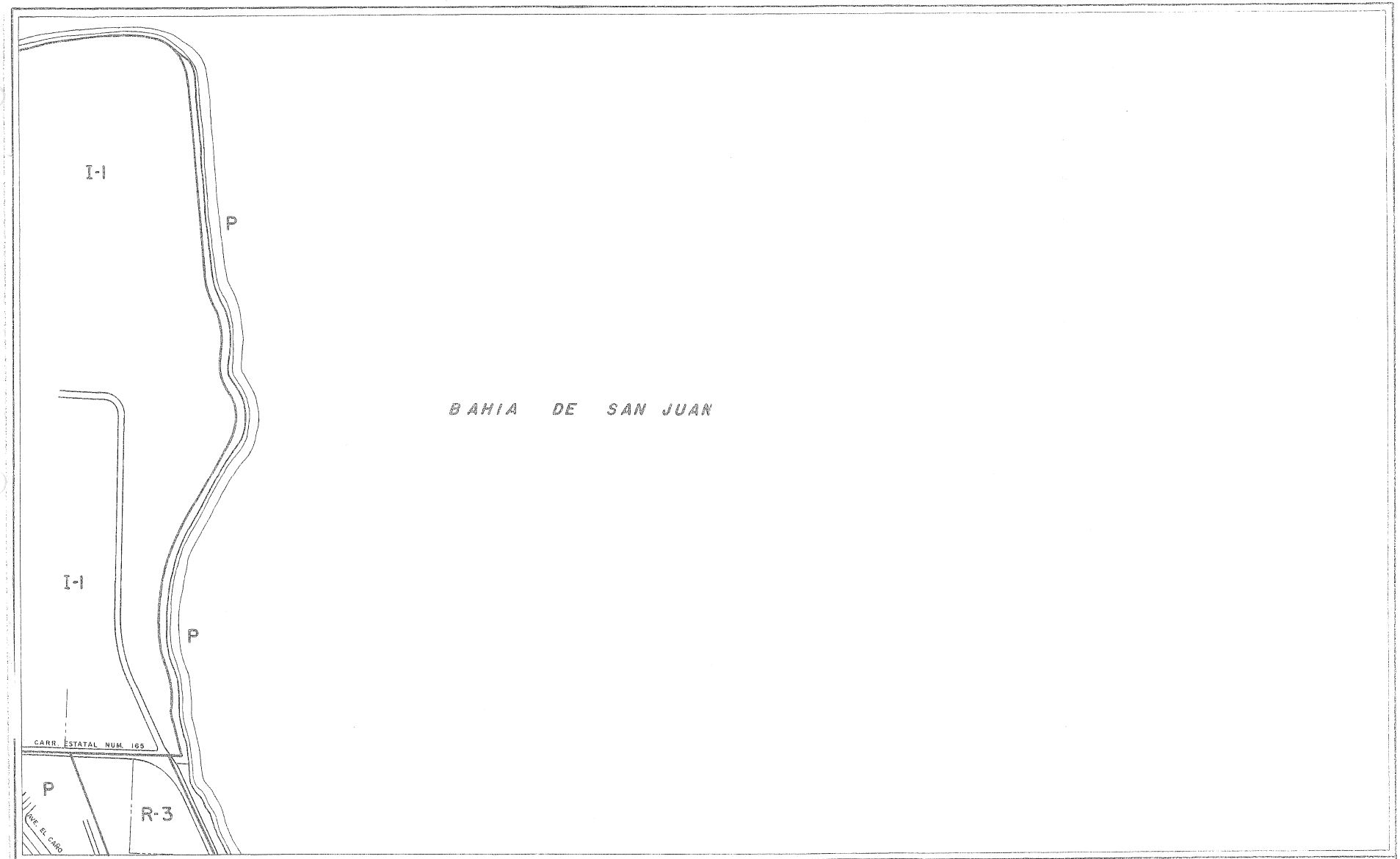
INDICE DE HOJAS ADYACENTES

ESCALA 1:2,000

HOJA NUMERO 4



CERTIFICACION
ADOPTADA POR LA JUNTA DE PLANIFICACION DE PUERTO RICO
RESOLUCION 2-6M 13 DE DICIEMBRE DE 1972

(FIRMADO)
TERESA BIAGGI LUGO
SECRETARIA

NOTA IMPORTANTE: La altura de las estructuras en los proyectos que se propongan ubicar en los distritos incluidos en esta hoja, podrán quedar afectada por las zonas de acercamiento de los aeropuertos Internacional de Isla Verde y de Isla Grande. Para determinar el grado de afectación se debe consultar el Mapa de Zonificación de Aeropuertos que forma parte de este Mapa de Zonificación de Cataño como último hoja del mismo, según aprobado por la Junta en 1 de Diciembre de 1976.

MAPA DE ZONIFICACION DE CATAÑO

HOJA NUMERO 5

SEGUN ENMENDADA EN: 13 DE DICIEMBRE DE 1972

VIGENCIA: 26 DE ENERO DE 1973

Certifico que esta es copia fiel y exacta del documento original y para que así conste, firmo la presente en San Juan, Puerto Rico a 29 DE JULIO DE 1985

