

Puerto Rico Soils Classification Map

INTRODUCTION:

This document is a compilation of Soil Type Classification Maps according to the 1994 National Earthquake Hazard Reduction Program (NEHRP, 1994), which was adopted by the 1997 Uniform Building Code (UBC, 1997) and later by modern codes. This work includes maps for the municipalities of Arecibo (split into 5 segments), Caguas (1 segment), Humacao (7 segments), Mayagüez (6 segments), Ponce (5 segments) and San Juan Metropolitan Area (SJMA) (22 segments), which includes Bayamón, Carolina, Cataño, Guaynabo, San Juan, Toa Baja, and Trujillo Alto municipalities.

OBJECTIVE:

The Civil Engineering and Surveying Department at the University of Puerto Rico in Mayaguez (UPRM) prepared the present maps originally for the Puerto Rico Insurance Commissioner's Office. These maps can be used to estimate the Soil Profile Type at the site where structures have to be evaluated to obtain their Probable Maximum Loss (PML). Under no circumstances the Soil Profile Type provided in these maps will substitute the Soil Profile Type obtained by geotechnical investigation or subsurface explorations performed by professional in the Geotechnical Engineering field. Therefore, the Soil Profile Type supplied in these maps should be used as a default value and in the lack of specific site studies. These maps are already included in the INSOL software developed by UPRM to calculate the PML.

Table 1. Soil Profile Type according to NEHRP.

Soil Profile Type	Soil Profile Name/Generic Description	Average Soil Properties for top 30 m of Soil Profile		
		Shear Wave Velocity (m/s)	Standard Penetration Test (N)	Undrained Shear Strength (kPa)
S_A	Hard Rock	> 1500		
S_B	Rock	760 to 1500		
S_C	Very Dense Soils and Soft Rock	360 to 760	> 50	> 100
S_D	Stiff Soil Profile	180 to 360	15 to 50	50 to 100
S_E	Stiff Soil Profile	< 180	< 15	< 50
S_F	Soil Requiring Site-specific Evaluation			

MAPS EXPLANATION:

Consider the segment 2-2 from San Juan Metropolitan Area (page 33) as an example. It can be observed that it has six frames at right; these explain the map content and its metadata. The information provided by these frames is:

- ★ The first frame establishes that the map was developed by the Puerto Rico Strong Motion Program under the Civil Engineering and Surveying Department at the University of Puerto Rico in Mayaguez (UPRM).
- ★ The second frame presents the municipality location to which the current map belongs; the municipalities could be Arecibo, Caguas, Humacao, Mayagüez, Ponce, or the San Juan Metropolitan Area. For the purposes of the example, this map belongs to the San Juan Metropolitan Area.
- ★ The third frame presents the segments in which the municipality or the San Juan Metropolitan Area was split, and the number assigned to each segment. The segment for the current map is drawn with yellow and red diagonal lines.
- ★ The fourth frame presents the color assigned to each Soil Profile Type in the map. Soil Type C (S_C) is blue, Soil Type D (S_D) is green, Soil Type E (S_E) is yellow, and Soil Type F (S_F) is red, note that no map has Soil Type A (S_A) nor B (S_B).
- ★ The fifth frame presents the map scale 1:20000. This means 1 centimeter in the map corresponds to 20,000 centimeters (200 meters) over the field. North American Datum from 1983 (NAO 83) was the spatial reference used in the maps.
- ★ The sixth frame presents the disclaimer; it establishes that the use of these maps is not a substitute for the proper geotechnical investigations nor surface explorations.

The main map shows the assigned segment number at the center. The adjacent segments are also identified and separated by thick, straight and black lines. The Soil Profile Type is indicated by the hatch color area and by its corresponding letter. The municipality divisions are shown by thin and black lines. The number inside a circle indicates the street or avenue number.

KNOWLEDGMENT:

The following graduate students worked in the preparation of these maps: Arturo Llavona (Mayaguez), Joanna Cataño (Ponce), Edwin Gutiérrez (Humacao), Álvaro Bernal (Caguas and SJMA), Amabelle Aponte (SJMA), Andrea Carolina Paredes (SJMA), Sixto Fernández (SJMA), and Alan Rivera (Arecibo). In addition, the graduate student Guillermo Gerbaudo set in the maps in the software INSOL. These students worked under the supervision of professors Miguel A. Pando, Luis E. Suárez, Ricardo Ramos, Ali Saffar, and José A. Martínez-Cruzado. Also, it has to be recognized that many undergraduate students collaborated to acquire the data for the preparation of the maps. Finally, thanks to the geotechnical companies and agencies that supplied data to develop the maps. These are: Jaca & Sierra, Geo-Cim, Western Soils, Despiiau Associates, Geo Engineering, Geo Consult, Geo Practica, Advanced Soil Engineering, Víctor Rivera & Asoc., Caribbean Soils Eng., Ponce I & M Engineering Lab., Puerto Rico Highways & Transportation Authority, and Public Building Authority.

Programa de Movimiento Fuerte de Puerto Rico
Departamento de Ingeniería Civil y Agrimensura
Universidad de Puerto Rico, Recinto Universitario de Mayagüez

Mapa de Clasificación de Suelos de Puerto Rico

INTRODUCCIÓN:

Este documento es una recopilación de Mapas de la Clasificación de Tipos de Suelos según el Programa Nacional de Reducción de Peligrosidad Sísmica de 1994 (NEHRP, 1994), clasificación que fue adoptada por el Código de Edificación Uniforme de 1997 (UBC, 1997) y luego por códigos más modernos. Se incluyen los mapas para las ciudades de Arecibo (subdividido en 5 segmentos), Caguas (1 segmento), Humacao (7 segmentos), Mayagüez (6 segmentos), Ponce (5 segmentos) y la Zona Metropolitana de San Juan (ZMSJ) (22 segmentos), que a su vez incluye los municipios de Bayamón, Carolina, Cataño, Guaynabo, San Juan, Toa Baja y Trujillo Alto.

OBJETIVO:

Estos mapas han sido delineados por el Departamento de Ingeniería Civil y Agrimensura de la Universidad de Puerto Rico en Mayagüez (UPRM) originalmente para la Oficina del Comisionado de Seguros de Puerto Rico. Los mapas han de utilizarse como un estimado del Tipo de Suelo donde se hallen cimentadas las propiedades a ser evaluadas para obtener la Perdida Máxima Probable (PML). En ningún momento la Clasificación del Tipo de Suelo provista en estos mapas substituirá la Clasificación del Tipo de Suelo del lote de interés determinada por profesionales en el área de la Ingeniería Geotécnica, de modo que la Clasificación del Tipo de Suelo provista en estos mapas se utilizará como un valor inicial y en ausencia de estudios de suelos particulares. Estos mapas están de antemano considerados de forma automática en el Programa de Computadora INSOL que preparó la UPRM para el cálculo del PML.

Tabla 1. Clasificación de Suelos según NEHRP.

Tipo de Perfil de Suelo	Nombre del Perfil de Suelo	Propiedades promedio de los suelos para los 30 m superiores del perfil		
		Velocidad de la Onda de Corte (m/s)	Prueba de Penetración Estándar (N)	Resistencia al Cortante no Drenada (kPa)
S _A	Roca Dura	> 1500		
S _B	Roca	760 to 1500		
S _C	Suelo Bien Denso y Roca Blanda	360 to 760	> 50	> 100
S _D	Perfil de Suelo Rígido	180 to 360	15 to 50	50 to 100
S _E	Perfil de Suelo Rígido	< 180	< 15	< 50
S _F	Suelos que requieren una evaluación específica del lugar			

EXPLICACIÓN DE LOS MAPAS:

Tomando a modo de ejemplo el Segmento 2-2 del Mapa de la Zona Metropolitana de San Juan (página 33) se observa que el mismo contiene una columna de seis recuadros a mano derecha que explican el contenido del mapa y sus metadatos; la información de estos recuadros es la siguiente:

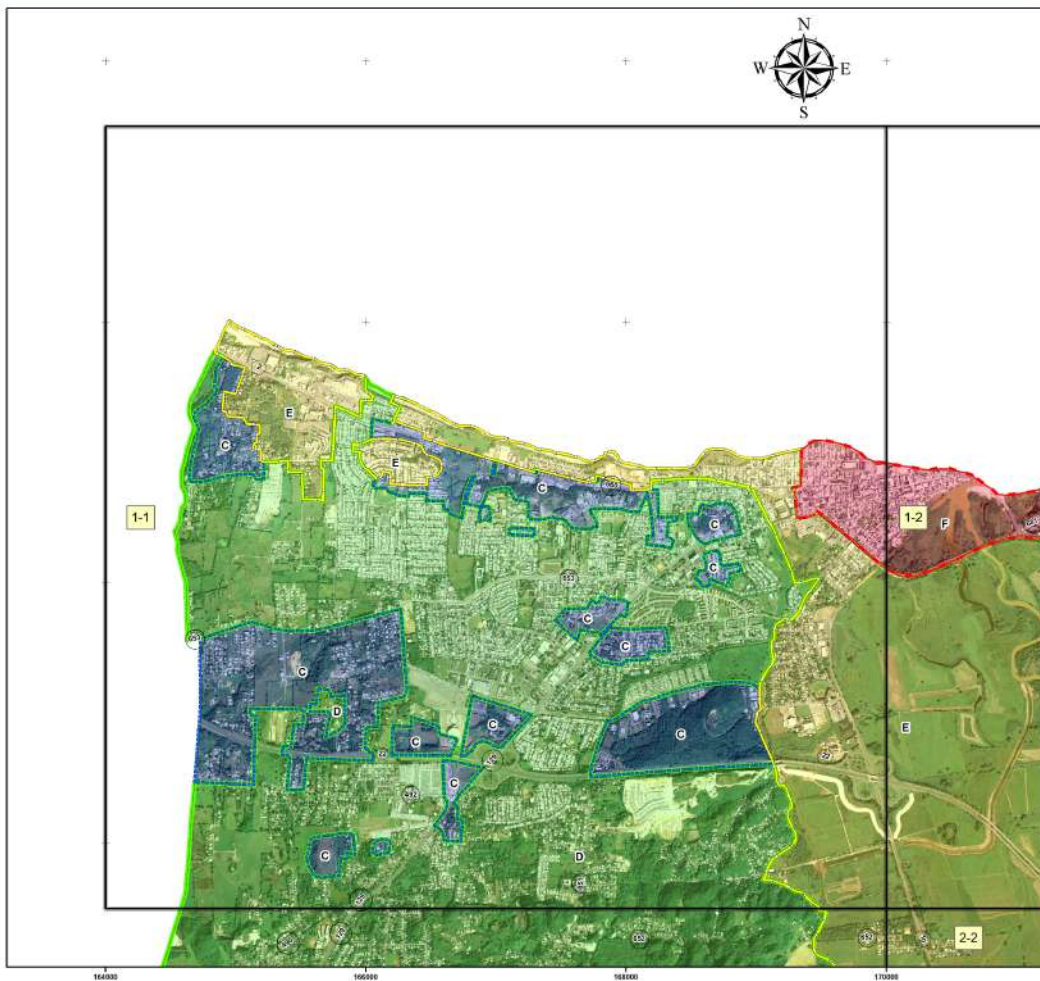
- ★ El primer recuadro establece que el mapa fue realizado por el Programa de Movimiento Fuerte de Puerto Rico del Departamento de Ingeniería Civil y Agrimensura de la Universidad de Puerto Rico en Mayagüez.
- ★ El segundo recuadro presenta la localización del municipio al que pertenece el mapa, ya sea Arecibo, Caguas, Humacao, Mayagüez, Ponce o la Zona Metropolitana de San Juan. En el caso del ejemplo, nos indica que este mapa pertenece a la Zona Metropolitana de San Juan.
- ★ El tercer recuadro presenta los segmentos en que se dividió el municipio o la Zona Metropolitana de San Juan y el número asignado a cada segmento. Note que el segmento del mapa en cuestión está coloreado con líneas diagonales amarillas y rojas.
- ★ El cuarto recuadro presenta el color asignado en el mapa para los distintos tipos de suelos. El azul se le asignó al Tipo de Perfil de Suelo C (S_C), el verde al Tipo de Suelo D (S_D), el amarillo al Tipo de Suelo E (S_E), y el rojo al Tipo de Suelo F (S_F). Note que en ninguno de los mapas se clasificaron suelos como Tipos de Suelos A (S_A) o B (S_B).
- ★ El quinto recuadro establece la escala del mapa 1:20,000. Esto implica que un centímetro en el mapa equivale a 20,000 centímetros (200 metros) en el campo. La referencia espacial utilizada es el Datum de Norte América de 1983 (NAO 83).
- ★ El sexto recuadro corresponde al descargo de responsabilidad, donde se establece que estos mapas no sustituyen investigaciones geotécnicas ni exploraciones del subsuelo.

En el mapa principal notará que en el centro se halla el número del segmento asignado. Los segmentos adyacentes también están identificados y a su vez separados por líneas muy gruesas, rectas y negras. El color que sombrea el área indica el Tipo de Suelo, el cual a su vez está indicado por la letra correspondiente. Puede notarse también una línea delgada y negra que establece la separación entre municipios. Adicionalmente el numero dentro de un círculo indica el número de la carretera o avenida.

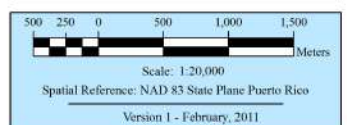
RECONOCIMIENTO:

Los siguientes estudiantes graduados trabajaron en la creación de estos mapas: Arturo Llavona (Mayagüez), Joanna Cataño (Ponce), Edwin Gutiérrez (Humacao), Álvaro Bernal (Caguas y ZMSJ), Amabelle Aponte (ZMSJ), Andrea Carolina Paredes (ZMSJ), Sixto Fernández (ZMSJ), y Alan Rivera (Arecibo). Por otro lado, el estudiante graduado Guillermo Gerbaudo se encargó de introducir los mapas en el programa de computadora INSOL. Estos estudiantes graduados trabajaron bajo la supervisión de los profesores Miguel A. Pando, Luis E. Suárez, Ricardo Ramos, Alí Saffar y José A. Martínez-Cruzado. Hay que reconocer que múltiples estudiantes de bachillerato se involucraron en la toma de datos. Finalmente se agradece también a las compañías geotécnicas y agencias que colaboraron proveyendo datos para la realización de estos. Estas son: Jaca y Sierra, Geo-Cim, Western Soils, Despiou Associates, Geo Engineering, Geo Consult, Geo Practica, Advanced Soil Engineering, Víctor Rivera & Asoc., Caribbean Soils Eng., Ponce I & M Engineering Lab., Autoridad de Carreteras y Autoridad de Edificios Públicos de Puerto Rico.

Soils Classification Map - Arecibo Municipality

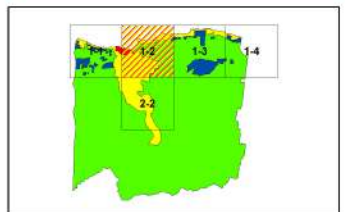
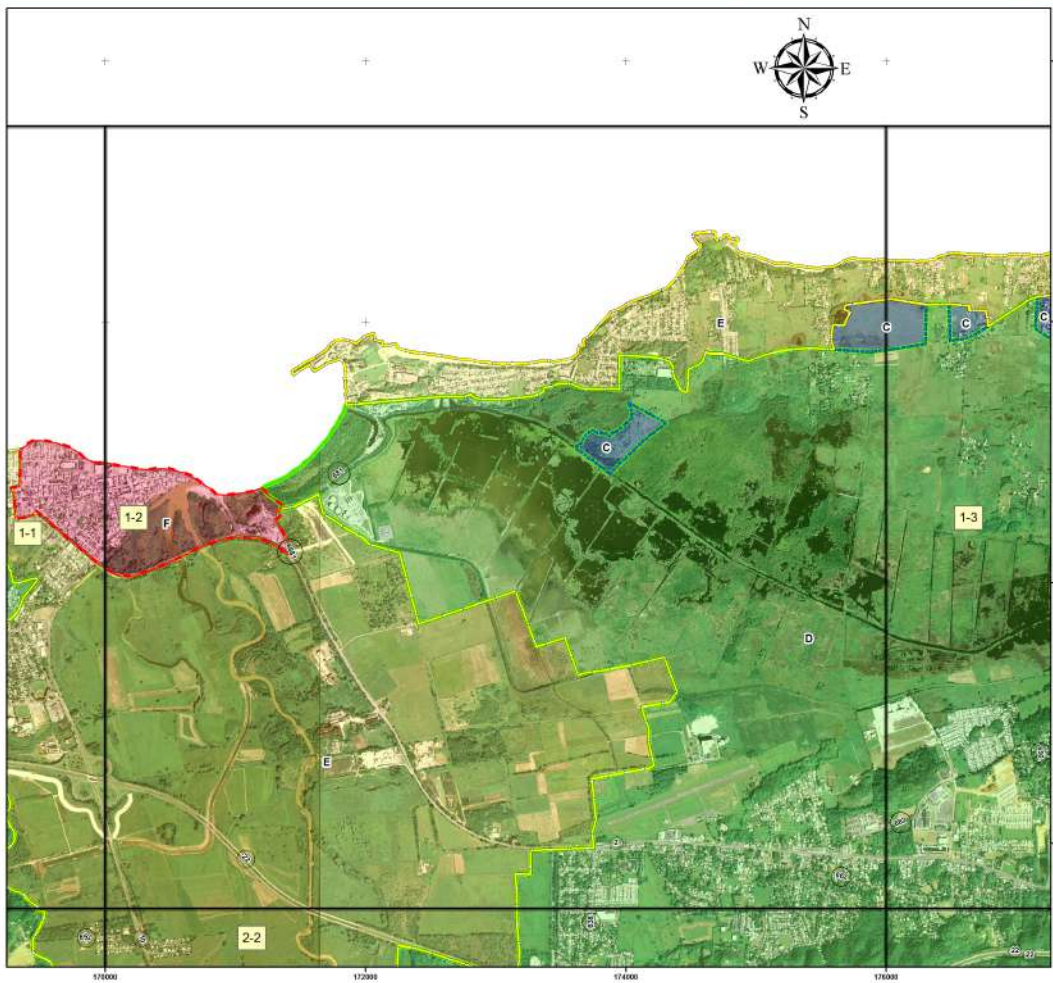


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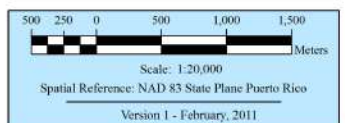


DISCLAIMER:
This map shall not substitute geotechnical investigations nor subsurface explorations.