Secretaria

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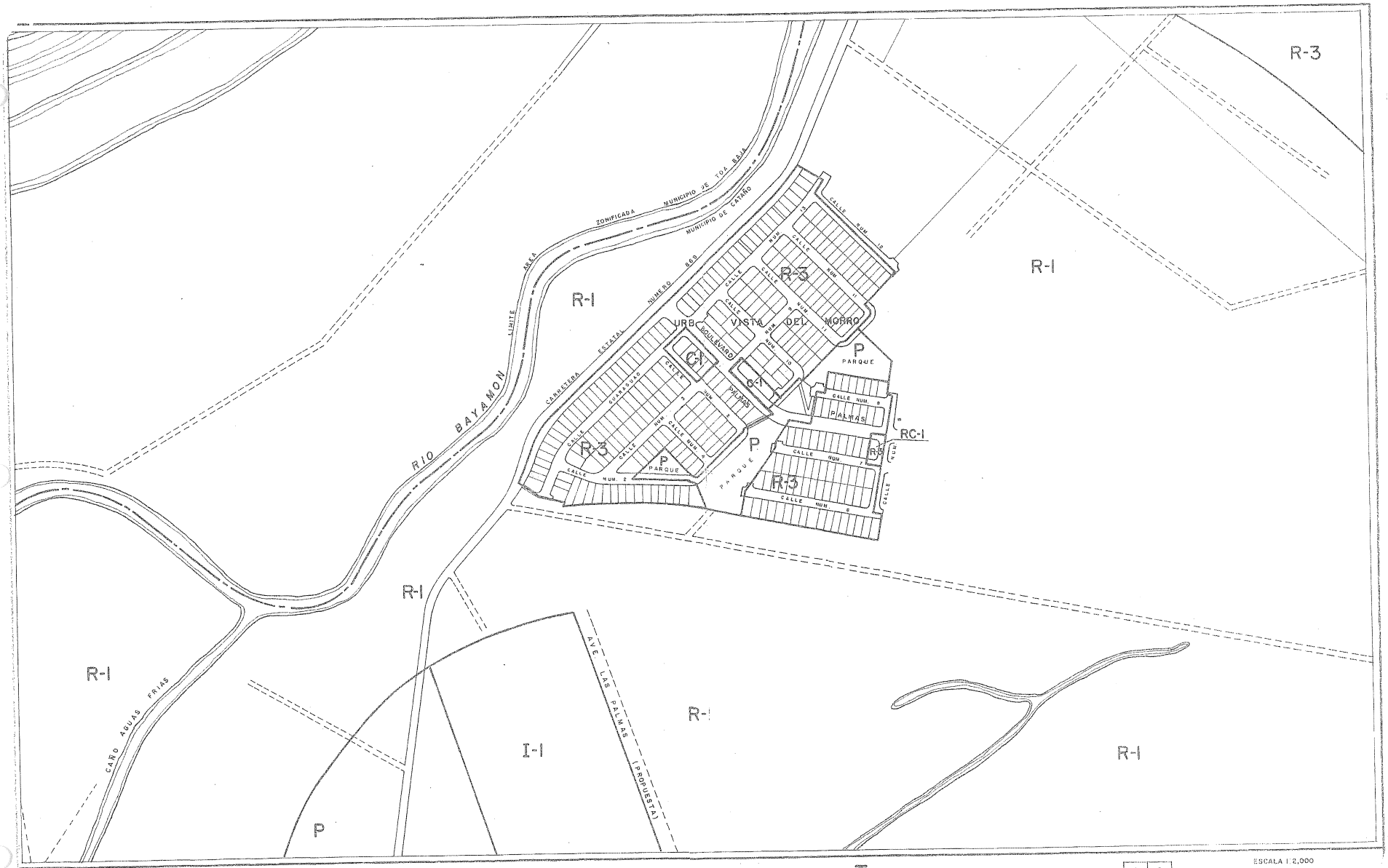
INDICE DE HOJAS ADYACENTES

ESCALA 1:2,000

HOJA NUMERO 5



CERTIFICACION

ADOPTADA POR LA JUNTA DE PLANIFICACION DE PUERTO RICO
RESOLUCION Z-6-A-5 17 DE ENERO DE 1990

MIRIAM ALMODOVAR
SECRETARIA

NOTA IMPORTANTE: La altura de las estructuras en los proyectos que se propongan ubicar en los distritos incluidos en esta hoja, podría quedar afectada por las zonas de acercamiento de los aeropuertos internacional de Isla Verde y de Isla Grande. Para determinar su grado de afectación se debe consultar el Mapa de Zonificación de Aeropuertos que forma parte de este Mapa de Zonificación de Cataño como última hoja del mismo, según aprobada por la Junta en 1 de Diciembre de 1970.

MAPA DE ZONIFICACION DE CATAÑO

HOJA NUMERO 7

SEGUN ENMENDADA EN 17 DE ENERO DE 1990

VIGENCIA 15 DE FEBRERO DE 1990

ESCALA 1:2,000

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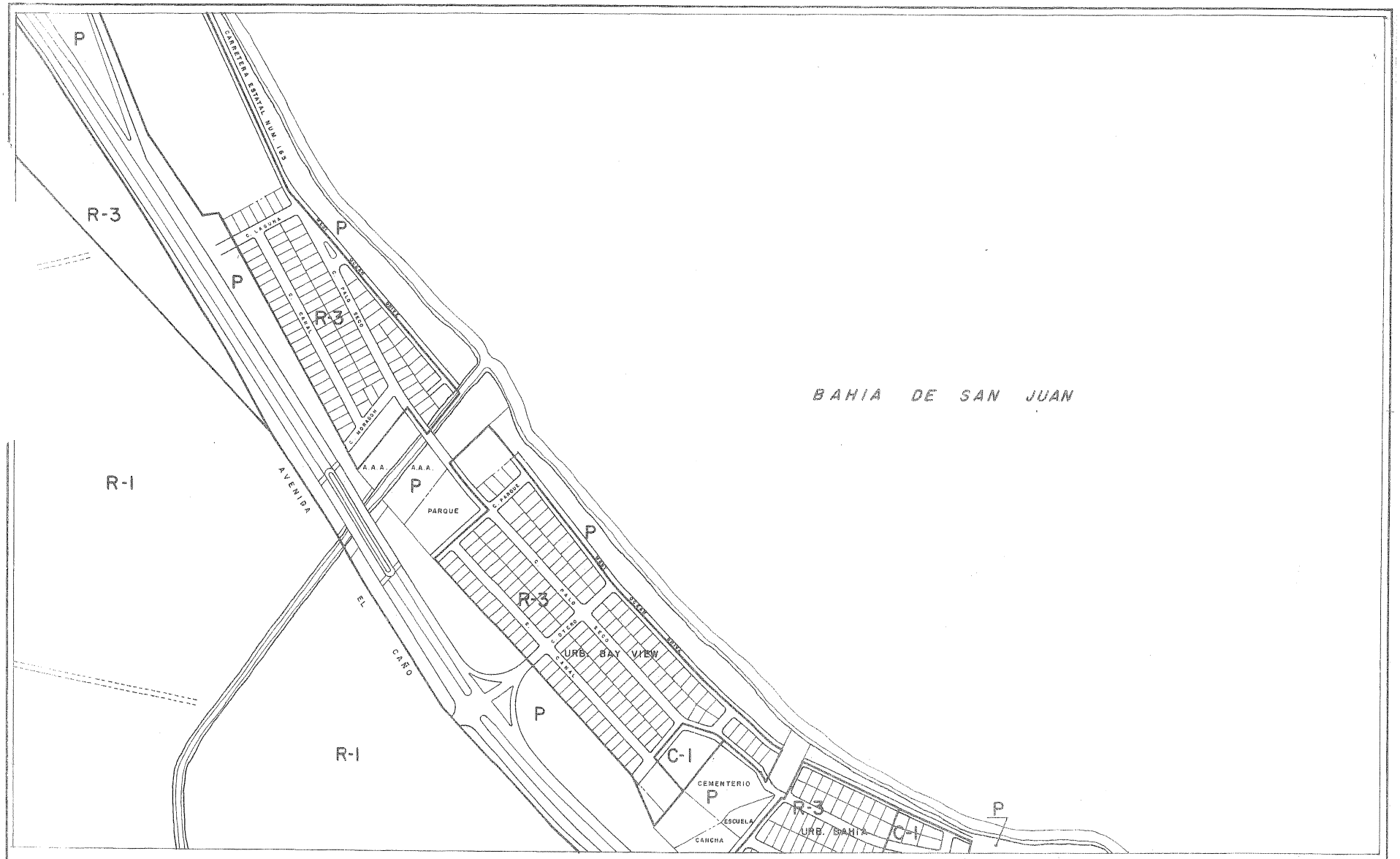
INDICE DE HOJAS ADYACENTES

HOJA NUMERO 7



CERTIFICACION
ADOPTADA POR LA JUNTA DE PLANIFICACION DE PUERTO RICO
RESOLUCION 76-M 13 DE DICIEMBRE DE 1972

FIRMADO
TERESA BIAGGI LUGO
SECRETARIA

NOTA IMPORTANTE: La altura de las estructuras en los proyectos que se propongan ubicar en los distritos incluidos en esta hoja, podría quedar afectada por las zonas de acercamiento de los aeropuertos Internacional de Isla Verde y de Isla Grande. Para determinar su grado de afectación se debe consultar el Mapa de Zonificación de Aeropuertos que forma parte de este Mapa de Zonificación de Cataño como última hoja del mismo, según aprobado por la Junta en 1 de Diciembre de 1976.

MAPA DE ZONIFICACION DE CATAÑO

HOJA NUMERO 8

SEGUN ENMENDADA EN: 13 DE DICIEMBRE DE 1972

VIGENCIA 26 DE ENERO DE 1973

Certifico que esta es copia fiel y exacta del documento original y para que así conste, firmo la presente en San José, Puerto Rico a 3 de abril de 1986.

Secretaria

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INDICE DE HOJAS ADJACENTES

ESCALA 1:2,000

HOJA NUMERO 8

14.8 Mapa de Inundaciones

ty map revision history prior to Commonwealth of Puerto Rico and Municipalities
er to the Community Map History table located in the Flood Insurance Study
s jurisdiction.

e if flood insurance is available in this community, contact your insurance
the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE
1:10,000

.25 0 .5
Kilometers

0 500 1000 1500 2000 2500 3000 3500
Feet

1/4 0 1/4
Miles

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0335H

FIRM
FLOOD INSURANCE RATE MAP

COMMONWEALTH OF
PUERTO RICO
AND MUNICIPALITIES

PANEL 335 OF 2160

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
PUERTO RICO	720000	0335	H

-NOTE-
THIS MAP INCORPORATES APPROXIMATE BOUNDARIES OF COASTAL BARRIER RESOURCES SYSTEM UNITS AND/OR OTHERWISE PROTECTED AREAS ESTABLISHED UNDER THE COASTAL BARRIER IMPROVEMENT ACT OF 1990 (PL 101-591).

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
72000C0335H

EFFECTIVE DATE
APRIL 19, 2005

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

14.9 Análisis Hidrológico-Hidráulico Preliminar

GAM Realty S.C, S.E

OFFICE AND STORAGE BUILDING FOR
CARIBBEAN RESTURANT L.L.C.
PR-165, PALMAS WARD, CATAÑO, PUERTO RICO

HYDROLOGIC – HYDRAULIC STUDY

Prepared by:

Roberto Rexach Cintrón & Associates

October 2007

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Appendix Q: Preliminary Storm Sewer System Profiles of the Second Hydraulic Model With the Corresponding Hydraulic Grade Lines (25-Year Return Period Storm Event)

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Appendix S: Porous Concrete Information

I. PROJECT SUMMARY

The project consists of the construction of two (2) warehouse buildings, each with a new parking lot, within a property located adjacent to State Road PR-165 at Palmas ward in Cataño, Puerto Rico. The property has been subdivided into three sections: north, middle, and south.

The first building is to be constructed within the north section of the property (Finca A), which is currently undeveloped. The building shall contain office and storage areas that will be rented to none-contaminant light industrial entities.

The second building is proposed to be located within the middle-south section of the property (Finca B). The middle-north area is currently developed and occupied by Casco Sales. The middle-south area is also currently undeveloped. The building shall consist of a steel, concrete, and cement block structure that shall contain offices and storage areas for Caribbean Restaurant LLC.

II. INTRODUCTION

A. Study Purpose

This study has been prepared to determine the hydrologic and hydraulic characteristics for both the existing and proposed conditions of the property described in section III.A of this report. The analysis made within this report shall be performed for both ordinary and extraordinary storm events. Also, the results from the analysis shall be used to determine what, if any, mitigation designs are needed to ensure that the proposed work does not cause any negative effects to the adjacent areas, which include the Cucharillas marchland.

Parallel to the efforts of this study, a Final Declaration of Environmental Impact (DIA-F) has been and is currently being evaluated by the Environmental Quality Board (EQB) of Puerto Rico.

B. Parties Involved

Owner:	Enrique Irizarry, Jr. (GAM Realty S.C., S.E.)
Developer:	Caribbean Restaurant LL.C.
Consultant:	Roberto Rexach Cintrón and Associates

C. Authorization

Enrique Irizarry, Jr., president of GAM Realty S.C., S.E., authorized Roberto Rexach Cintrón and Associates to prepare and submit all the documents necessary to obtain the required permits for this project. This authorization was given through a written letter dated January 29, 2002. A copy of this letter is included in **Appendix A** of this report.