Soils Classification Map - Arecibo Municipality

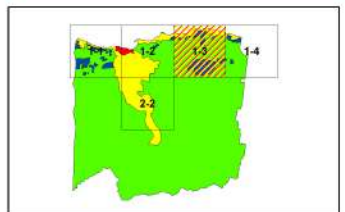
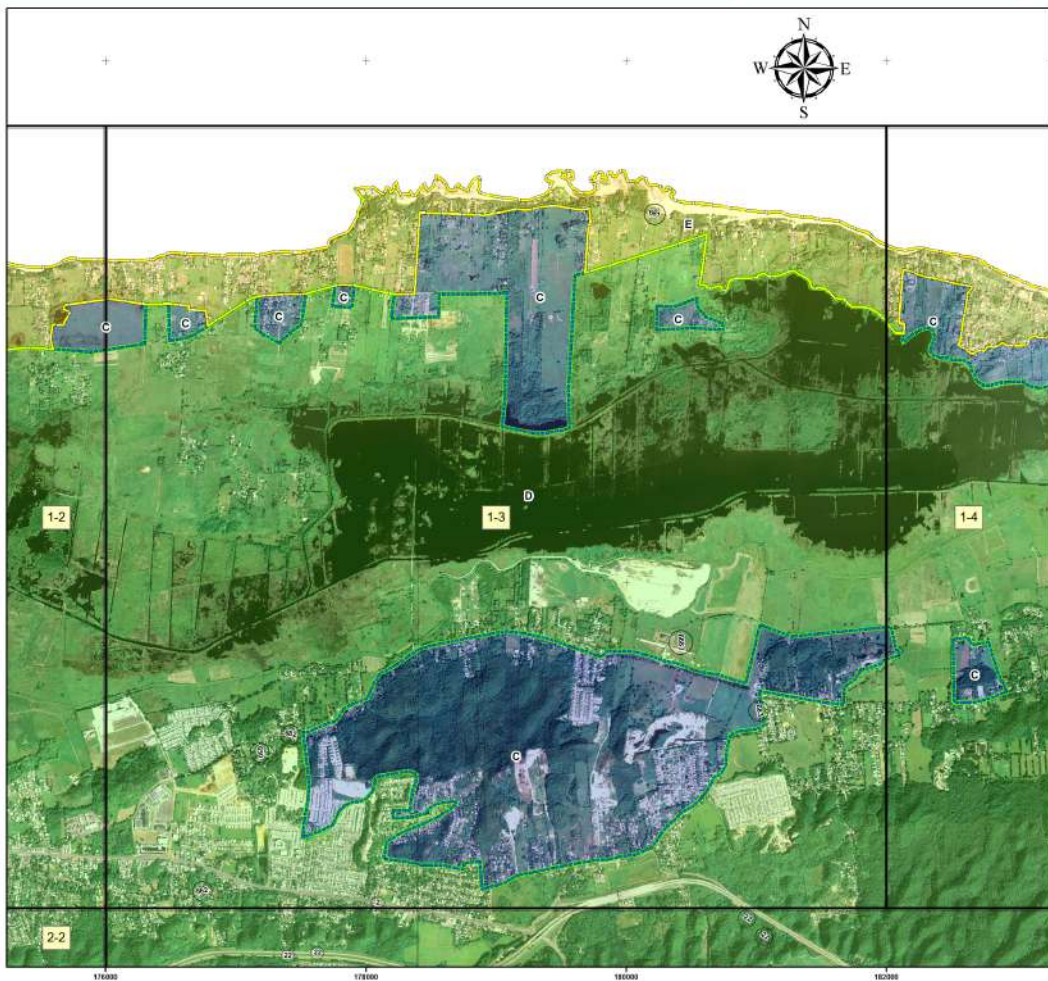


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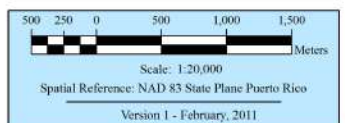


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Soils Classification Map - Arecibo Municipality

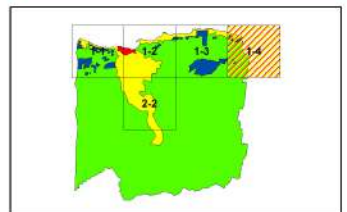
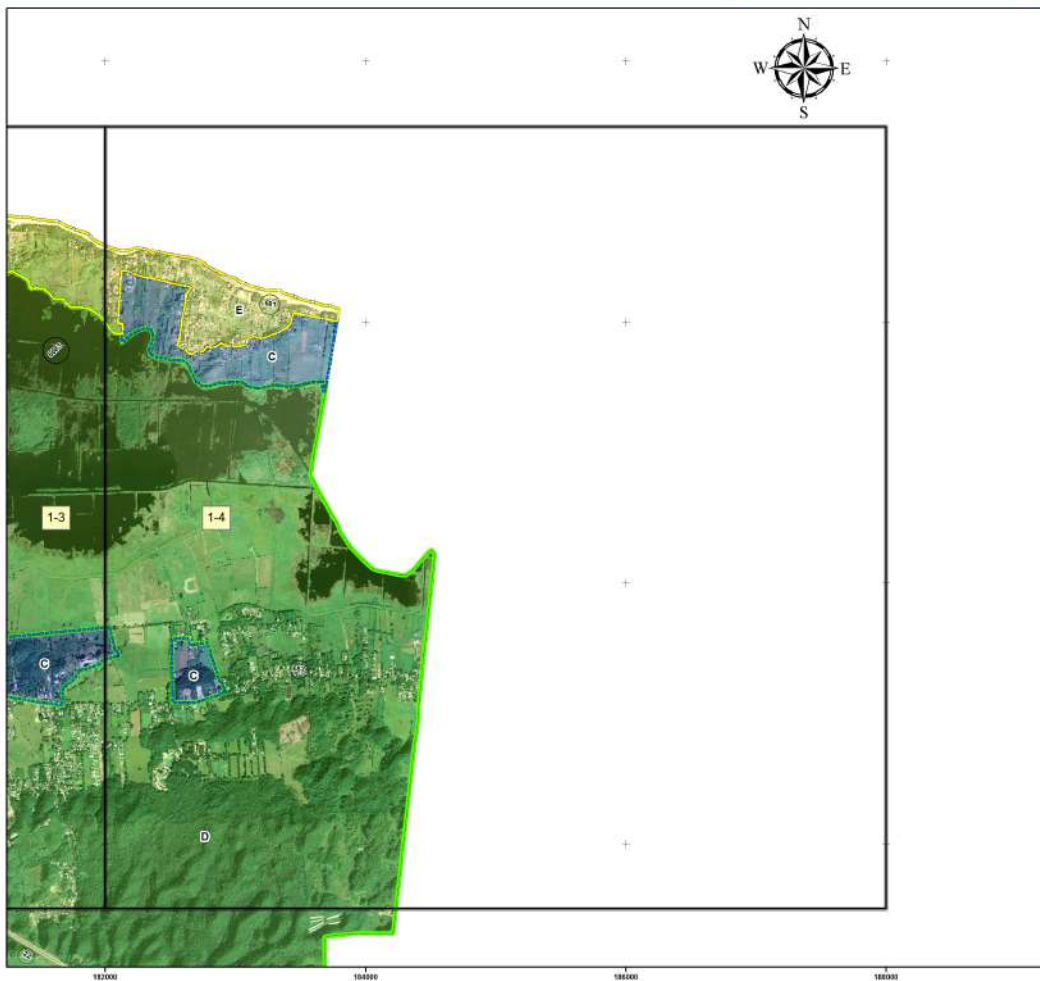


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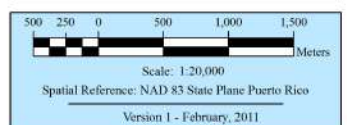


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Soils Classification Map - Arecibo Municipality

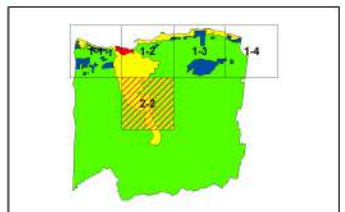
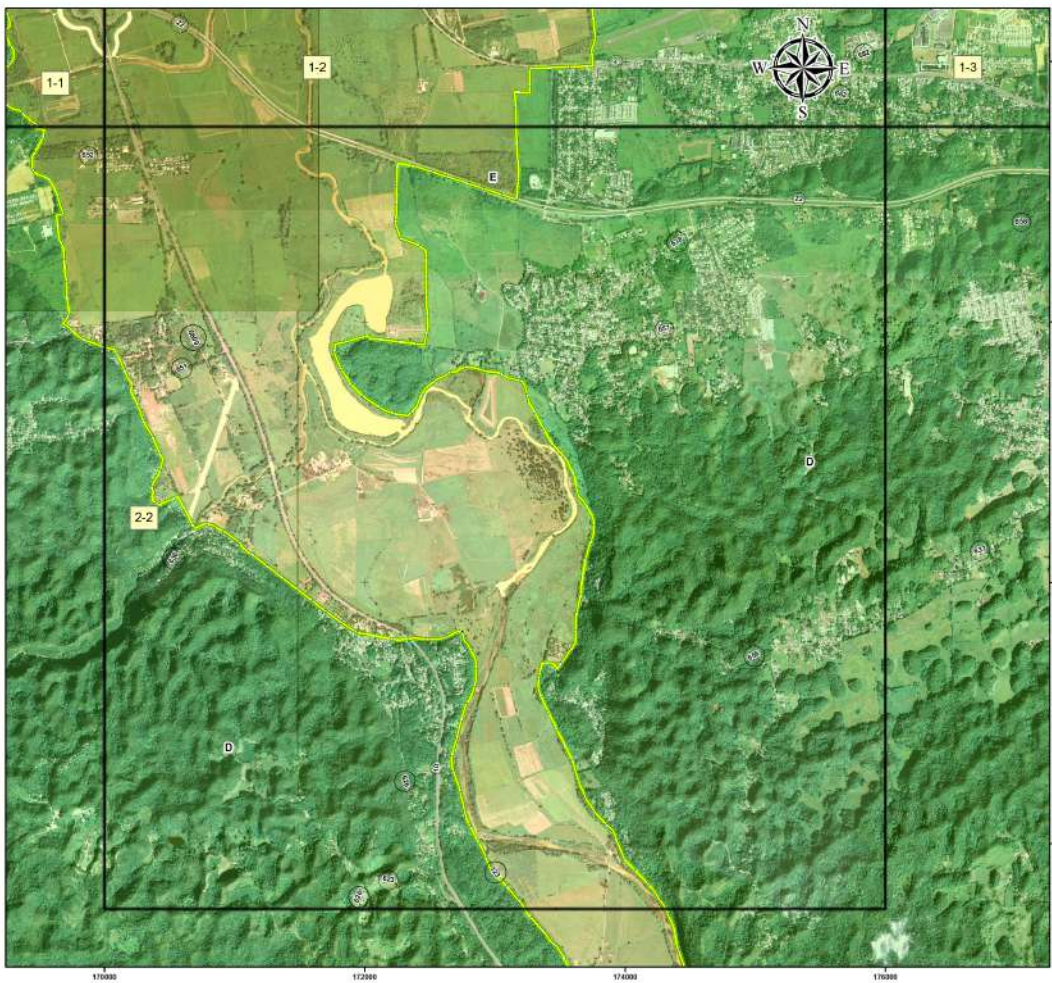


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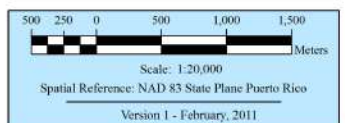


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Soils Classification Map - Arecibo Municipality

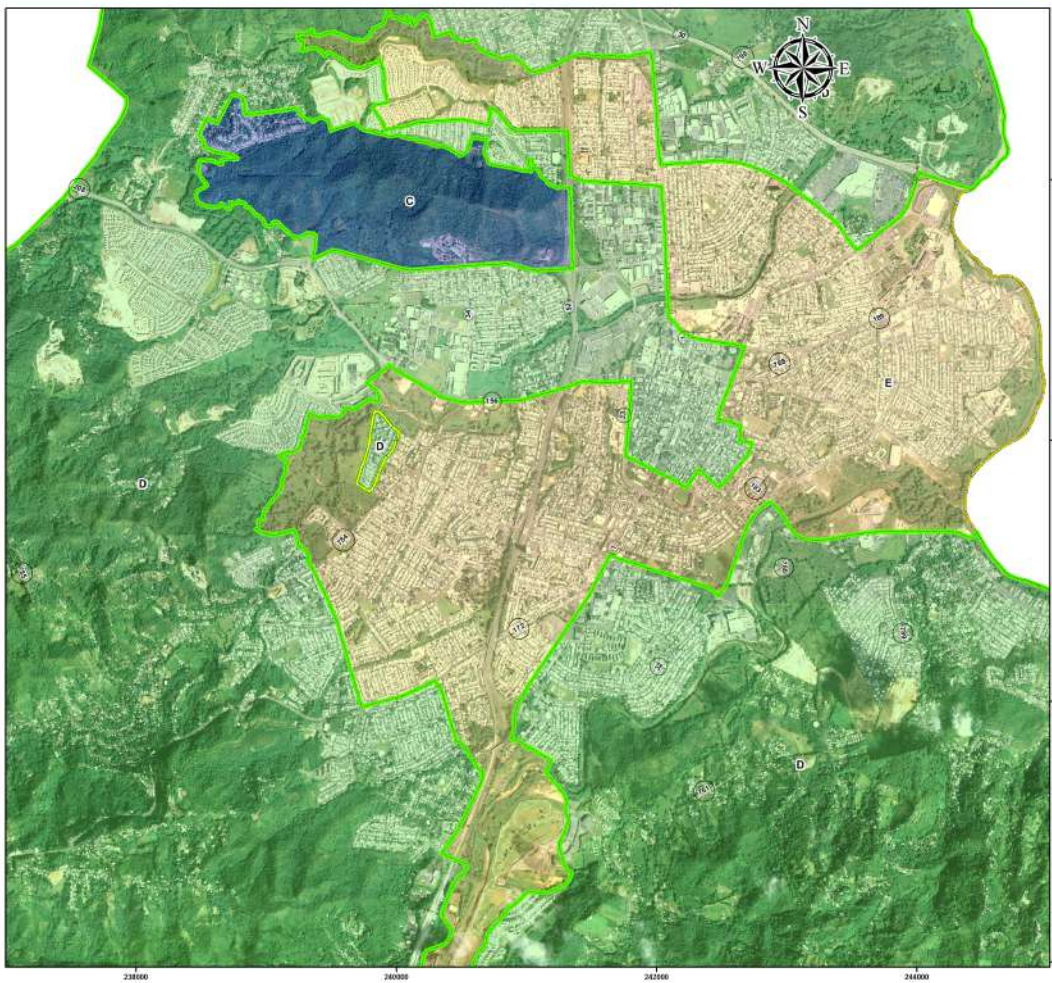


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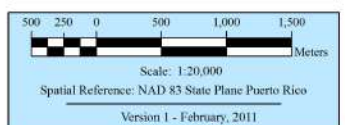


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Soils Classification Map - Humacao Municipality

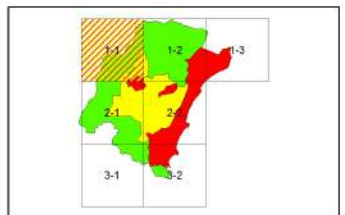
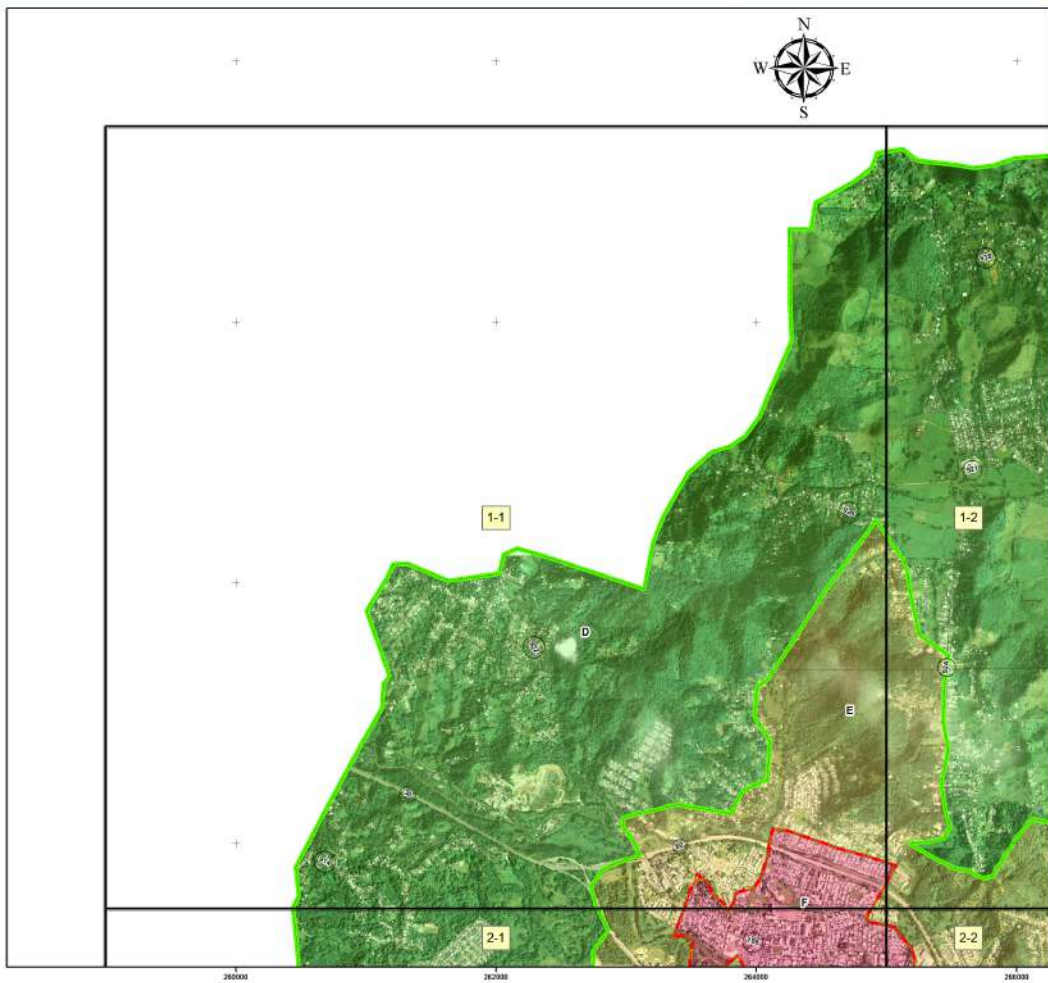


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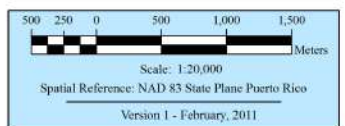


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Soils Classification Map - Humacao Municipality

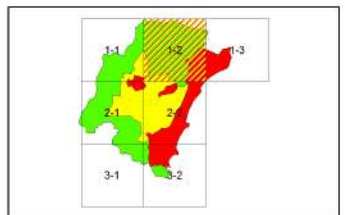
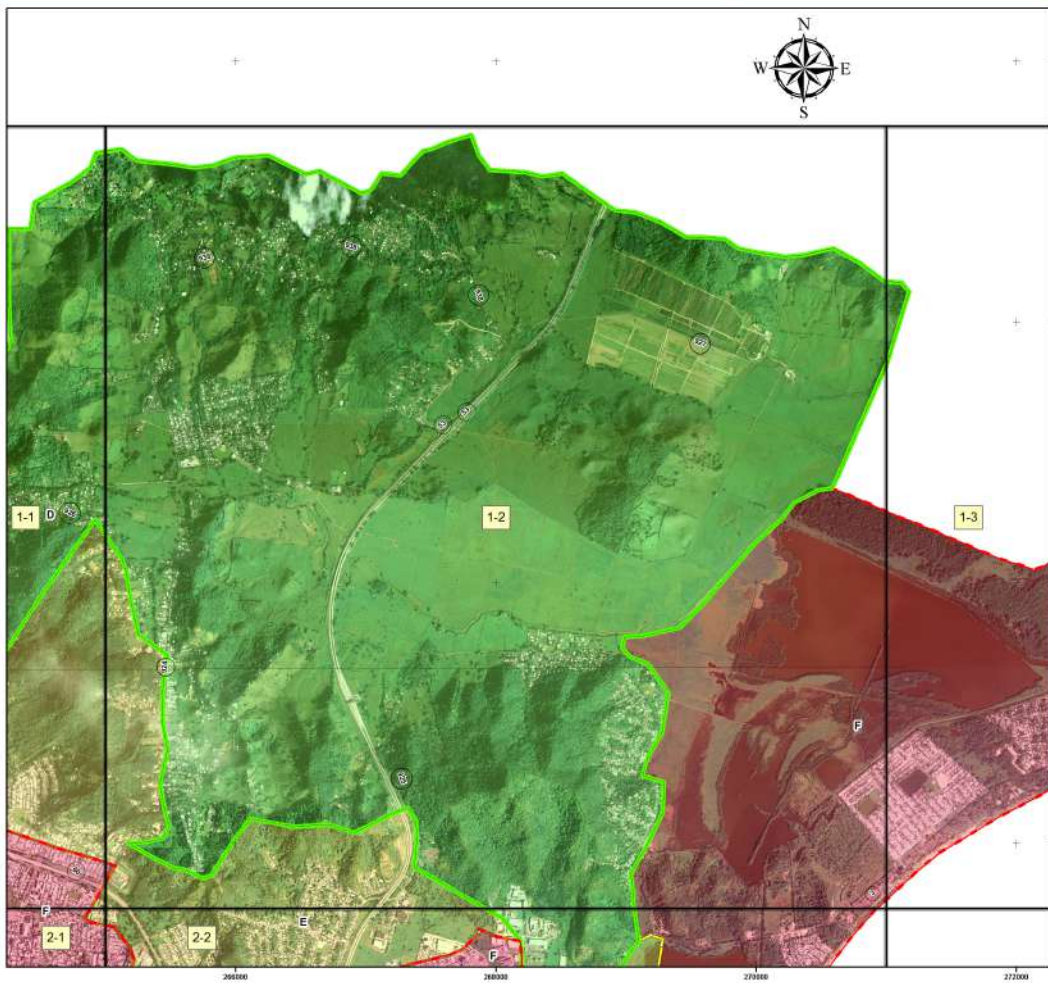


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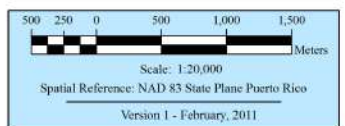


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Soils Classification Map - Humacao Municipality

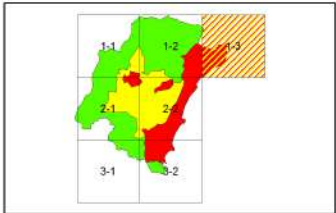


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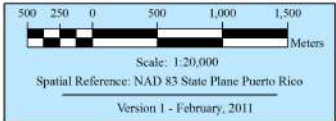
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Soils Classification Map - Humacao Municipality