III. STUDY DESCRIPTION

A. Project Location

The project property is located off of State Road PR-165 at Palmas Ward, Cataño (see **Figures 1** and **2**). Adjacent properties include:

North: State Road PR-165 and a Puerto Rico Electrical Power Administration (PREPA) right-of-way.
East: PREPA right-of-way and the Segarra Boerman and Sons Foundation.
South: Fuller Brush and the Segarra Boerman and Sons Foundation.
West: Las Palmas Boulevard, Fuller Brush, and the Segarra Boerman and Sons Foundation.

Access to the property is made through Las Palmas Boulevard.

Figure 1. Aerial photograph of the proposed project area.

Figure 2. San Juan Topographic Quadrangle (not to scale)

B. Existing Topography

The existing site is virtually flat with elevations[1] varying from 1.65-meters to 3.10-meters. The existing site was subdivided into five sub-areas so as to best define their properties. These are:

- **North Area**

  This 4.85-acres undeveloped area is placed along the north edge of the property. The surface area is currently covered in weed and gravel and is used to store heavy machinery. The area's direct runoff flows southwest towards Las Cucharillas marchland.

- **Middle-North Area**

  The area includes the existing Casco Sales building, a parking lot, and the access road. The direct runoff flow of this 4.24-acres area discharges into

[1] All elevations referenced within this report refer to mean sea level (MSL).

an inlet at the southwest edge of this area through a 30-inch pipe to a headwall.

- **Middle-West Area**

  This 0.69-acre undeveloped area has a mainly pasture type vegetation cover and it discharges runoff to the west edge of the property.

- **Middle-South Area**

  This area is located just south of the existing Casco Sales facilities. It has an area of 1.65-acres covered mainly in pasture. Direct runoff flows towards the Middle West Area.

- **South Area**

  The south side of the property has an area of 3.44-acres and consists mainly of dense grass and weeds. A creek enters this area at the southwest end of the property, turns south at an angle of approximately 90-degrees, and exits through the south end of the property.

C. Water Bodies

The south and southwest edges of the property are part of the Las Cucharillas marchland. This marchland is located west of the San Juan Bay and forms part of the San Juan Bay estuary. Las Cucharillas occupies an area of approximately 1,236-acres between Bayamón, Cataño, and Gaynabo. Las Cucharillas and the marchland's surrounding area drain to the San Juan Bay through the Malaria Channel.

The Las Cucharillas marchland is used for flood mitigation to the surrounding developments. It is also used to control erosion of the coastal areas, to recharge and discharge the subsoil, improve water and air quality, diminish noise effects, and as habitat for flora and fauna.

D. Current Flood Control System

Cataño is part of the hydrographical basin of the San Juan Bay estuary to which the Bayamón Rio forms part of. The estuary's basin is almost completely urbanized. Currently, part of this land area discharge runoff to the channel located along the south edge of the project's property (see south area description in section III.B). From there, runoff is discharged into the Las Cucharillas Marchland. A pump station is used to discharge flow from the marchland to the

San Juan Bay. The Department of Natural and Environmental Resources (DRNA) operates this pump station.

A diagram of the estuary system is shown below.

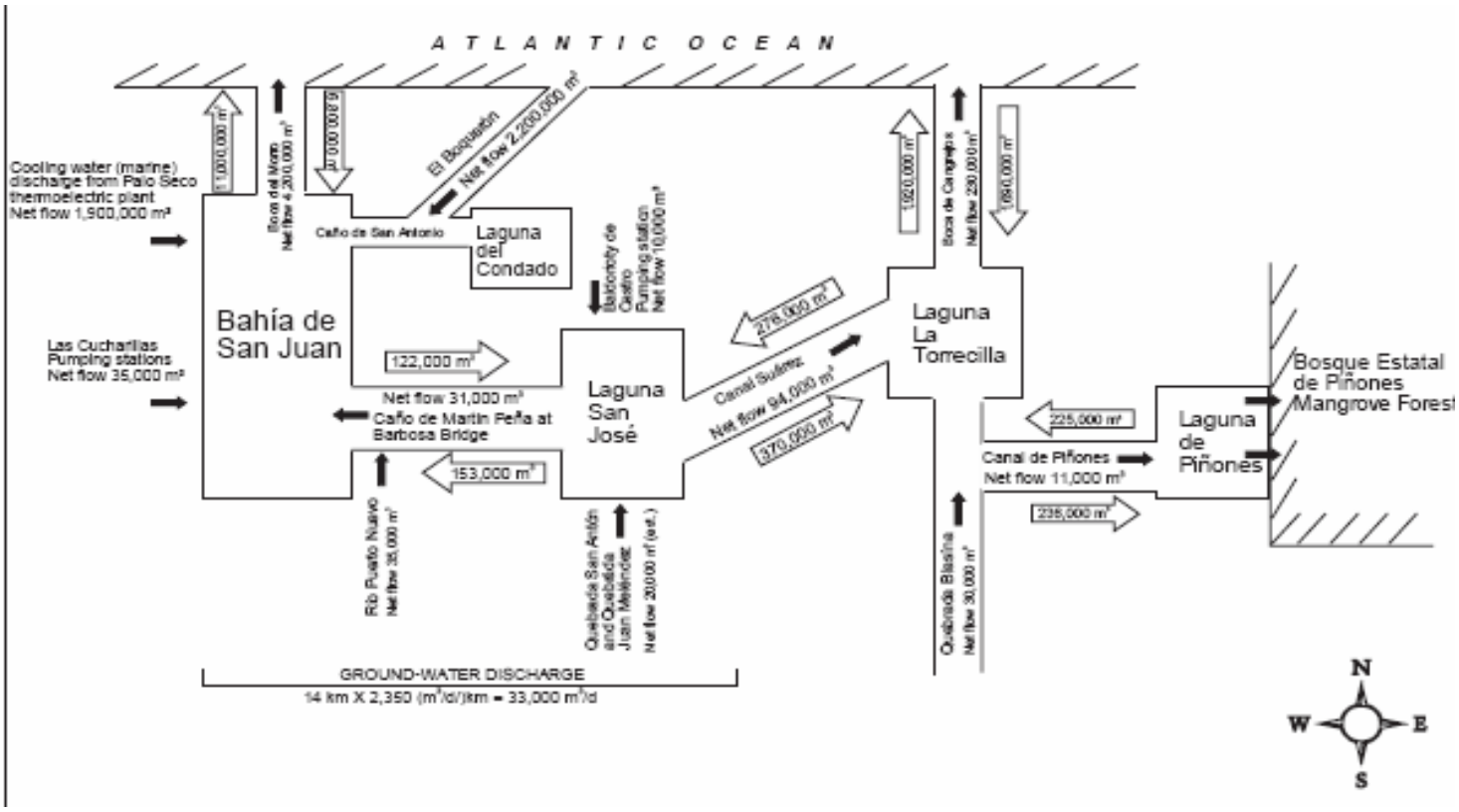

Figure 3. Average daily flows for dry weather conditions in the San Juan Bay estuary system.[2]

Figure 4 shows a map of the estuary system.