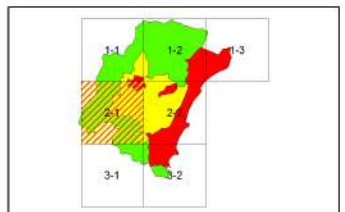
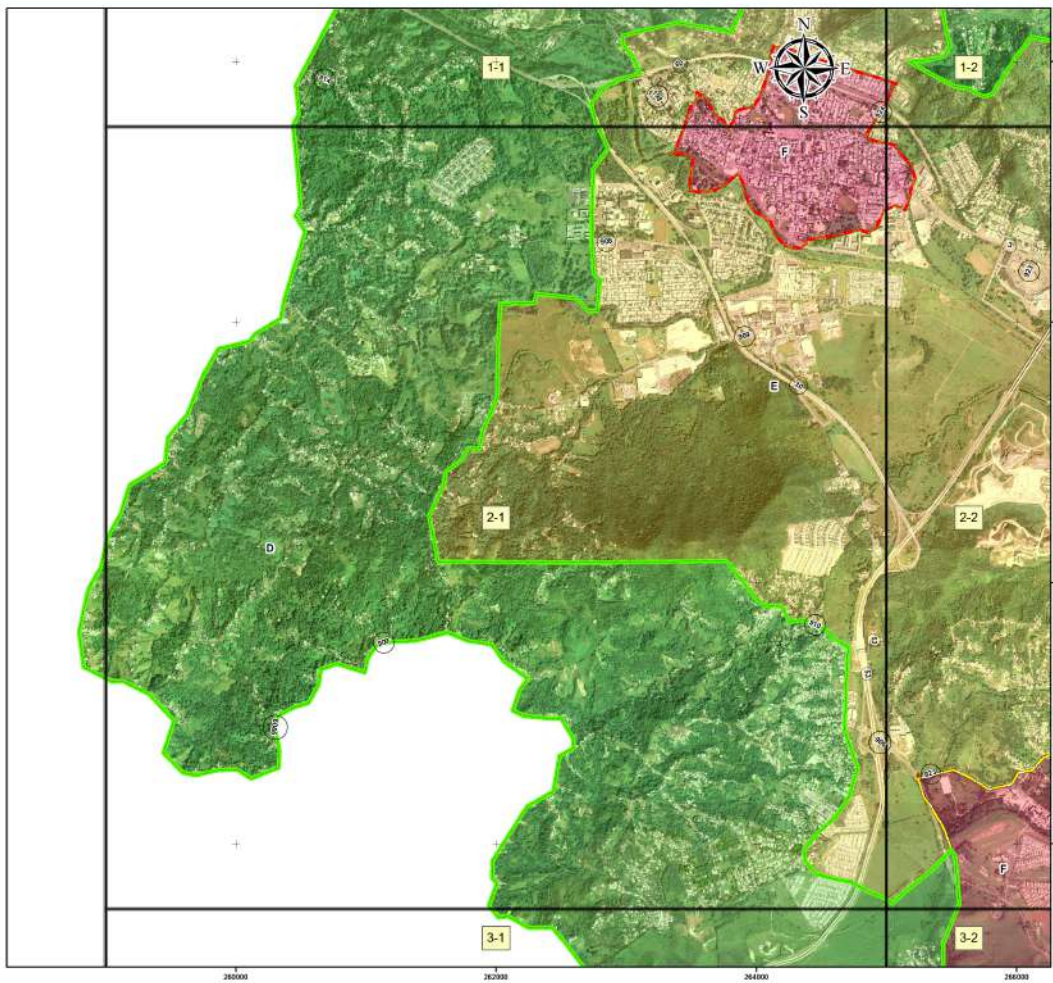
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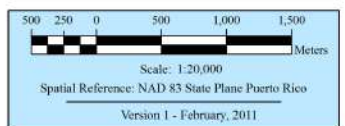


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Soils Classification Map - Humacao Municipality

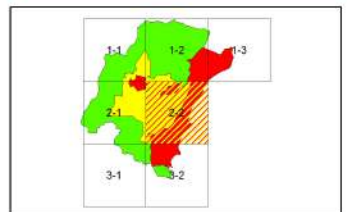
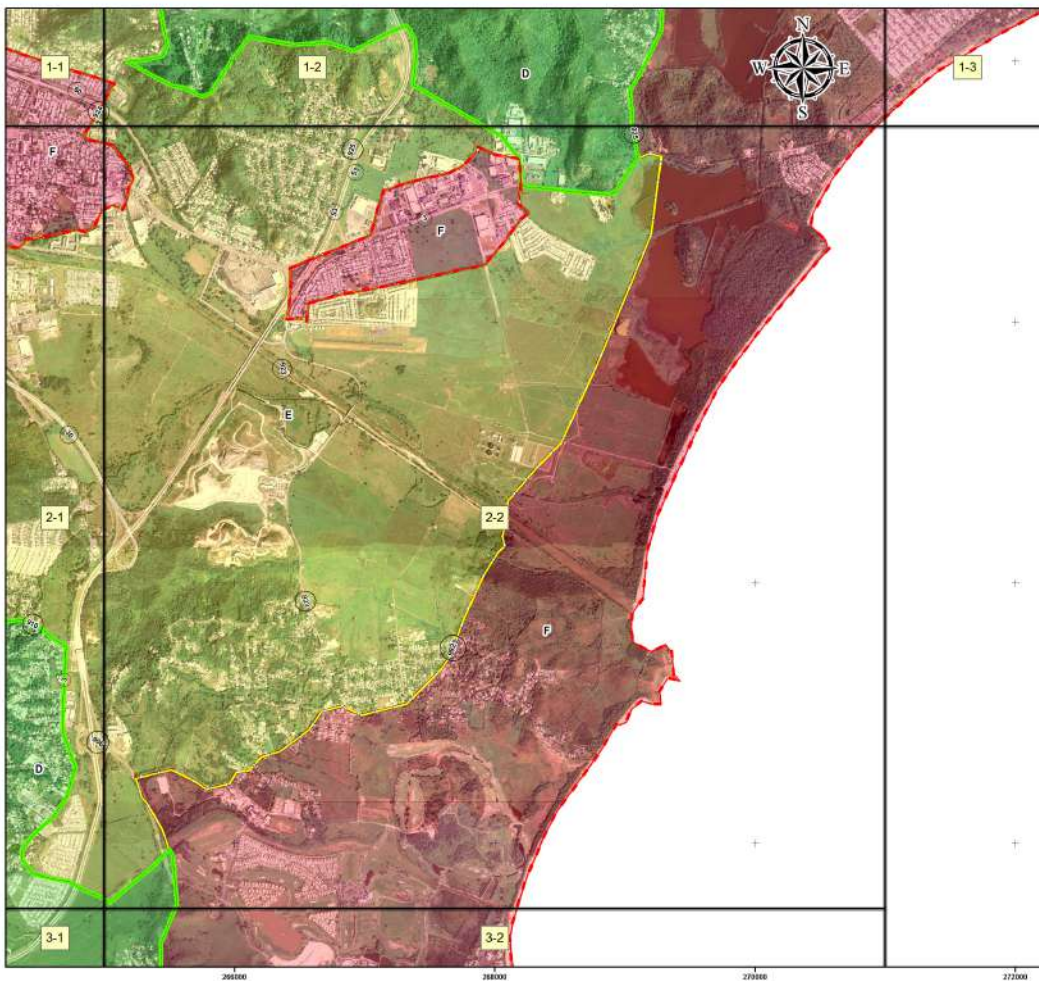


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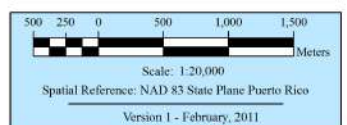


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Soils Classification Map - Humacao Municipality

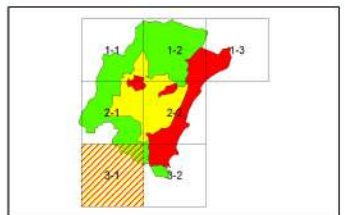
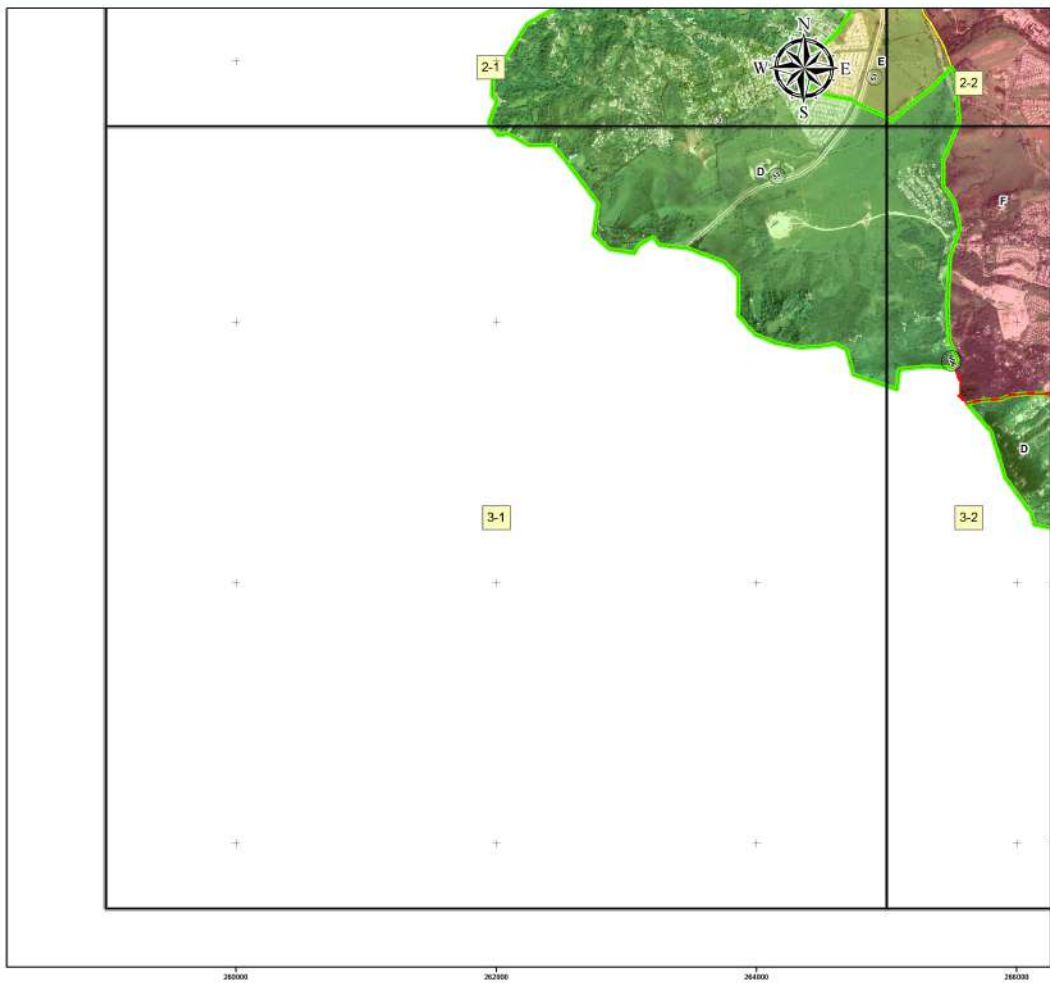


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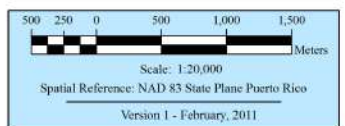


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Soils Classification Map - Humacao Municipality

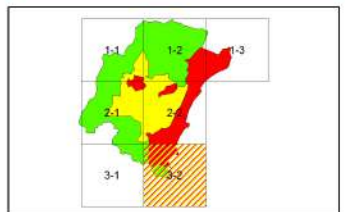
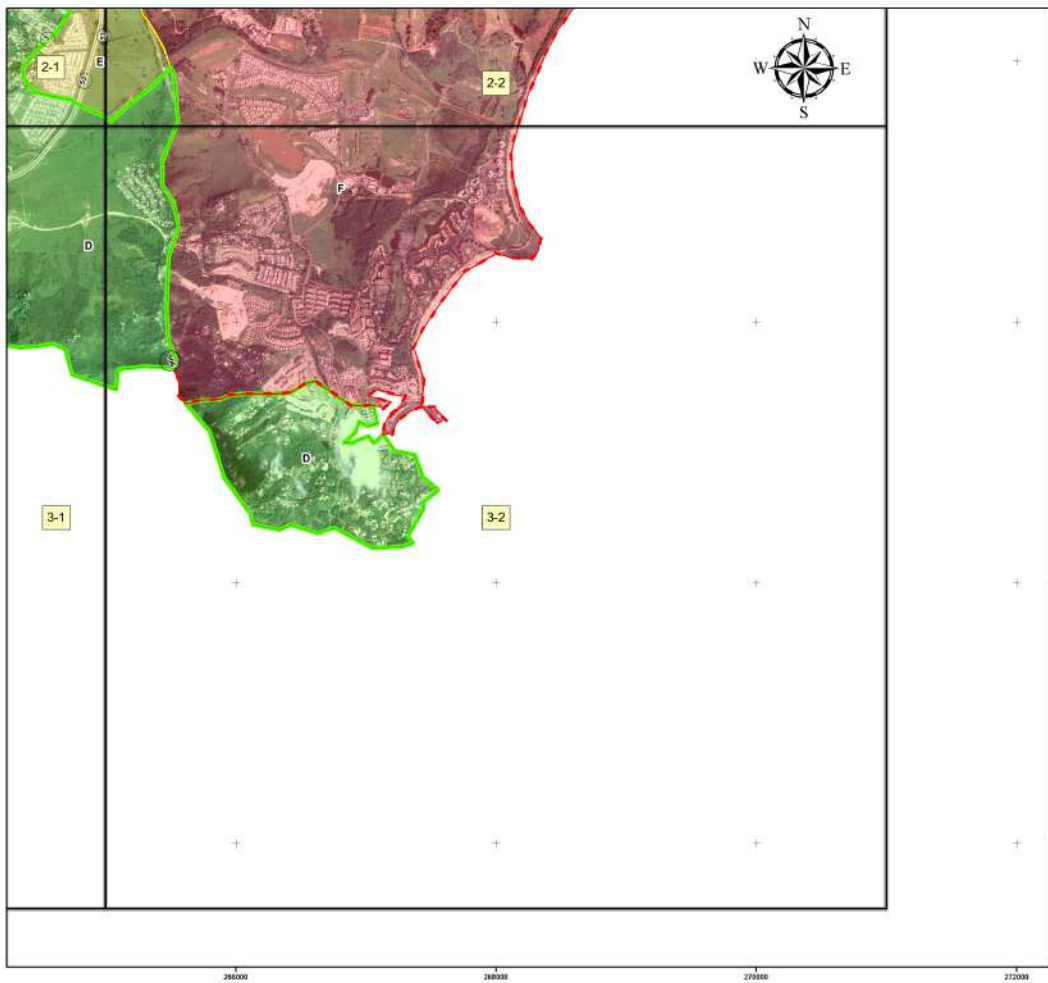


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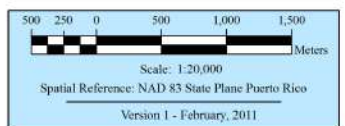


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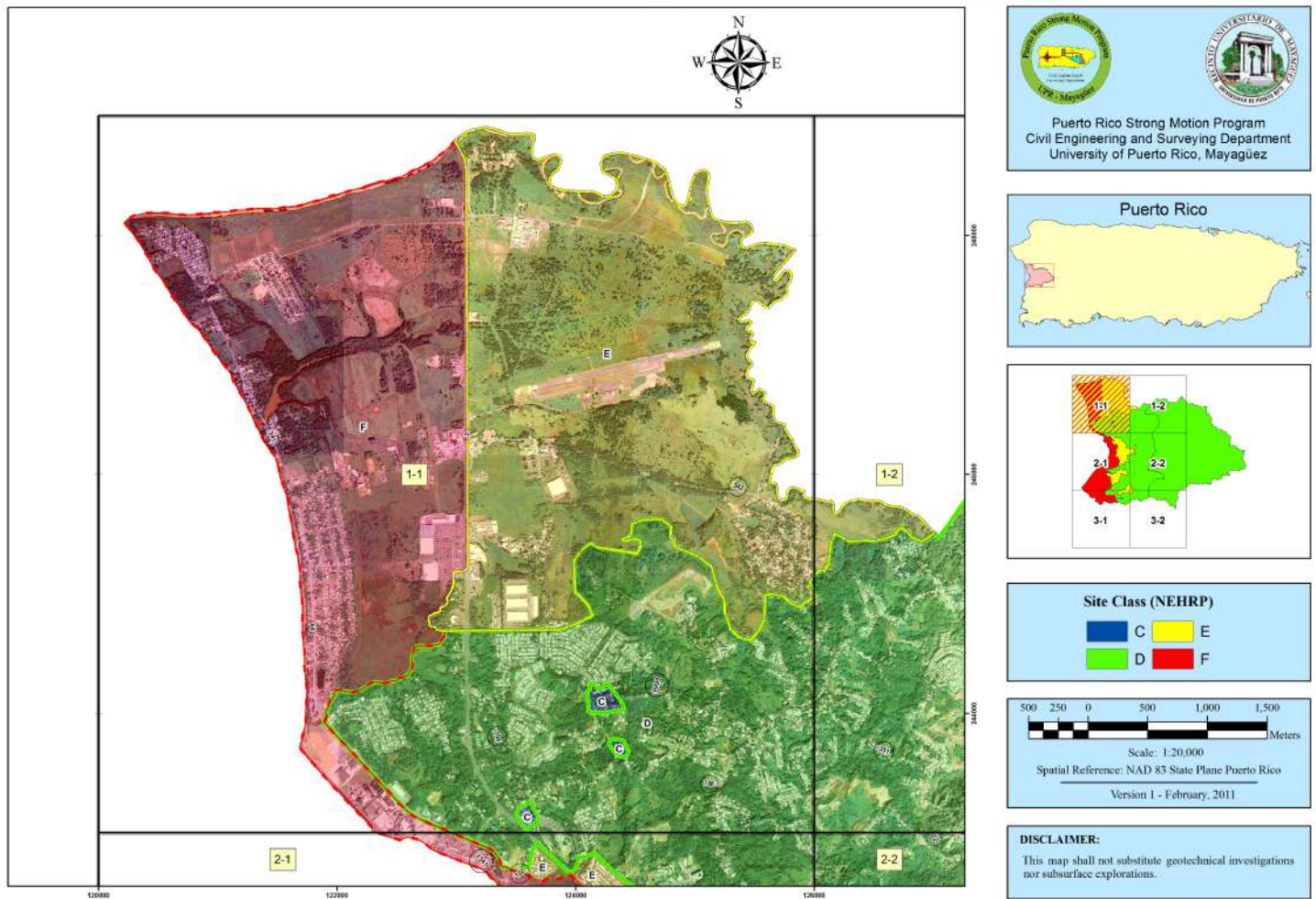


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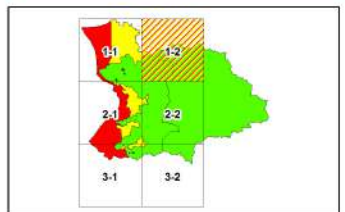
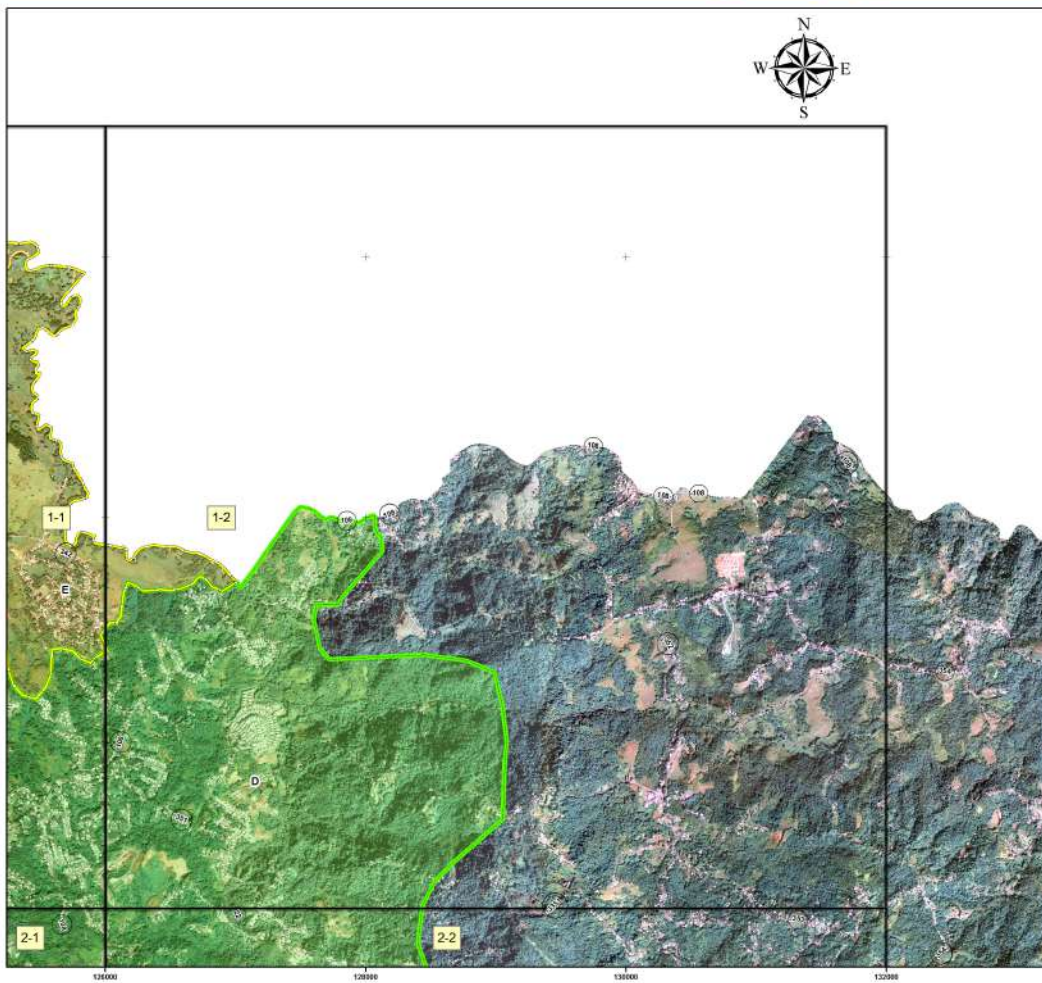