E. Study Level

This hydrologic – hydraulic study corresponds to a conceptual project design stage directed towards acquiring the DRNA's permit. The project design drawings shall be revised so as to incorporate all recommendations made in this report once it has been approved by DRNA.

[2] This flow diagram was obtained from *Synoptic Survey of Water Quality and Bottom Sediments, San Juan Bay Estuary System, Puerto Rico, December 1994 – July 1995* as prepared by the USGS in coordination with the PREQB and the USEPA.

Figure 4. San Juan Bay Estuary Map.

F. Proposed Project

The proposed project includes the construction of two steel, concrete, and cement block structures that will have both office and storage areas. Each building shall have a surrounding parking area and a loading deck. One of these structures shall be constructed on the North Area of the property and the other shall be built on the Middle South Area.

The building proposed for the North Area (Finca A) shall be rented to light industry entities. It will have a parking lot with 242 parking spaces. Access to this development shall be provided by the existing access road.

The building proposed for the Middle-South Area (Finca B) will have a 20,000-square feet office area and a 35,000-square feet storage area. The parking lot for this building will have 156 regular parking spaces and 10 trailer parking spaces. Access to this development shall be provided by a new access road that will be constructed along the southwest edge of the property. This road will have 1.50-meters wide planting and sidewalk at one side of the road.

Two new pipe alignments will collect direct runoff from the newly developed areas. These two new alignments will converge and discharge along the southwest edge of the property. Measures will be taken to maintain permeable areas. Also, both pipe alignments will have french drain sections so as to decrease the direct runoff discharge.

The proposed work requires minimal earth movement above FEMA's 100-year storm flood elevations (1.6-meters).

G. Scope of Study

This study has been prepared to determine the hydrologic and hydraulic characteristics for both the existing and proposed conditions of the property described in section III.A of this report. The analysis made within this report shall be used to determine what, if any, mitigation designs are needed to ensure that the proposed work does not cause any negative effects to the adjacent areas.

The new storm sewer system design shall be based on a 100-year frequency storm event as requested by the DRNA. It will be designed so as to not detriment the Las Cucharillas marchland or its drainage channels during ordinary or extraordinary storm events. This shall be done by ensuring and proving that discharge into the marchland will not increase due to the construction of the proposed facilities.

This study will not evaluate the overall hydrology or hydraulics of the Las Cucharillas marchland or its drainage channels since we do not expect there to be any changes to this existing storage and conveyance system.

H. Impacts Caused by this Project

All the expected impacts caused by this project have been discussed in the Final Environmental Impact Declaration (DIA-F). The most resent version of this DIA was submitted to the Puerto Rico Planning Board on May 2007. The impact discussions that relate to this hydrological – hydraulic study are summarized below. See the DIA-F for complete impacts discussions.

- **Storm drainage system impacts**

  The project area has two existing point discharges that shall be maintained. The net increase in the storm discharge was evaluated in this H-H study. The evaluation concluded that no increase in storm runoff discharge is expected. Sufficient storage and infiltration capacity will be provided to compensate for making the surface area more impermeable.

- **Soil cover impacts and mitigation measures**

  A fill of approximately 1,400-cubic yards is expected since a significant amount of the existing soil will need to be replaced as per the soils engineer. Proposed elevations at these areas will vary between 2.00-meters and 3.34-meters. The existing elevations throughout these areas area are also above 2.00-meters.

- **Erosion, sedimentation, and contamination impacts and mitigation measures**

  Temporary sedimentation mitigation structures and traps shall be built. These works shall consider the terrains specific conditions and characteristics. Proposed mitigation measures include: straw bales, silt fences, and brush barriers along with any other measure deemed necessary by the respective governmental agencies.

- **Property flood level impact**

  The existing topography is flat and classified as an AE Zone by FEMA's flood insurance maps. The flood elevation identified in these maps is 1.60-meters while the minimal existing and proposed elevations within the project areas is 2.00-meters.

- **Impacts to the Las Cucharillas marchland**

  The main impact to the Las Cucharillas marchland is the possible increase in storm water discharge. As such, this study is aimed at determining what measures will be required to ensure that the proposed storm discharge to the marchland is equal or smaller to the existing discharge.

  This project will not perform any work to any terrain that forms part of the Las Cucharillar marchland.

IV. PRLIMINARY EVALUATION

A. Site Inspection Observations

The north area of the property is currently being used for heavy and construction equipment parking (Casco Sales). The constant movement of this equipment appears to impair grass and weed growth in some areas. Some mud areas were observed.

The middle-south area is not being used. The land cover contains large patches of grass and weeds. A negligible amount of puddles and wet areas were observed.

Both areas are relatively flat with the storm draining mostly in a southwestern direction.

The photograph shown below was obtained from Google Earth. This photograph reflects the conditions observed during our last field visit.

Figure 5. Aerial photograph of the project area.

V. MITIGATION ALTERNATIVES

A. Available Mitigation Alternatives

Various Best Management Practices (BMPs) are available to mitigate the increase in direct runoff. These BMPs can be characterized by three methodological strategies used to control direct runoff. These are:

- Runoff detention strategies
- Runoff retention strategies
- Subsoil recharging strategies (can be used along with the detention and retention strategies)

Implementation of these methodological strategies is dependent on the site's properties, the available area to implement them, and the cost-benefits associated with them. Each of them are directed towards decreasing the direct runoff being discharged so that the impact of the proposed facilities do not impact the Las Cucharillas marchland.

1. Runoff Detention

This methodology requires the use of detention structures to store excess runoff on site and discharge it at flows that are not higher than the existing discharge. Detention structures include:

a. Surface detention ponds

These ponds are constructed above ground. Bottom and side covers can be either natural (ground, grass, etc) or structural (concrete, shotcrete, etc). The areas of these ponds are dependent on the available depth and storage requirements.

b. Underground detention ponds

These are installed underground. Excess storm water is allowed to be stored within the pipeline or other conveyance systems (arches, boxes, etc). Sizing of these systems is based on the storage capacity of the conveyance system and the storage requirements.

2. Runoff Retention

This mitigation strategy requires the use of retention structures to store the excess runoff on site. The retained excess runoff is stored and allowed to evaporate or infiltrate the soil.

a. Surface retention ponds

The detention ponds are constructed above ground. The bottom and side covers can be either natural (ground, grass, etc) or structural (concrete, shotcrete, etc). The area of these ponds tend to be much greater than for detention ponds since it is must have the capacity to store water for greater periods of time without discharging it.

3. Subsoil Recharging

This philosophy consists of capturing the storm runoff and recharging it into the subsoil.

a. Injection to subsoil aquifers

Water stored in detention ponds is injected directly to the aquifer. These systems require additional studies to determine the injection rate capacity.

b. Infiltration systems

The storm runoff is allowed to infiltrate through the use of various strategies. These include, but are not limited to: Infiltration basins or trenches, porous pavement and concrete grid pavement, and French drains.

A first hydrological run will be performed to determine which of these strategies are required. See Section VI.D of this report for discussion regarding the selection of mitigation strategies.

VI. HYDROLOGIC STUDY

The hydrologic study was performed simulating both the existing and proposed conditions. The discussions and models included below were made for both of these conditions.

A. Basin Model Data

1. Basin Delineation

a. Existing Conditions

The existing conditions basins were delineated following the subdivisions discussed in section III.B. Figure 5 shows the existing conditions model delineation:

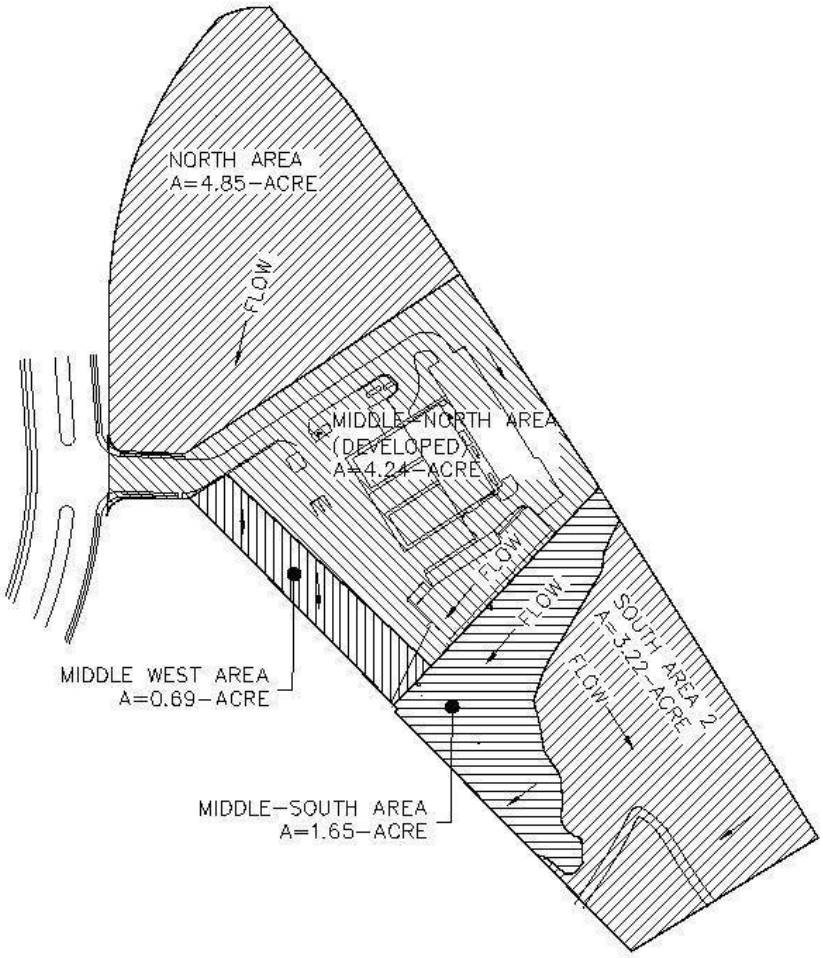

Figure 6. Existing Condition Model

b. Proposed Conditions

The proposed model was subdivided in accordance with the new drainage pattern and the corresponding pipe alignments. Figure 6 shows the proposed conditions model delineation. Note that parts of the existing condition's South Area and the Middle-South Area are now part of the South Warehouse North Area.