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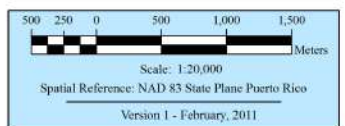
Soils Classification Map - Mayagüez Municipality



Soils Classification Map - Mayagüez Municipality

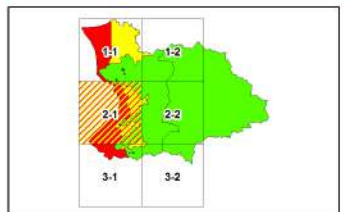
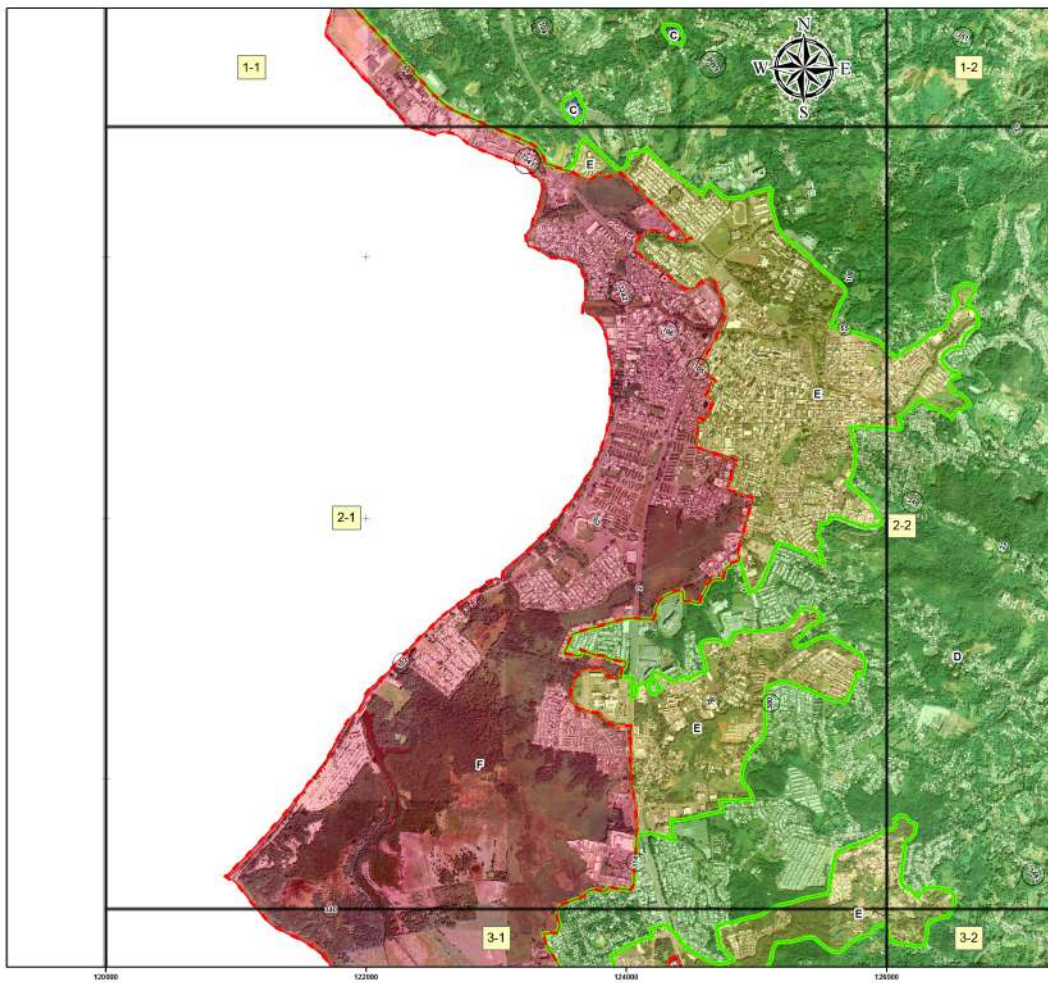


Site Class (NEHRP)			
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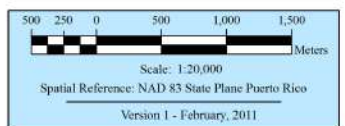


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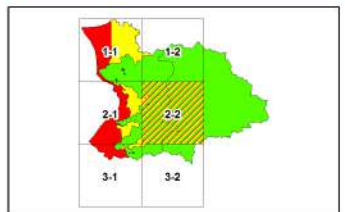
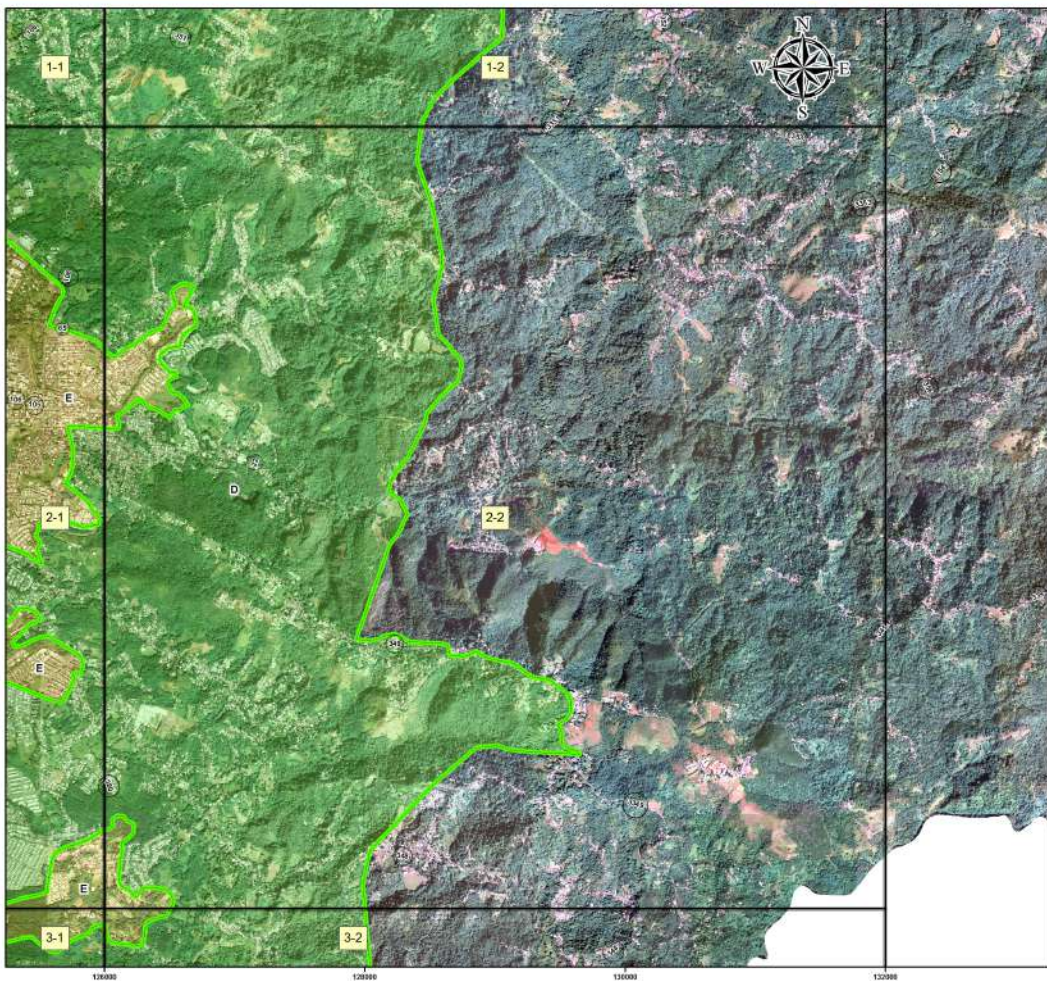


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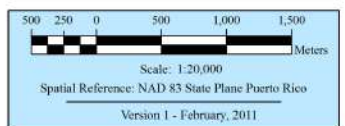


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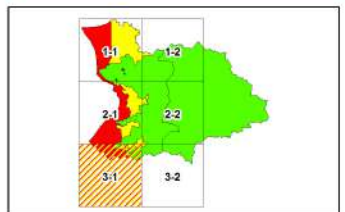
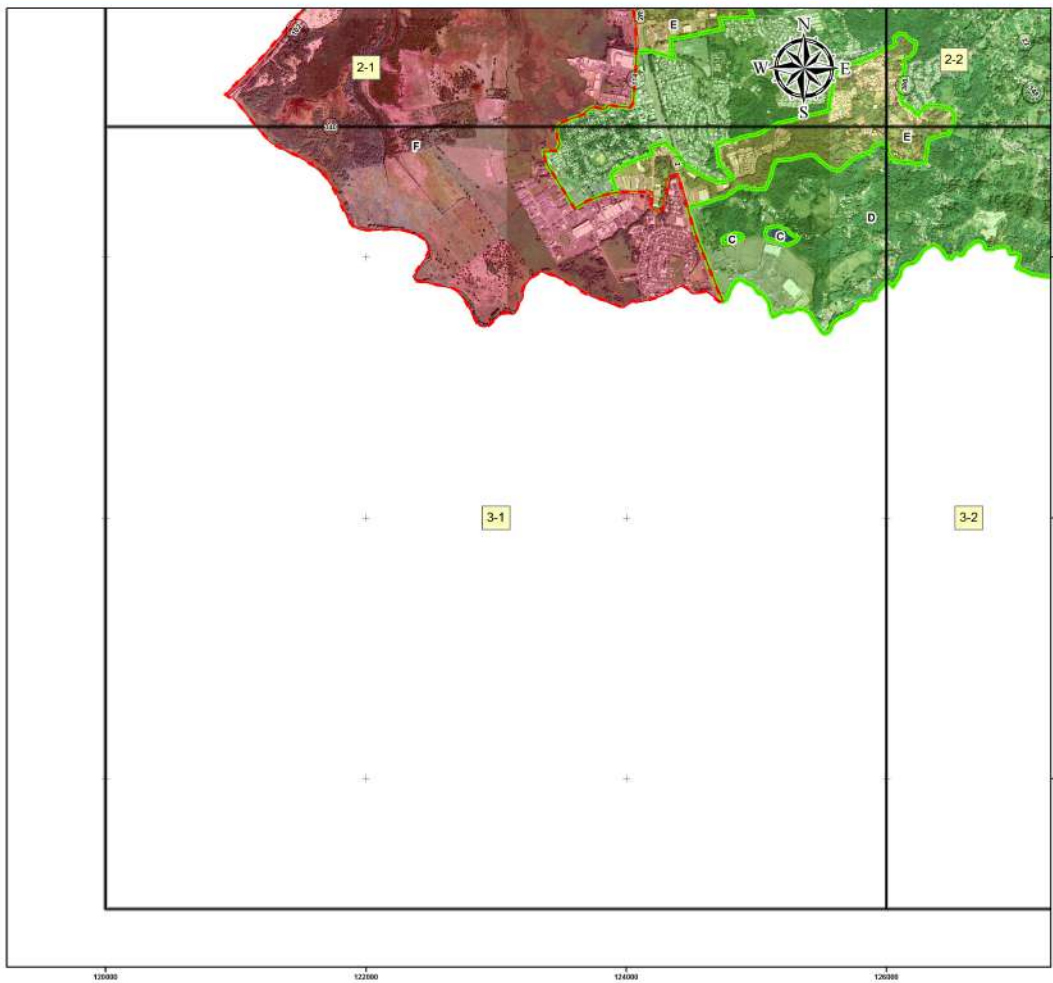


Site Class (NEHRP)			
	C		E
	D		F

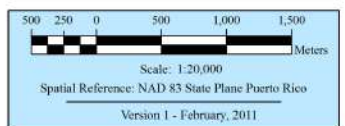


DISCLAIMER:
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Soils Classification Map - Mayagüez Municipality

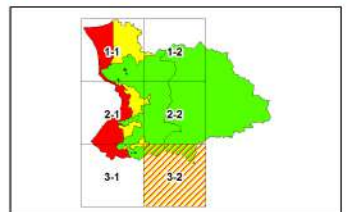
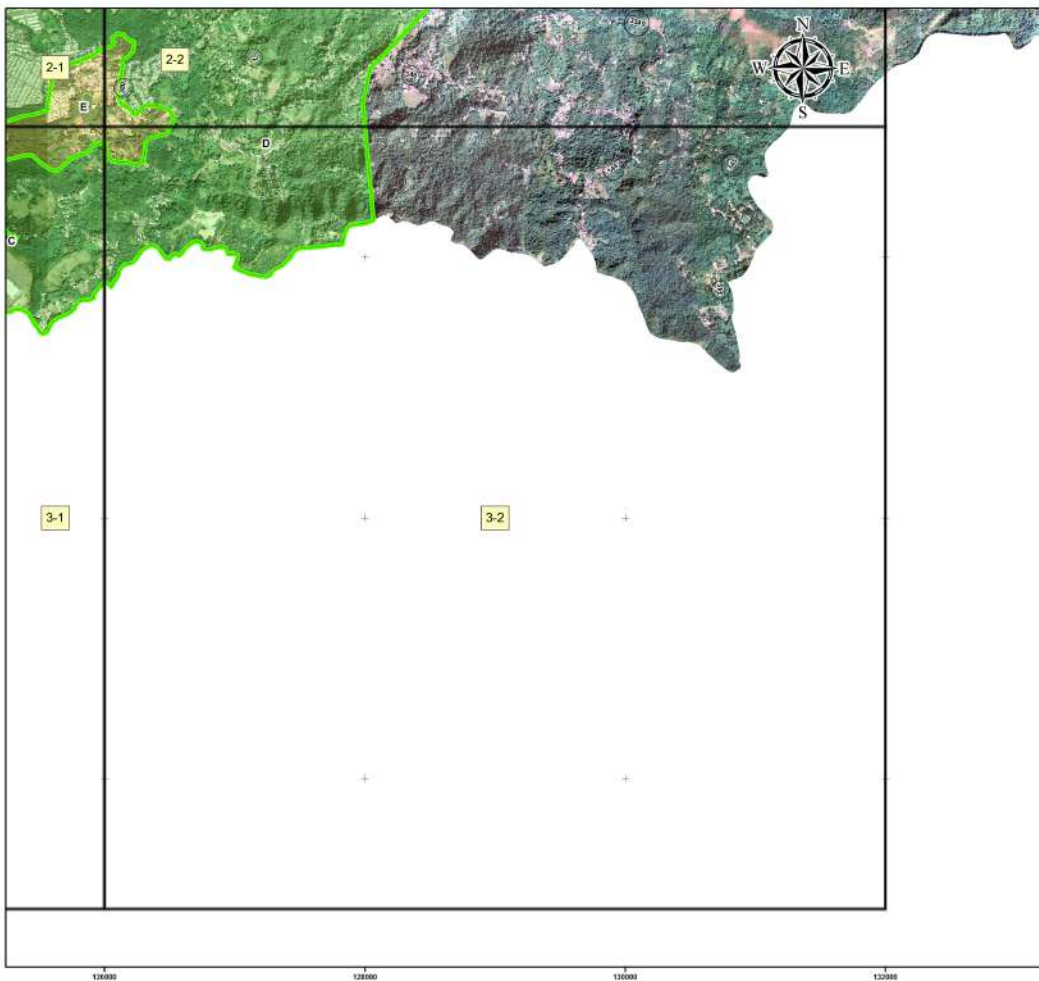


Site Class (NEHRP)			
■	C	■	E
■	D	■	F

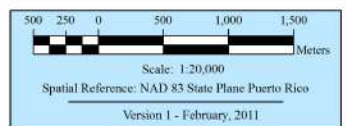


DISCLAIMER:
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Soils Classification Map - Mayagüez Municipality

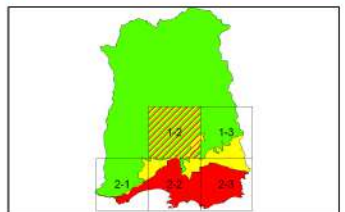
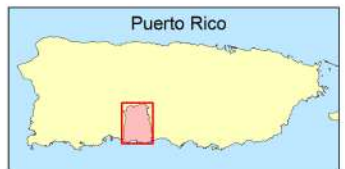
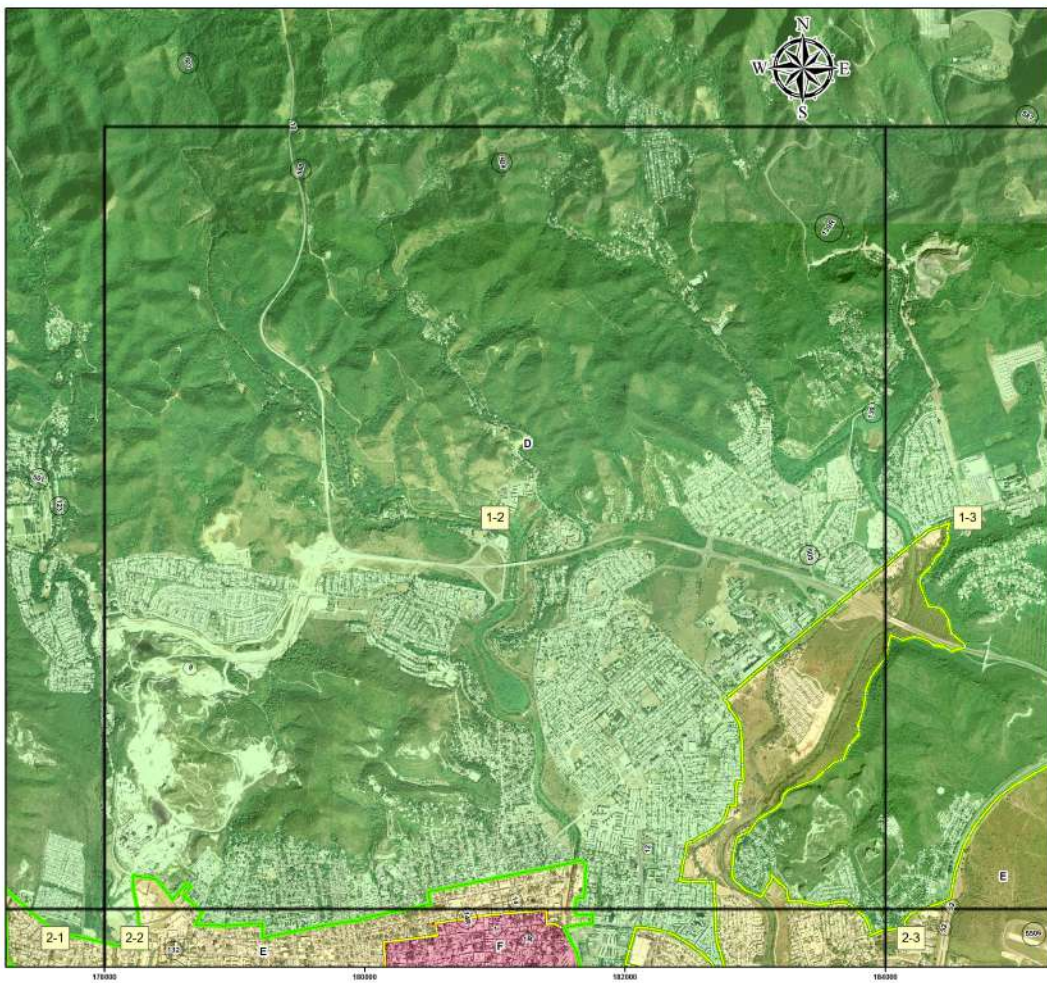


Site Class (NEHRP)			
	C		E
	D		F

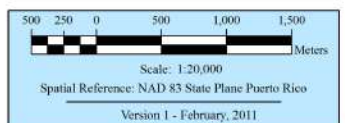


DISCLAIMER:
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Soils Classification Map - Ponce Municipality

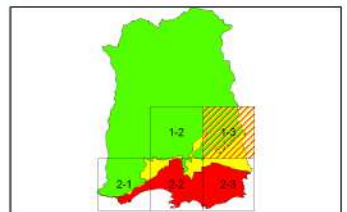
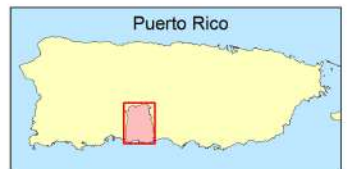
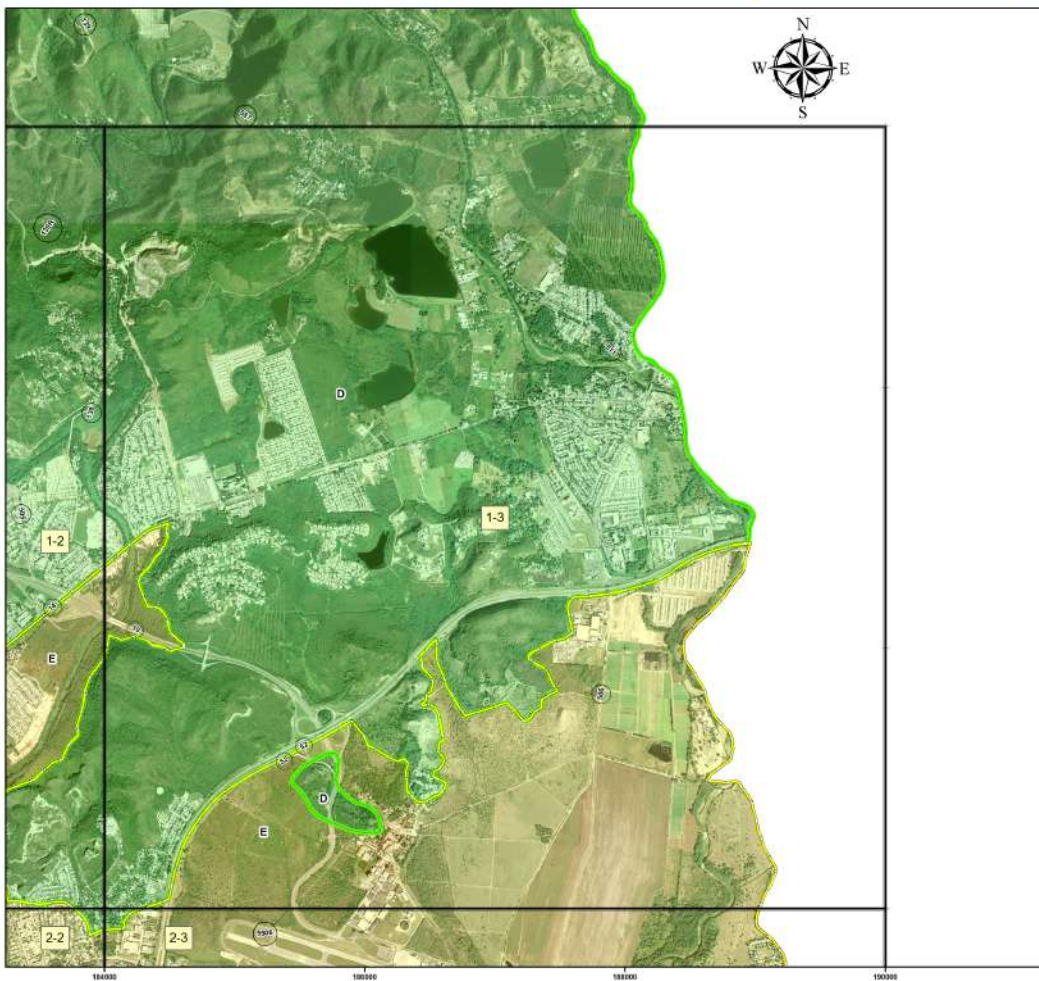


Site Class (NEHRP)			
C	E	F	
D			

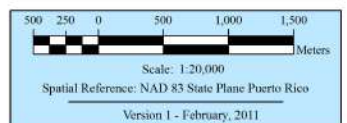


DISCLAIMER:
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Soils Classification Map - Ponce Municipality

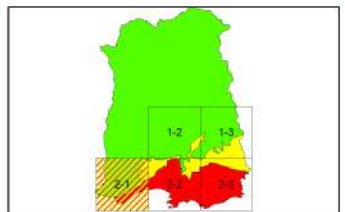
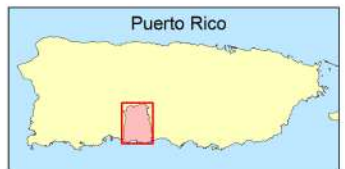
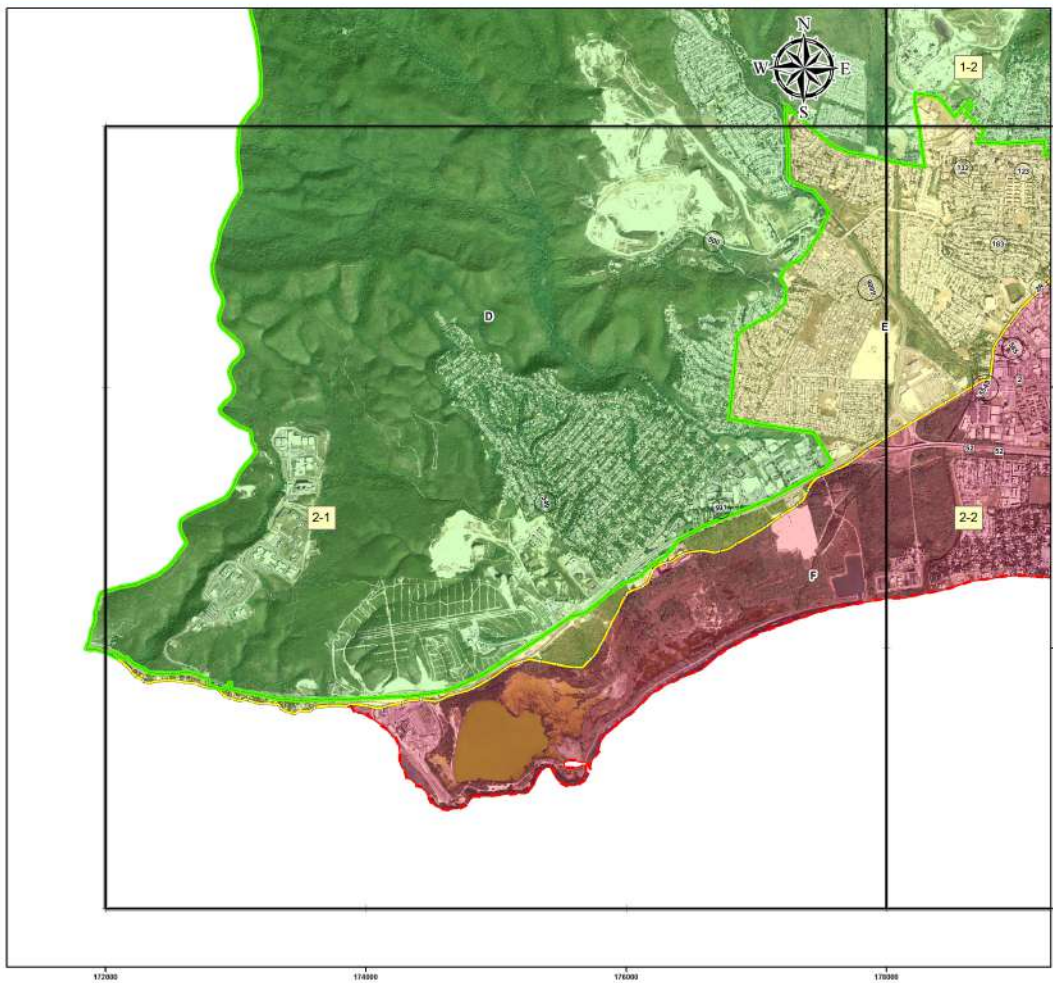


Site Class (NEHRP)			
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D			

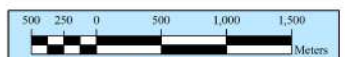


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Soils Classification Map - Ponce Municipality



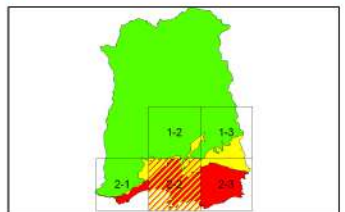
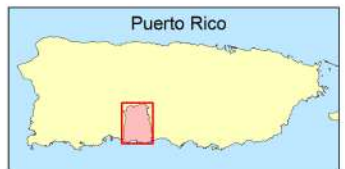
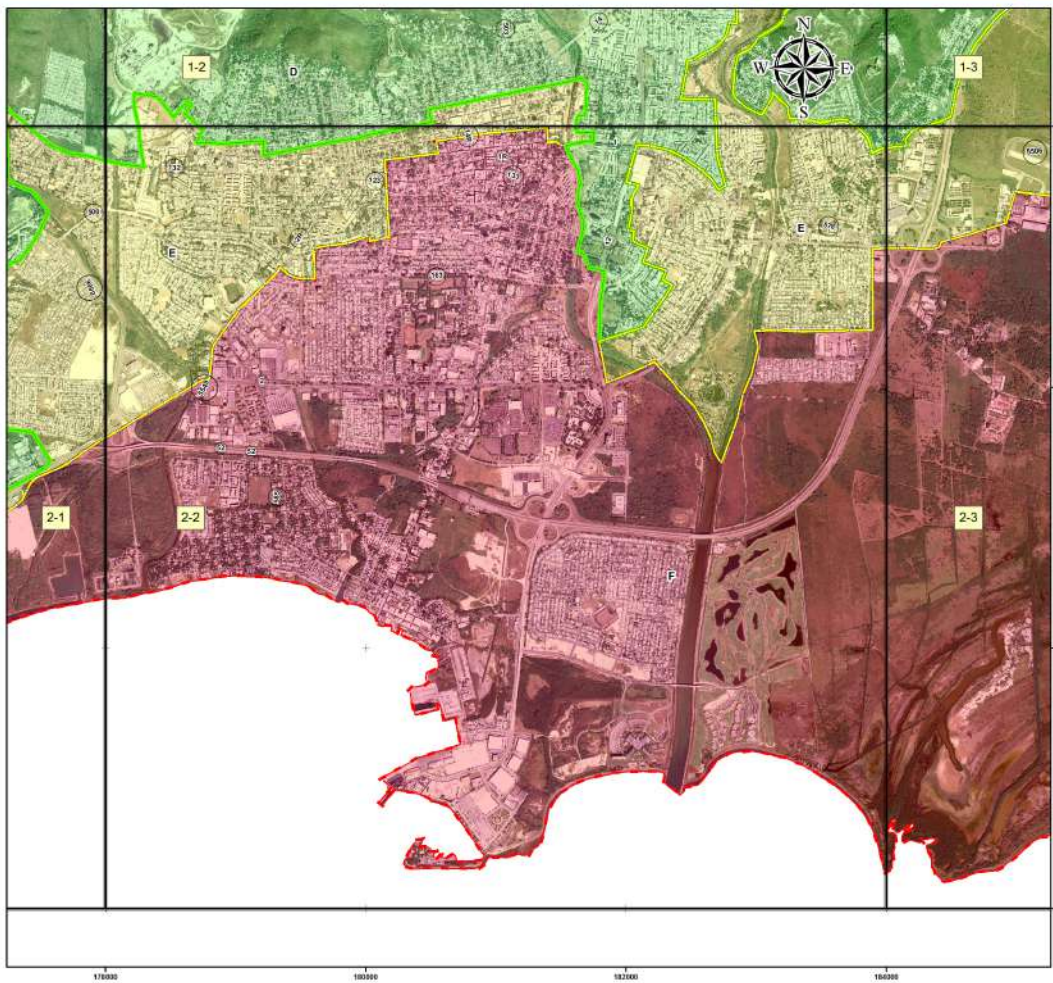
Site Class (NEHRP)			
C	E	F	
D			



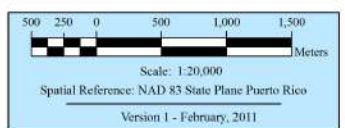
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Version 1 - February, 2011

DISCLAIMER:
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Soils Classification Map - Ponce Municipality

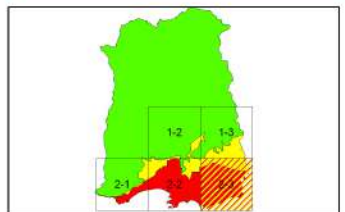
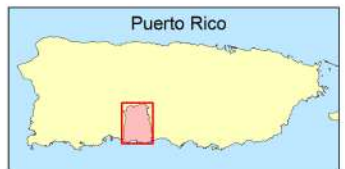
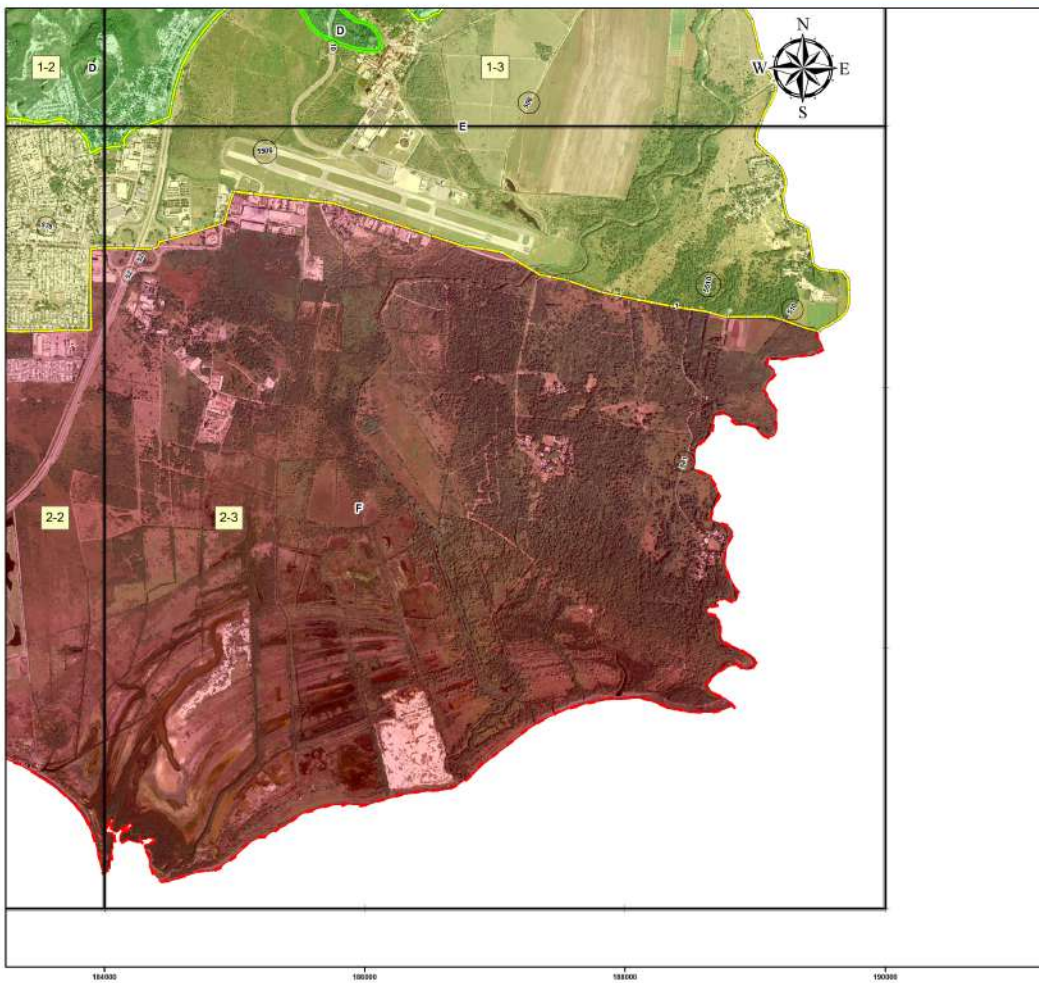


Site Class (NEHRP)			
C	D	E	F
Blue	Green	Yellow	Red

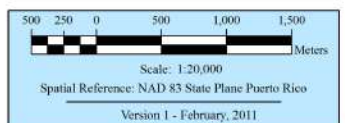


DISCLAIMER:
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Soils Classification Map - Ponce Municipality

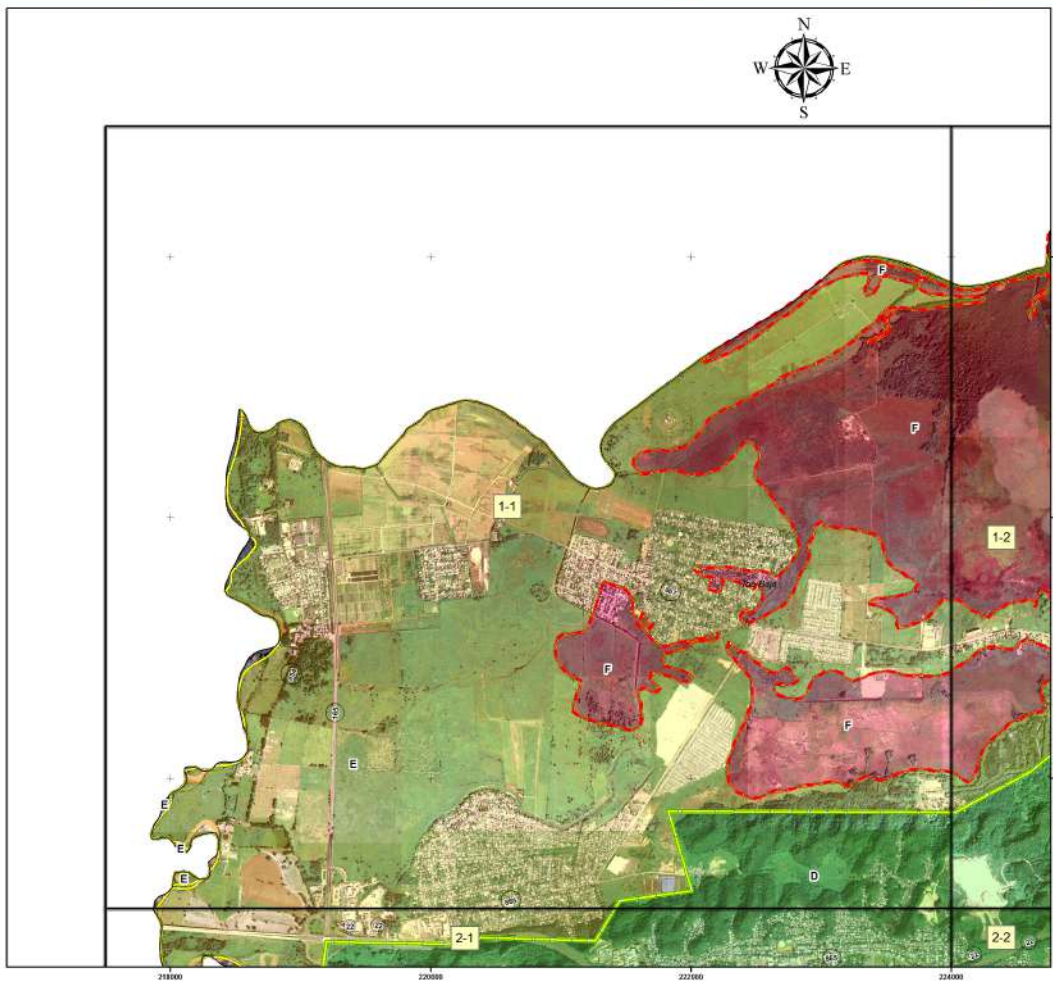


Site Class (NEHRP)			
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Blue	Green	Yellow	Red

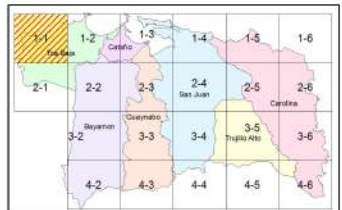


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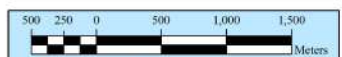
Soils Classification Map - San Juan Metropolitan Area



Puerto Rico Strong Motion Program
Civil Engineering and Surveying Department
University of Puerto Rico, Mayagüez