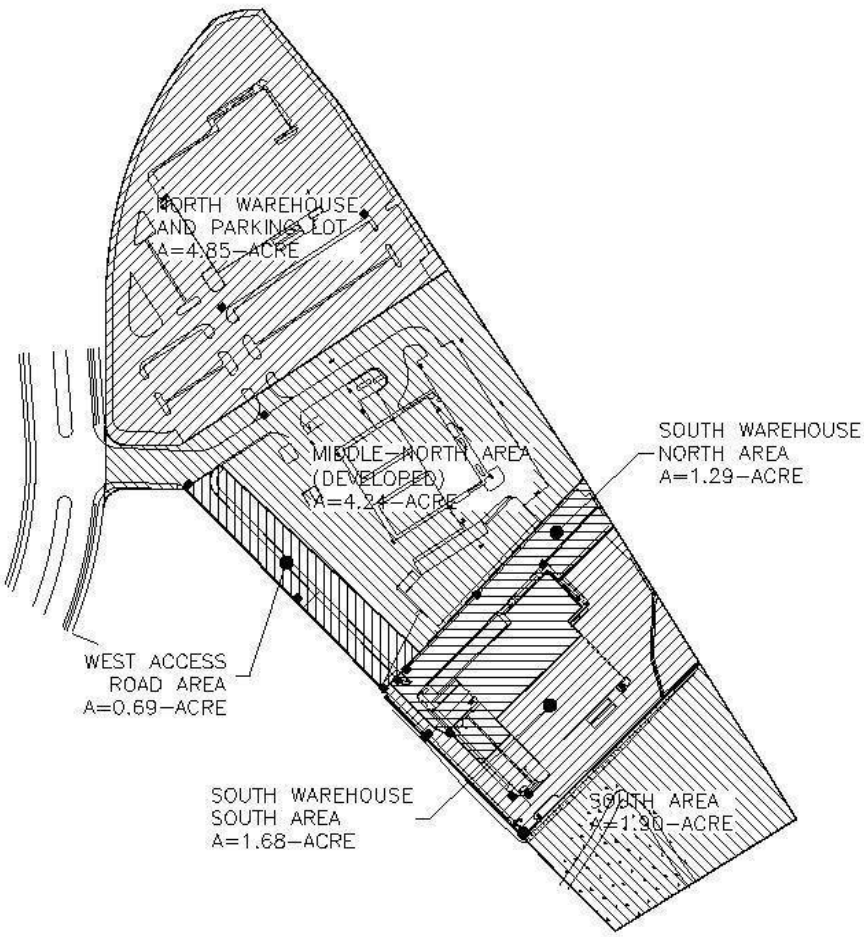

Figure 7. Proposed Conditions Model

2. Physical Data

a. Soil Survey Map

The National Resources Conservation Services (previously known as the Soil Conservation Services of the United States Department of Agriculture) published a series of soil surveys of Puerto Rico. The San

Juan Area soil survey sheet number 3 identifies the soil types within the project area.

The following extract from the soil survey map shows the project area with the existing conditions basin model imposed over it. As can be seen, most of the North Area and the access road are located within the Urban land-Durados complex area (Ud) while the rest of the site area is located within the Saladar muck (Sm) area.

Figure 8. Project area located within the Soil Map.

The Soil Survey Report provides the following information for these soil series:

Durados Series. Durados series soils consist of sandy, mixed, isohyperthermic Fluventic Hapludolls. These soils are excessively drained, and have dark grayish brown sandy loam Ap horizons over dark grayish brown loamy sand and sand C horizons. They formed in coarse textured materials which consist of san size shell fragments and miscellaneous volcanic subrounded fragments. Slope ranges from 0 to 2 percent.

Saladar Series. The Saladar series consists of euic, isoperthermic Fluvaquentic Trosposaprists. These soils are deep, are poorly drained, and have thick black muck O horizons. They formed in highly decomposed organic materials. Slope ranges from 0 to 2 percent.

Table 1. Engineering properties and classifications

Soil name and map symbol	Depth (in)	USDA Texture	Classification		Fragments > 3-in	Percent passing sieve number			
			Unified	AASHTO		4	10	40	200
Saladar: Sm	0-51	Muck	0H	-	0	-	-	-	-
Urband land, Durados part: Ud	0-14	Sandy loam	SM	A-2	0	100	100	60-70	25-35
	14-23	Loamy sand	SM	A-2	0	100	100	50-75	15-30
	23-60	Sandy loam	SP-SM, SM	A-2, A-3	0	95-100	75-100	50-70	5-15

Table 2. Physical and chemical properties

Soil name and map symbol	Depth (in)	Permeability (in/hr)	Available Water Cap. (in/in)	Soil Reaction	Shrink-Swell Potential	Risk of Corrosion	
						Uncoated Steel	Concrete
Saladar: Sm	0-51	0.06-0.2	0.15-0.20	6.6-7.8	Low	Moderate	Low
Urband land, Durados part: Ud	0-14	6.0-20	0.05-0.10	6.6-7.3	Low	Low	Low
	14-23	6.0-20	0.05-0.10	7.9-8.4	Low	Low	Low
	23-60	>20	<0.05	7.9-8.4	Low	Low	Low

b. Subsoil Exploration Report

Suelos Inc. performed a subsoil exploration study (see **Appendix B**). The goal of this study was to obtain and evaluate the physical properties of the subsurface soils at the project site. Six boreholes were drilled to a depth of 70-feet.

This study determined that the site where the south building is to be constructed (Middle-South Area) consists mainly of sand, sandy muck, clay, clayey sand, and sandy clay in various proportions.

The soil stratification is comprised of the following soil layers:

Table 3. Subsoil Exploration Findings

Stratum	Depths (feet)	Stratum Composition	SPT N-values (bpf)	Moisture Content (%)
First	4 to 8	Mostly fill material (brown silty clay mixed with sand and gravel).	7 to 42	20
Second	8 to 12	Organic silt and peat.	7 to 44	40-217
Third	30	Gray, silty coarse to fine sand	7 to 44	-
Fourth	30	Medium to stiff, brown lean to fat clays (sometimes sandy)	11 to 36	-
Fifth	50	Highly weathered limestone rock	76 and refusal	-

Groundwater level during the time of the exploration was measured varying between 7 and 10-feet, measured from the prevailing ground surface elevation. The report states that these reading cannot be considered invariant.

Suelos Inc. recommended the replacement of the weak solids with select fill material.

c. Land Use

The different areas are being used or will be used for the following functions:

Table 4. Terrain Land Use

Basin Area	Land Use
Exiting Conditions	
North Area	Large portion of this area is used to park heavy machinery.
Middle-North Area	Developed area (building and parking) used by Casco Sales.
Middle-South Area	Not used. Vegetation growth.
Middle-West Area	Not used. Vegetation growth.
South Area	Not used. Vegetation growth.
Proposed Conditions	
North Area	North warehouse with 242 parking spaces.
Middle-North Area	Developed area (building and parking) used by Casco Sales.
South Warehouse North Area	South warehouse with 156 parking spaces.
South Warehouse South Area	South warehouse with 10 trailer truck parking spaces.
West Access Road Area	Access road to the south warehouse.
South Area	Not used. Vegetation growth.

d. Land Cover

The following table summarizes the existing and proposed land cover.

Table 5. Existing and Proposed Land Cover

Basin Area	Total Area (acres)	Percent Land Cover				
		Concrete / Asphalt	Light Grass / Weed	Medium Grass / Weed	Dense Grass / Weed	Exposed Earth
Existing Conditions Model						
North Area	4.85	0	55	0	0	45
Middle-North Area	4.24	79	16	0	0	5
Middle-South Area	1.65	0	0	100	0	0
Middle-West Area	0.69	100	0	0	0	0
South Area	3.22	0	0	29	71	0
Total	14.65					
Proposed Conditions Model						
North Area	4.85	88	12	0	0	0
Middle-North Area	4.24	79	16	0	0	5
South Warehouse North Area	1.29	94	6	0	0	0
South Warehouse South Area	1.68	93	7	0	0	0
West Access Road Area	0.69	89	11	0	0	0
South Area	1.90	0	0	0	100	0
Total	14.65					

e. Runoff Coefficients

The land cover properties summarized above were used to obtain the corresponding Rational Method Runoff Coefficients (see justification discussion for the rational Method in Section VI.B.1). Table 6 lists the runoff coefficients, **C**, from which both the existing and proposed models were based. Note that these coefficients were obtained from Chow, Maidment, and Mays' *Applied Hydrology* (table 15.1.1). This list of coefficients were used to be consistent in their selection without having to choose the value within a range as is the case with both the FHA's Hydraulic Engineering Circular No.22 (HEC-22) and ACTs Highway design Manual.

Table 6.List of Runoff Coefficients for Rational Formula

Character of Surface	Return Period (years)						
	2	5	10	25	50	100	500
Developed							
Asphaltic	0.73	0.77	0.81	0.86	0.90	0.95	1.00
Concrete/roof	0.75	0.80	0.83	0.88	0.92	0.97	1.00
Grass areas (lawns, parks, etc.)							
Poor condition (grass cover less than 50% of the area)							
Flat, 0-2%	0.32	0.34	0.37	0.40	0.44	0.47	0.58
Average, 2-7%	0.37	0.40	0.43	0.46	0.49	0.53	0.61
Steep, over 7%	0.40	0.41	0.45	0.49	0.52	0.55	0.62
Fair condition (grass cover on 50% to 75% of the aera)							
Flat, 0-2%	0.25	0.28	0.30	0.34	0.37	0.41	0.53
Average, 2-7%	0.33	0.36	0.38	0.42	0.45	0.49	0.58
Steep, over 7%	0.37	0.40	0.42	0.46	0.49	0.53	0.60
Good condition (grass cover larger than 75% of the area)							
Flat, 0-2%	0.21	0.23	0.25	0.29	0.32	0.36	0.49
Average, 2-7%	0.29	0.32	0.35	0.39	0.42	0.46	0.56
Steep, over 7%	0.34	0.37	0.40	0.44	0.47	0.51	0.58
Undeveloped							
Cultivated Land							
Flat, 0-2%	0.31	0.34	0.36	0.40	0.43	0.47	0.57
Average, 2-7%	0.35	0.38	0.41	0.44	0.48	0.51	0.60
Steep, over 7%	0.39	0.42	0.44	0.48	0.51	0.54	0.61
Pasture / Range							
Flat, 0-2%	0.25	0.28	0.30	0.34	0.37	0.41	0.53
Average, 2-7%	0.33	0.36	0.38	0.42	0.45	0.49	0.58
Steep, over 7%	0.37	0.40	0.42	0.46	0.49	0.53	0.60
Forest / Woodlands							
Flat, 0-2%	0.22	0.25	0.28	0.31	0.35	0.39	0.48
Average, 2-7%	0.31	0.34	0.36	0.40	0.43	0.47	0.56
Steep, over 7%	0.35	0.39	0.41	0.45	0.48	0.52	0.58

Table 7 lists the weighted **C** values used for both models. In all cases, the terrain was considered to be flat (0-2% slopes). Also, we considered the South Area on both conditions to be undeveloped and the remaining areas to be developed.

Table 7. Weighted Runoff Coefficient for Both Existing and Proposed Conditions for a 25-Year Return Period Event

Basin Area	Concrete / Asphalt		Poor Grass		Fair Grass		Good Grass		Total / Weighted	
	C	%	C	%	C	%	C	%	C	%
Existing Conditions Model										
North Area	0.87	0	0.4	100	0.34	0	0.29	0	**0.40**	100
Middle-North Area	0.87	79	0.4	0	0.34	21	0.29	0	**0.76**	100
Middle-South Area	0.87	0	0.4	0	0.34	100	0.29	0	**0.34**	100
Middle-West Area	0.87	100	0.4	0	0.34	0	0.29	0	**0.87**	100
South Area	0.87	0	0.4	0	0.34	0	0.34	100	**0.34**	100
Proposed Conditions Model										
North Area	0.87	59	0.4	0	0.34	0	0.29	41	**0.63**	100
Middle-North Area	0.87	79	0.4	0	0.34	21	0.29	0	**0.76**	100
South Warehouse North Area	0.87	47	0.4	0	0.34	0	0.29	53	**0.56**	100
South Warehouse South Area	0.87	92.9	0.4	0	0.34	0	0.29	7	**0.829**	100
West Access Road Area	0.87	89	0.4	0	0.34	0	0.29	11	**0.81**	100
South Area	0.87	0	0.4	0	0.34	0	0.34	100	**0.34**	100

Table 8. Weighted Runoff Coefficient for Both Existing and Proposed Conditions for a 100-Year Return Period Event

Basin Area	Concrete / Asphalt		Poor Grass		Fair Grass		Good Grass		Total / Weighted	
	C	%	C	%	C	%	C	%	C	%
Existing Conditions Model										
North Area	0.96	0	0.47	100	0.41	0	0.32	0	**0.47**	100
Middle-North Area	0.96	79	0.47	0	0.41	21	0.32	0	**0.84**	100
Middle-South Area	0.96	0	0.47	0	0.41	100	0.32	0	**0.41**	100
Middle-West Area	0.96	100	0.47	0	0.41	0	0.32	0	**0.96**	100
South Area	0.96	0	0.41	0	0.41	0	0.41	100	**0.41**	100
Proposed Conditions Model										
North Area	0.96	88	0.47	0	0.41	0	0.32	12	**0.88**	100
Middle-North Area	0.96	79	0.47	0	0.41	21	0.32	0	**0.84**	100
South Warehouse North Area	0.96	94	0.47	0	0.41	0	0.32	6	**0.92**	100
South Warehouse South Area	0.96	93	0.47	0	0.41	0	0.32	7	**0.92**	100
West Access Road Area	0.96	89	0.47	0	0.41	0	0.32	11	**0.89**	100
South Area	0.96	0	0.41	0	0.41	0	0.41	100	**0.41**	100