Site Class (NEHRP)			
C	D	E	F
Blue	Green	Yellow	Red



Scale: 1:20,000

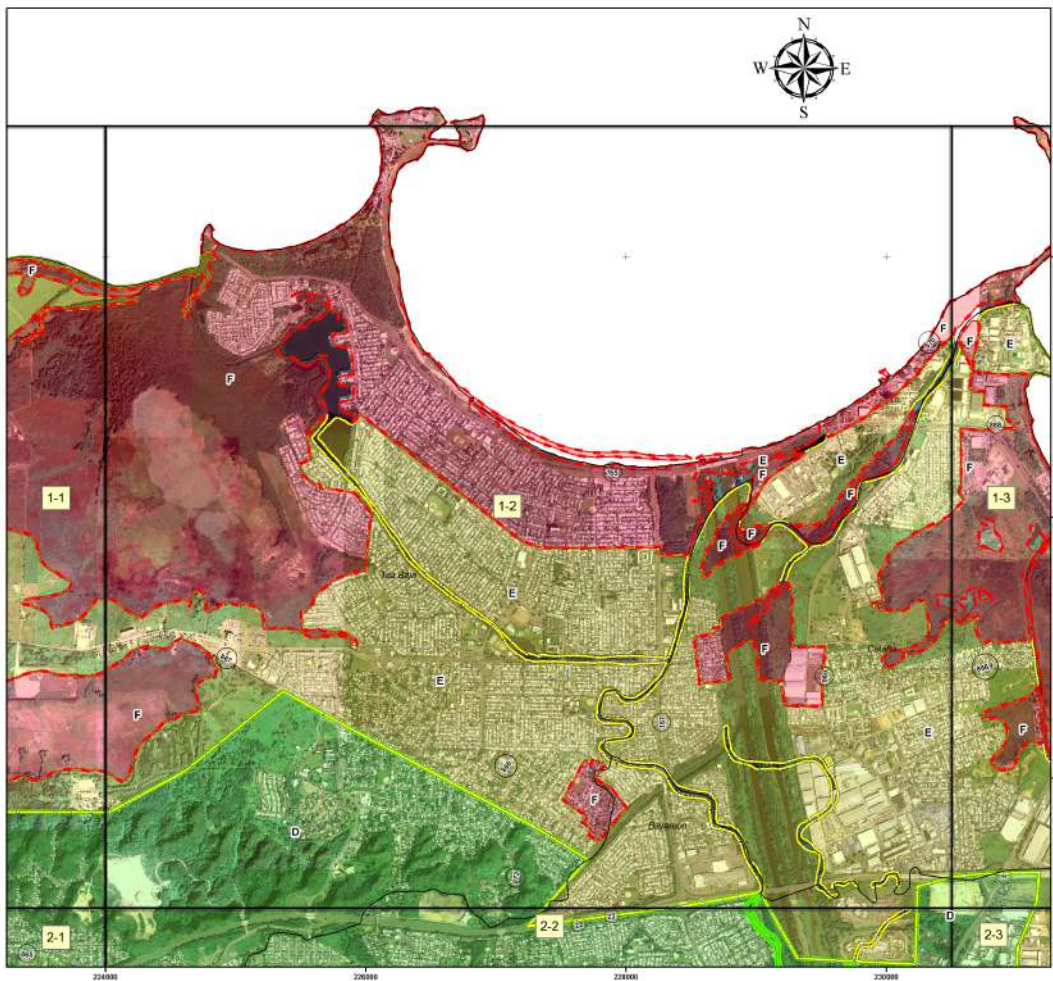
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Version 2 - February, 2011

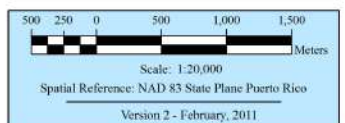
DISCLAIMER:

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Soils Classification Map - San Juan Metropolitan Area

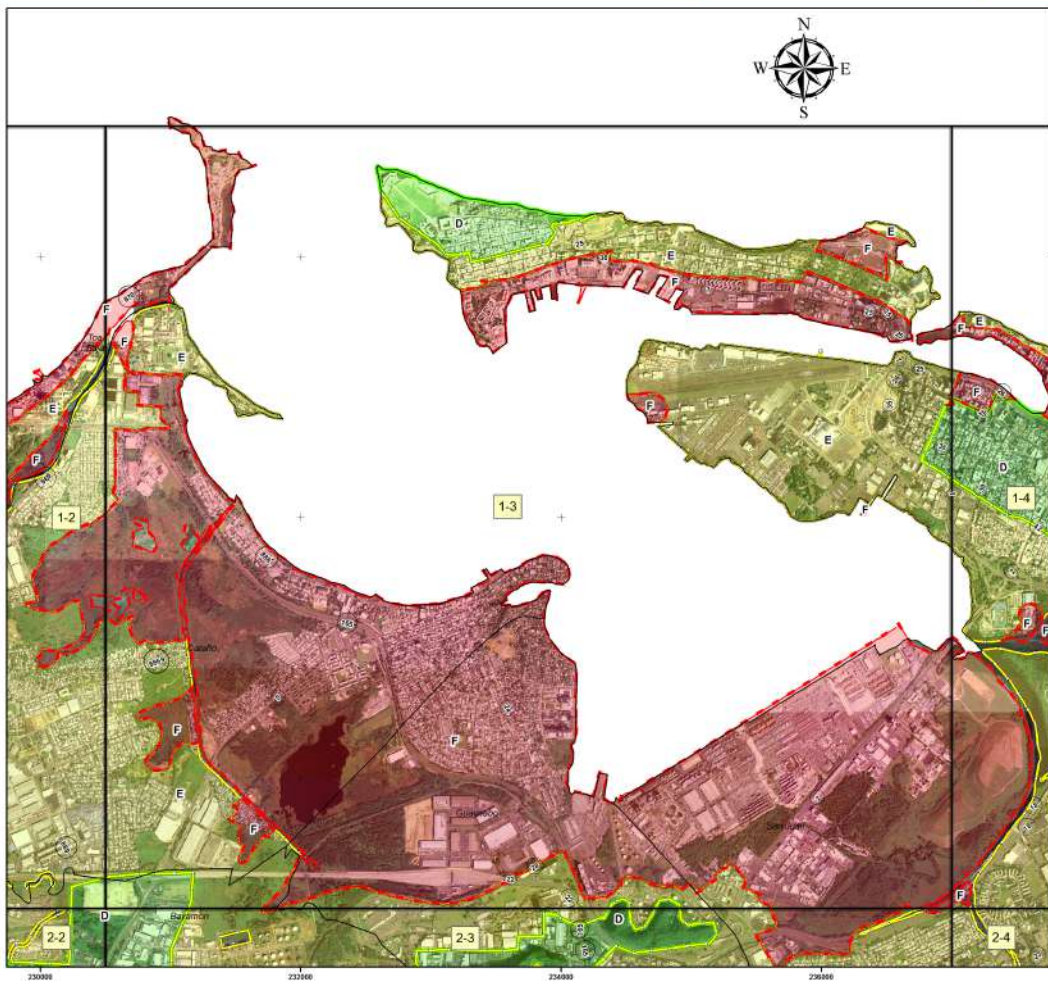


Site Class (NEHRP)			
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Blue	Green	Yellow	Red

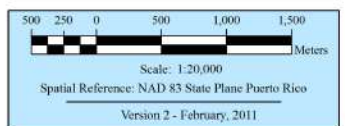


DISCLAIMER:
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Soils Classification Map - San Juan Metropolitan Area

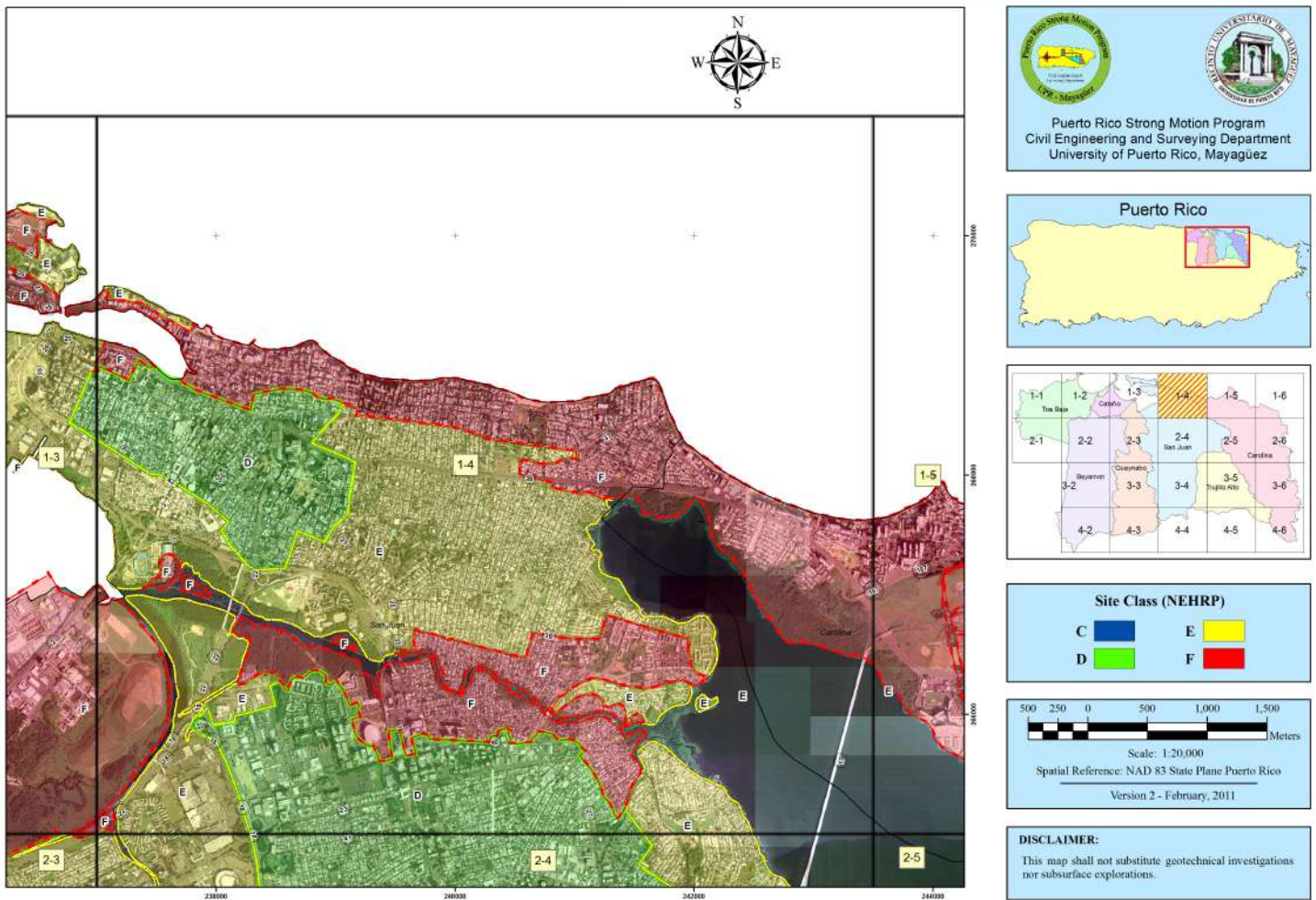


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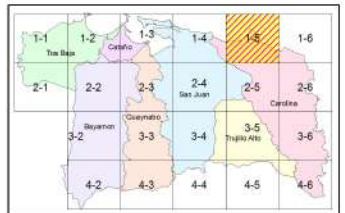
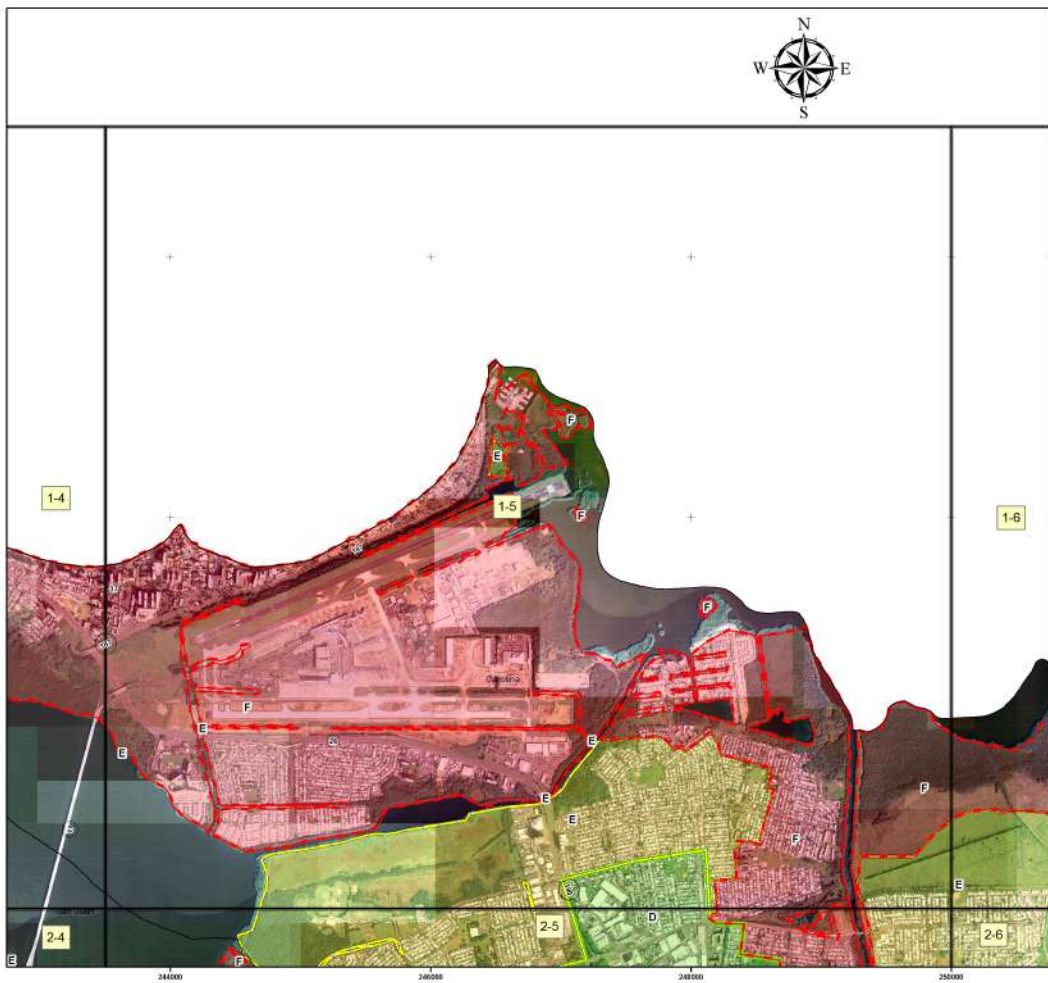


DISCLAIMER:
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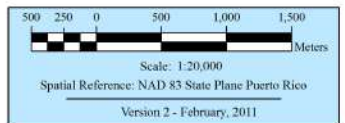
Soils Classification Map - San Juan Metropolitan Area



Soils Classification Map - San Juan Metropolitan Area

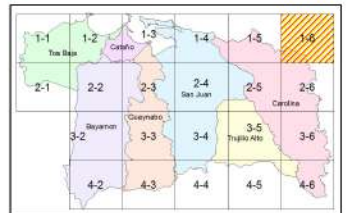
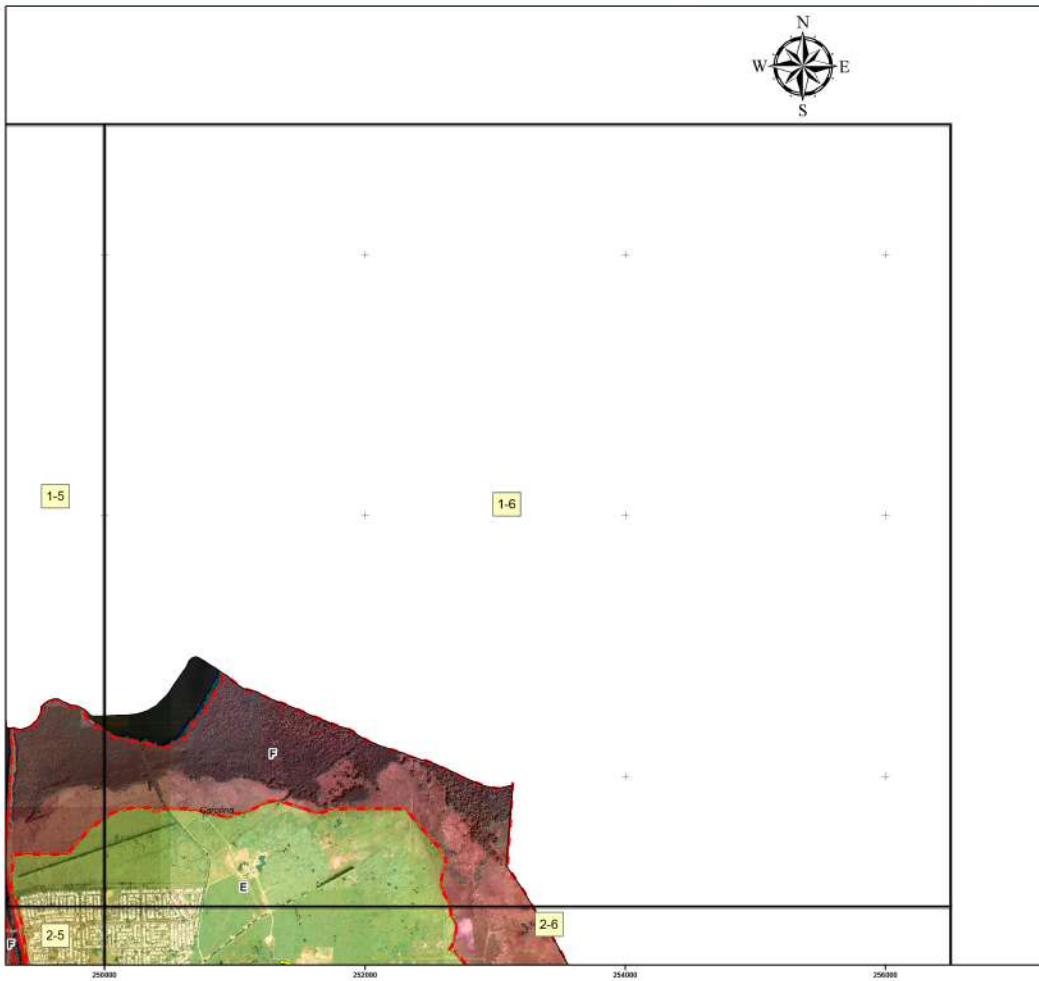


Site Class (NEHRP)			
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Blue	Green	Yellow	Red

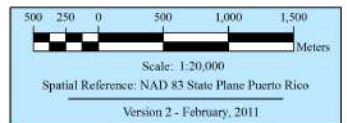


DISCLAIMER:
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Soils Classification Map - San Juan Metropolitan Area

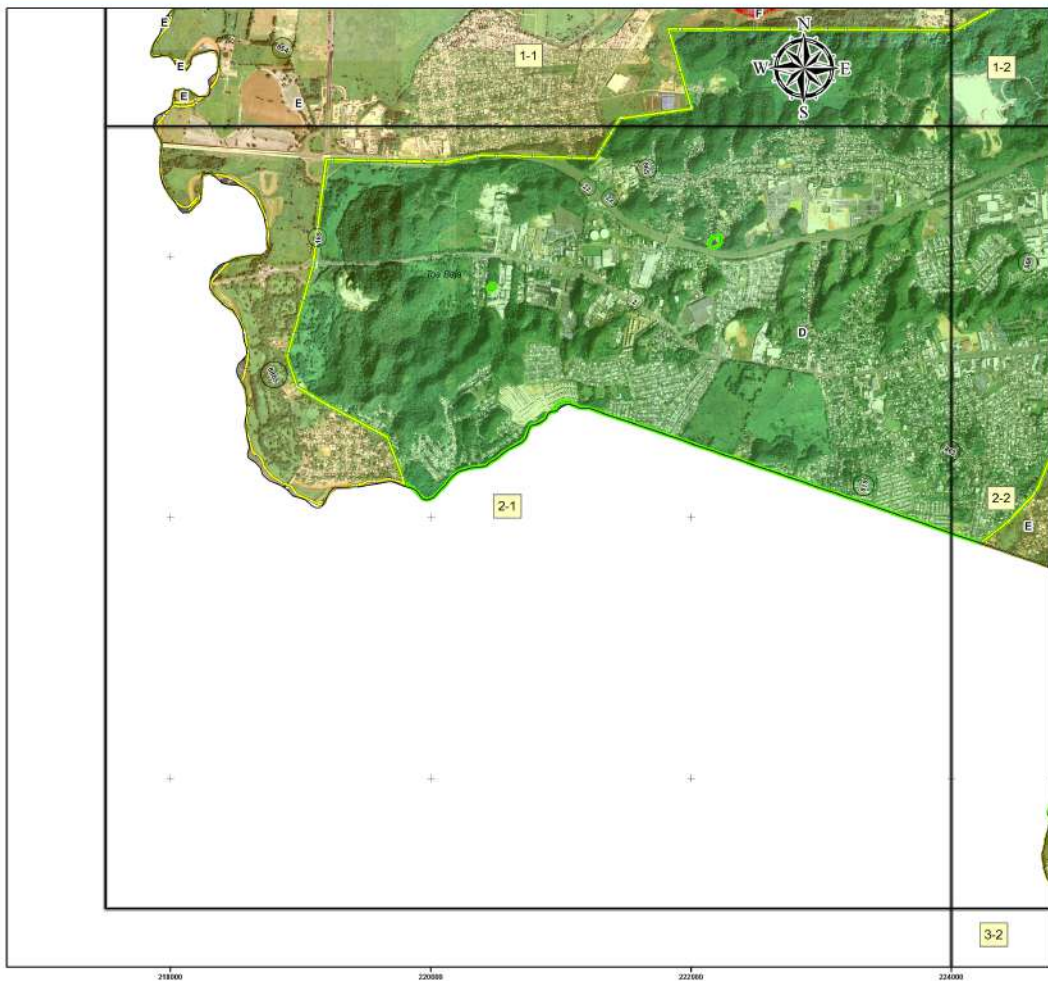


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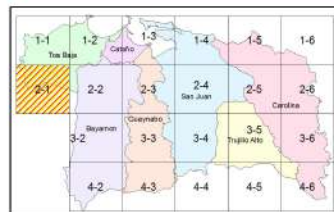


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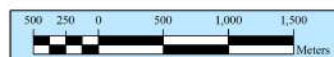
Soils Classification Map - San Juan Metropolitan Area



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University of Puerto Rico, Mayagüez



Site Class (NEHRP)			
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Blue	Green	Yellow	Red

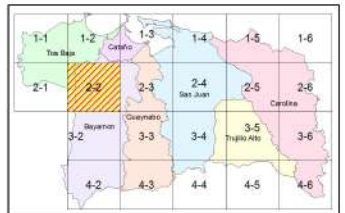
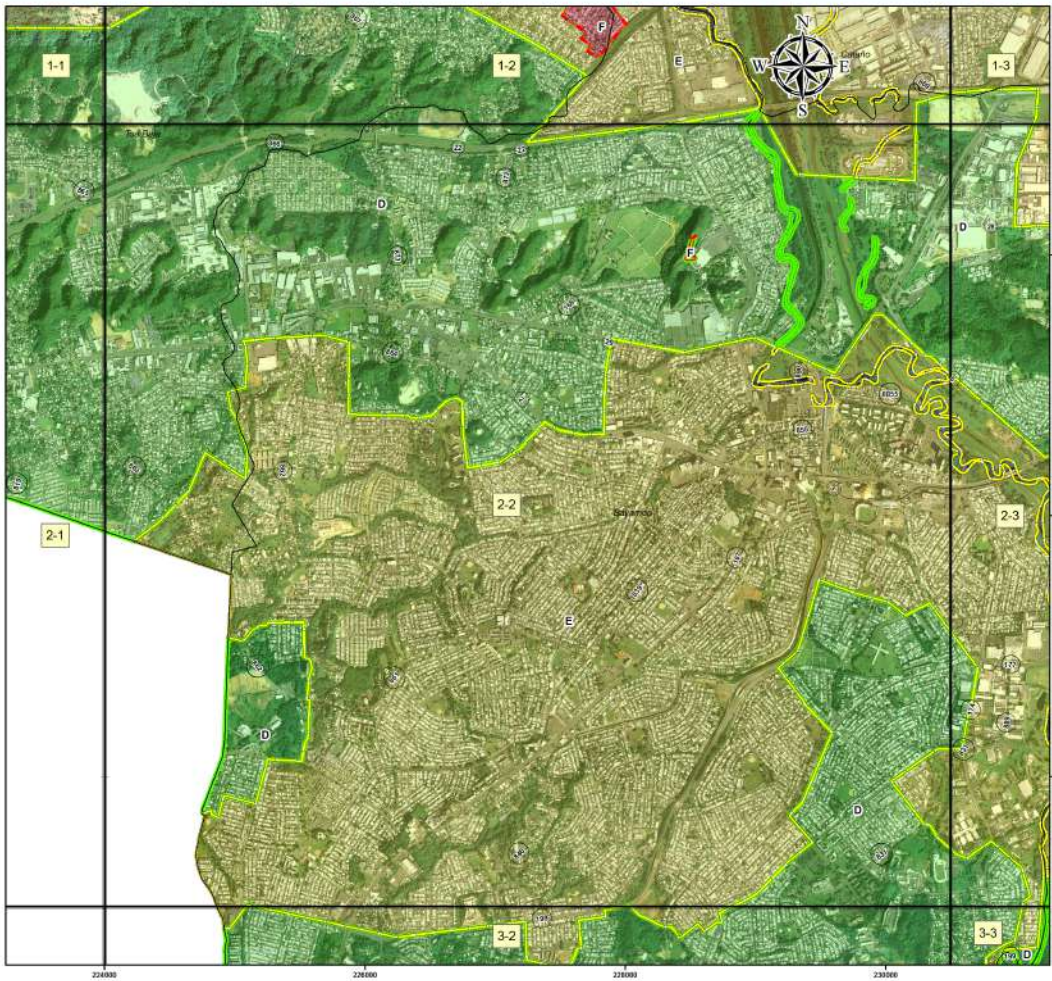


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Version 2 - February, 2011

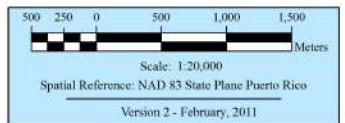
DISCLAIMER:

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Soils Classification Map - San Juan Metropolitan Area

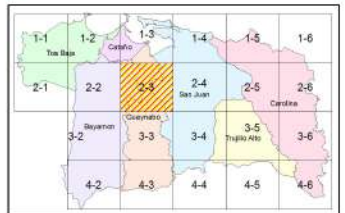
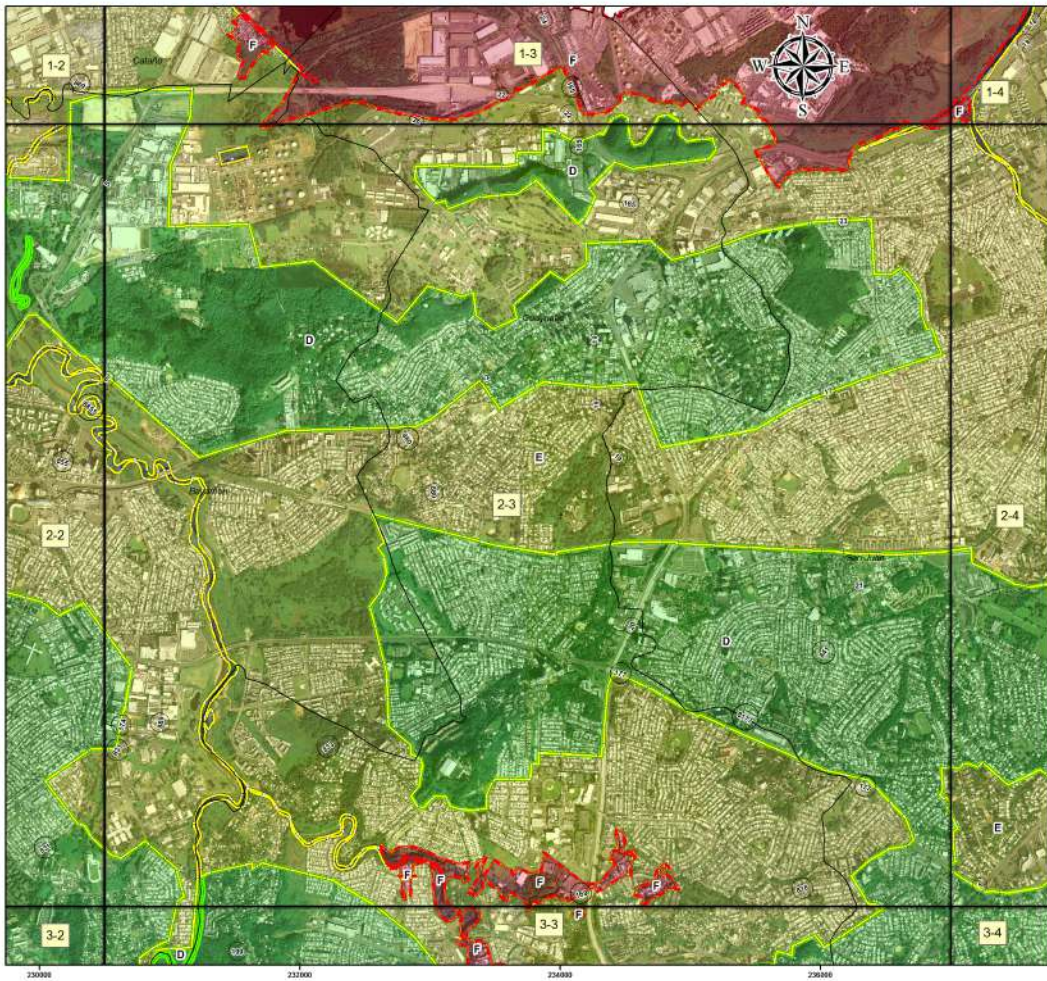


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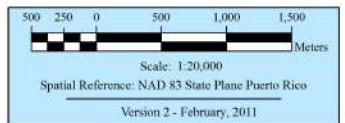


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Soils Classification Map - San Juan Metropolitan Area

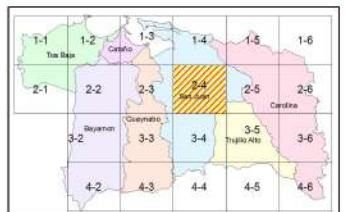
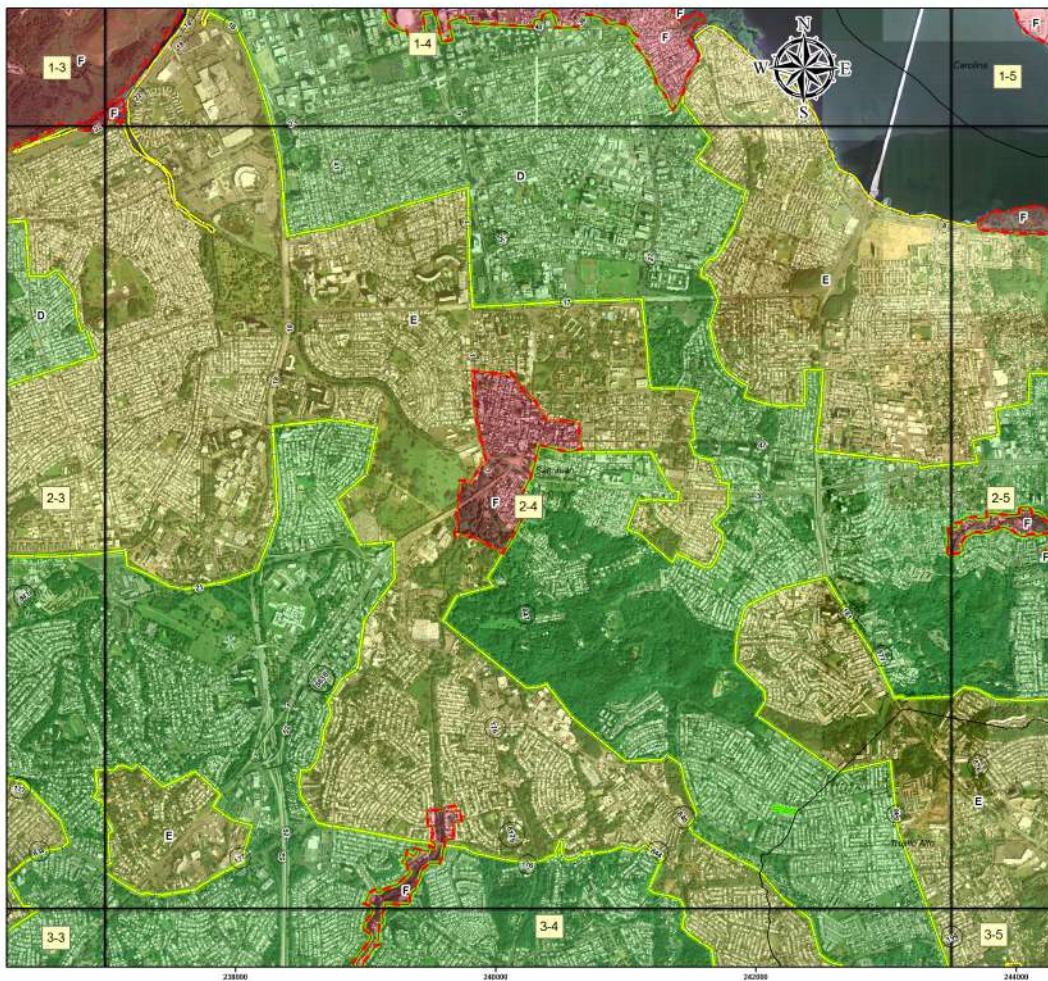


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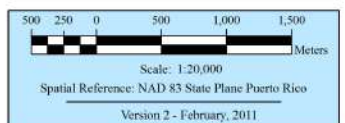


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Soils Classification Map - San Juan Metropolitan Area

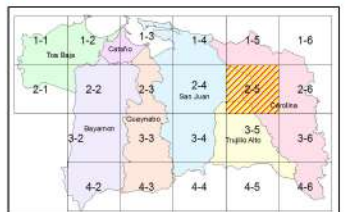
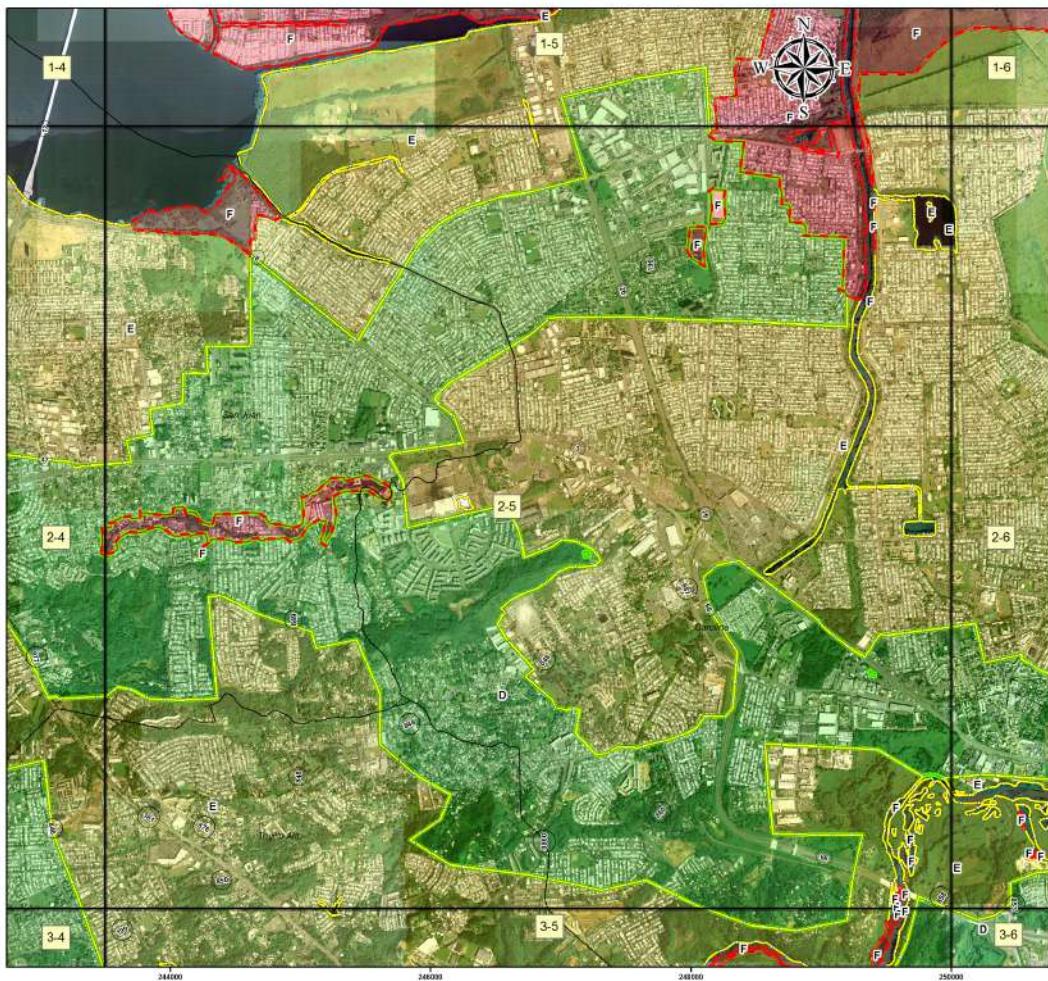


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Blue	Green	Yellow	Red

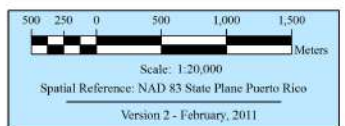


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Soils Classification Map - San Juan Metropolitan Area

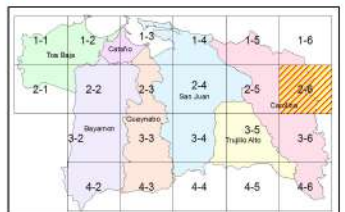
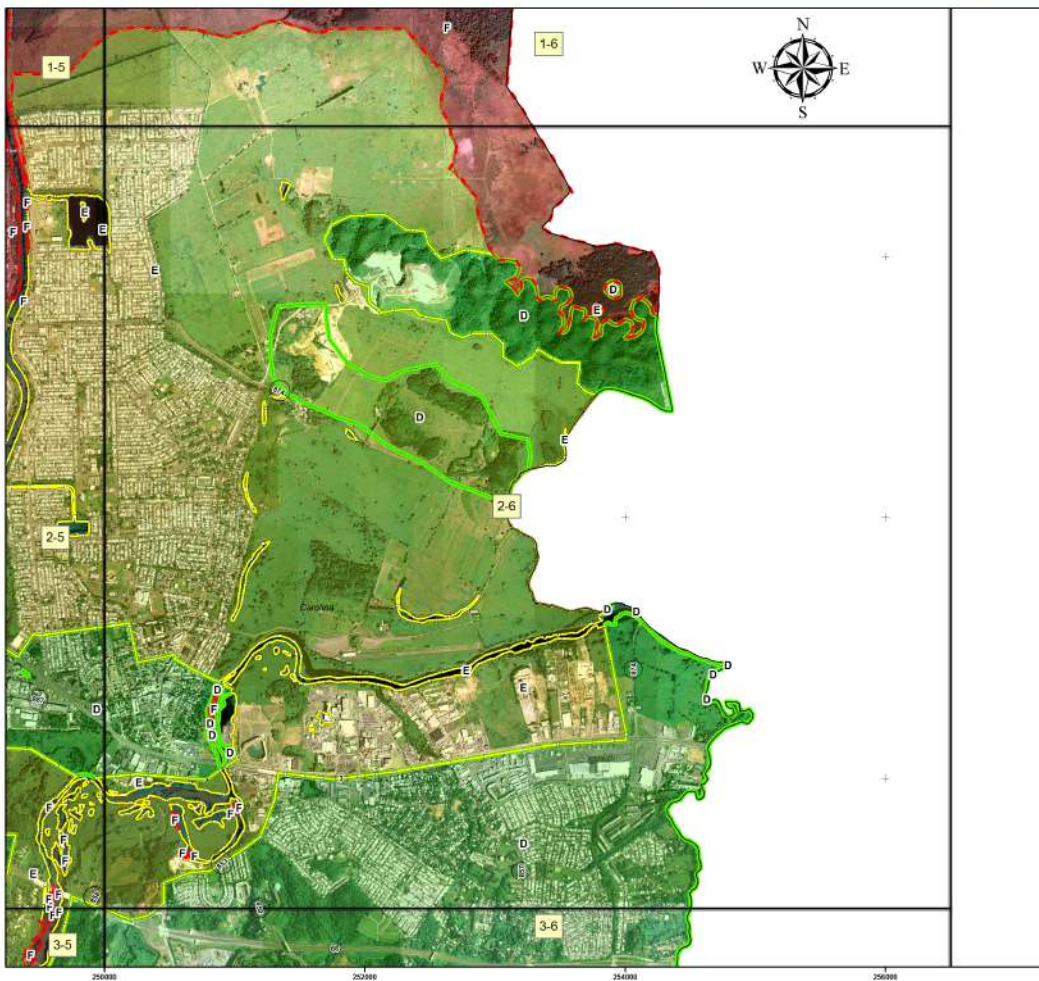


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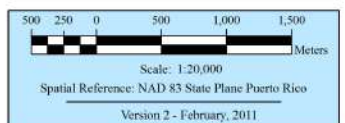


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Soils Classification Map - San Juan Metropolitan Area

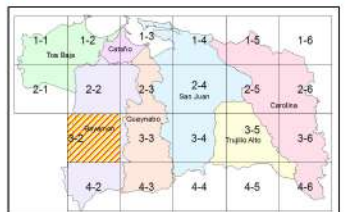
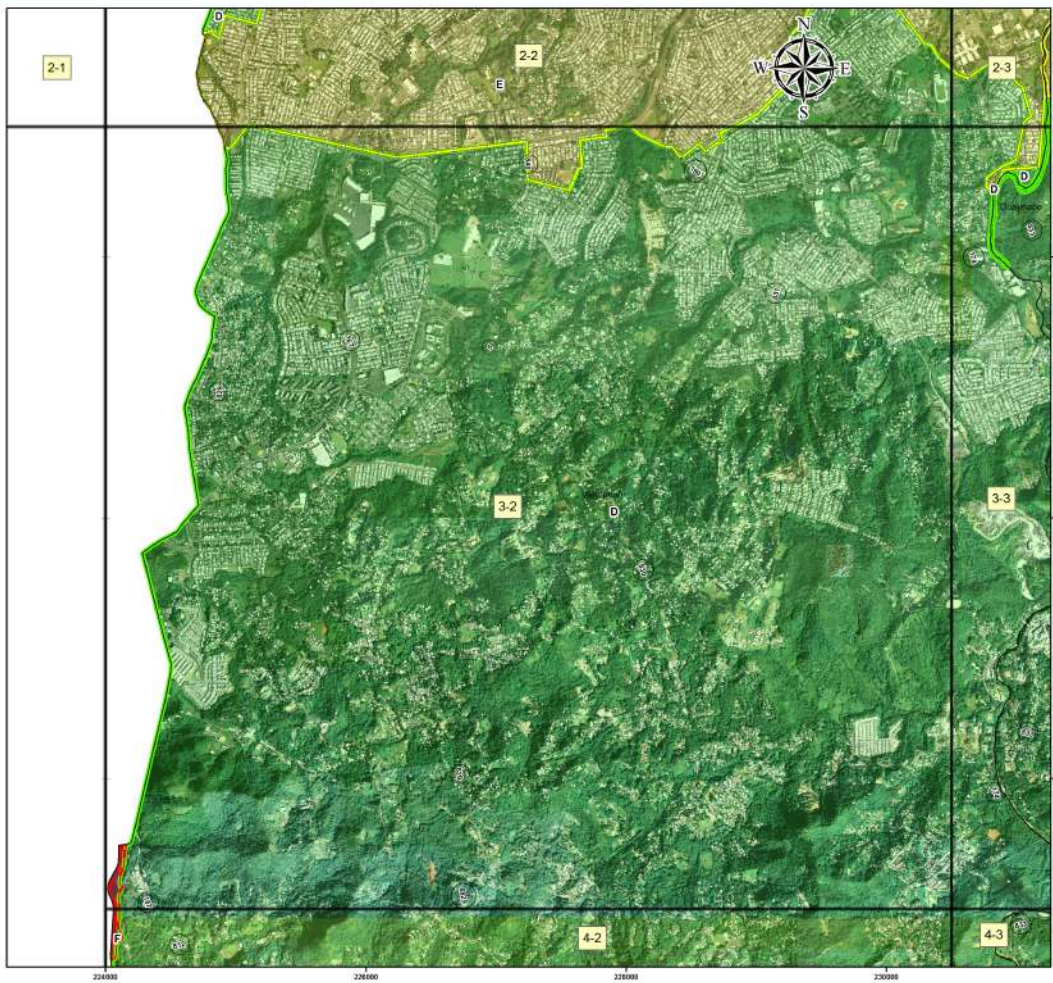


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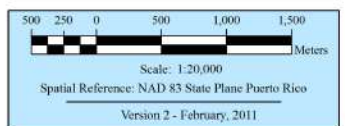


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Soils Classification Map - San Juan Metropolitan Area

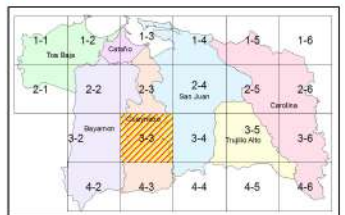
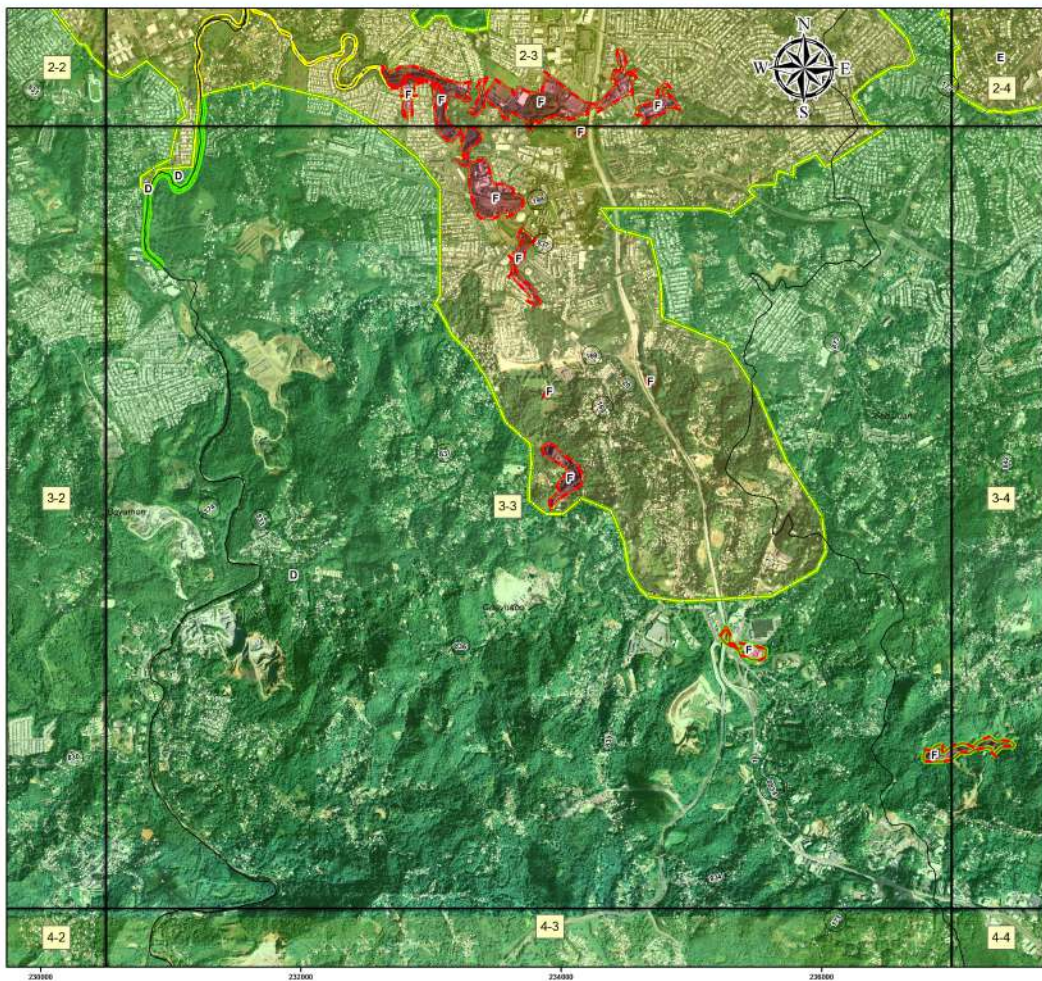


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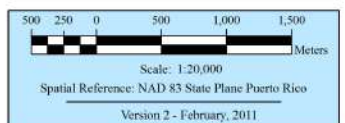


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Soils Classification Map - San Juan Metropolitan Area

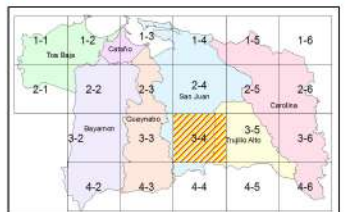
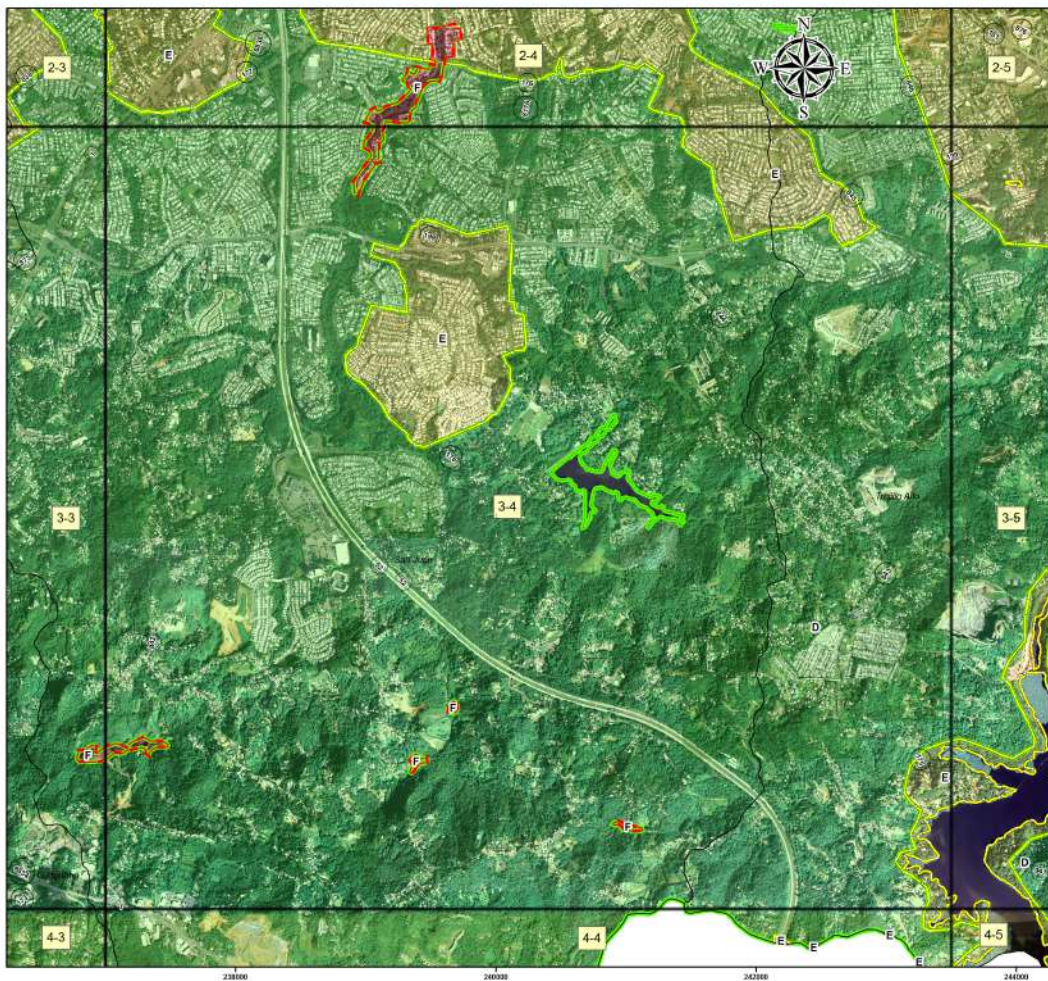


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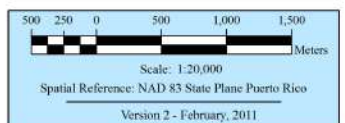


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Soils Classification Map - San Juan Metropolitan Area

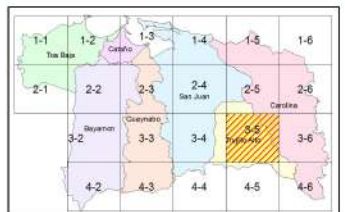
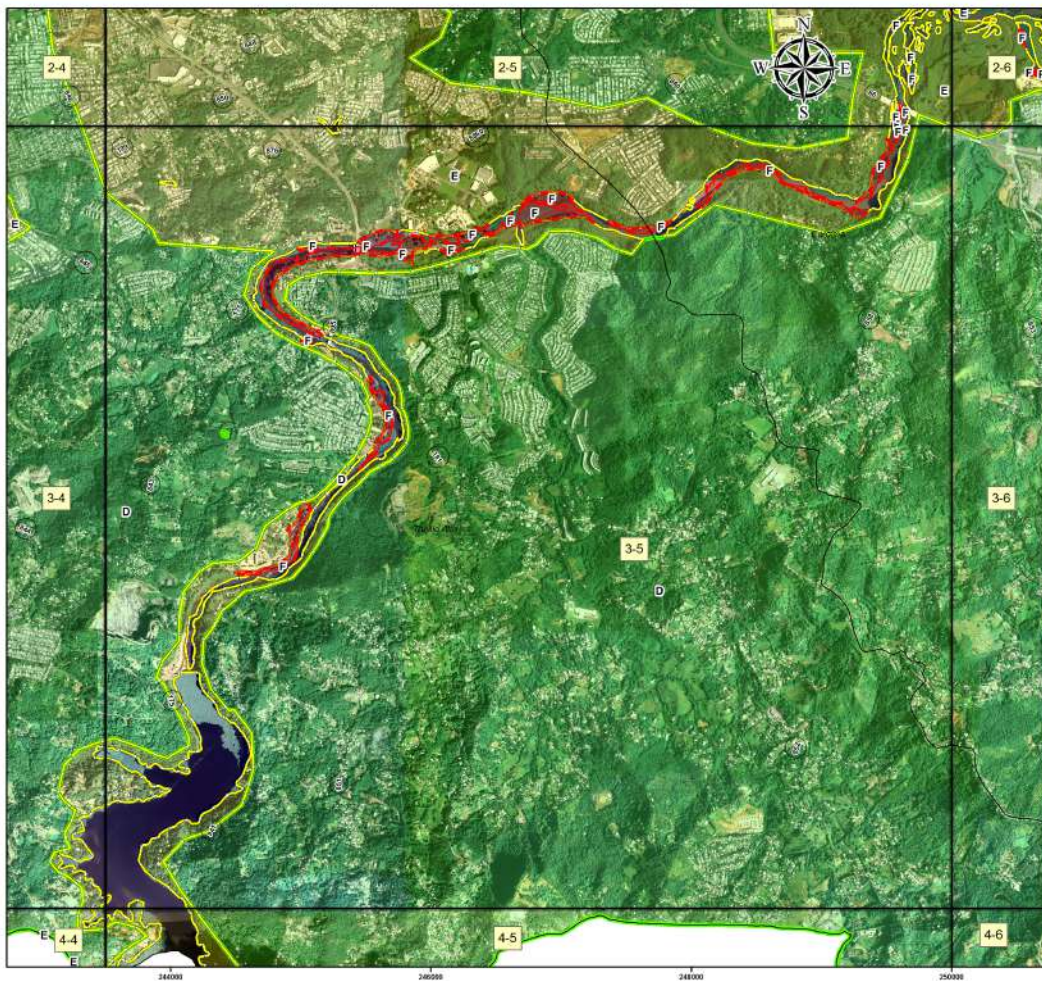


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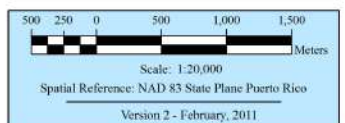


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Soils Classification Map - San Juan Metropolitan Area

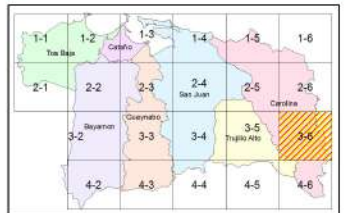
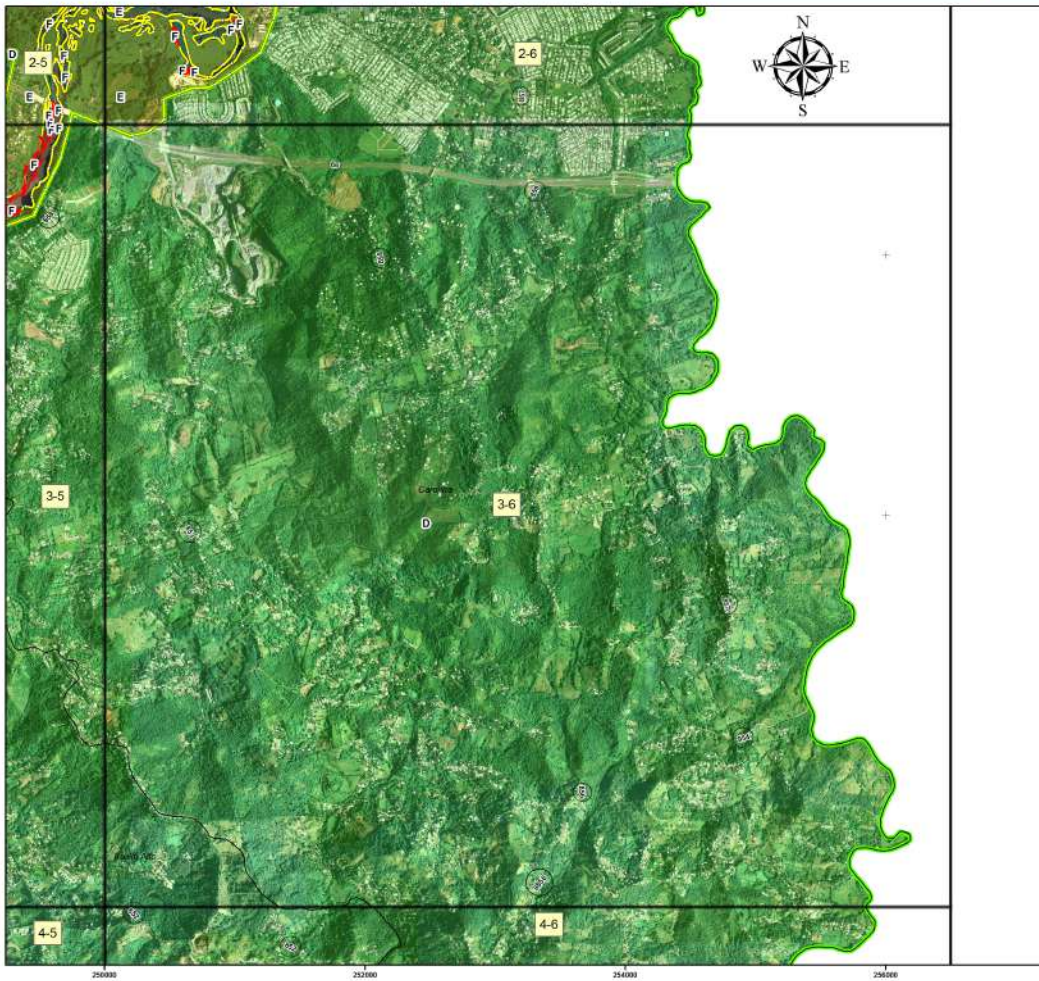


Site Class (NEHRP)			
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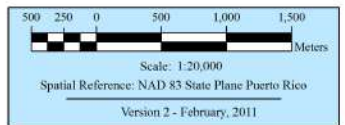


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Soils Classification Map - San Juan Metropolitan Area

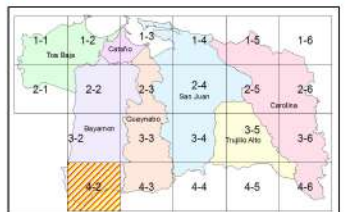
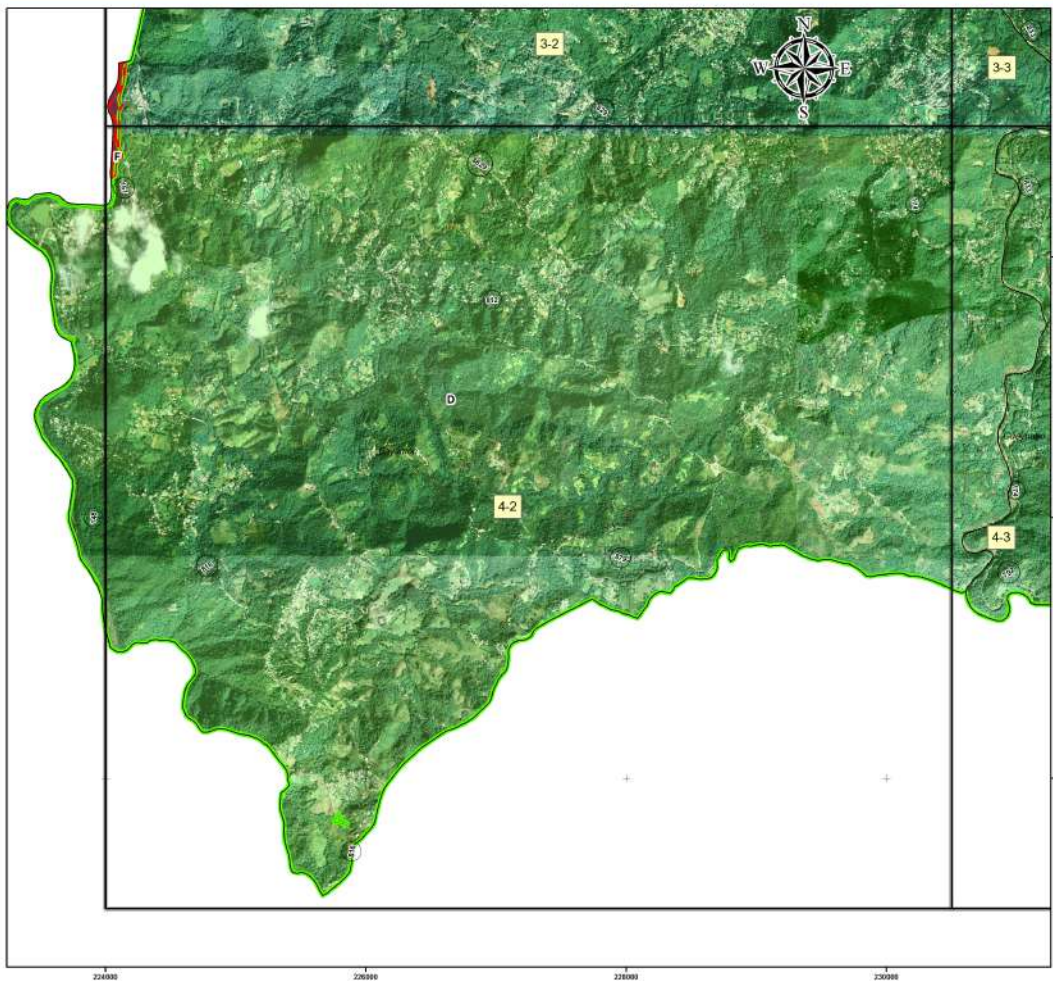


Site Class (NEHRP)			
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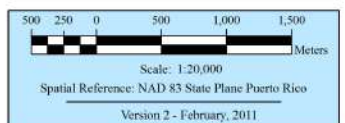


DISCLAIMER:
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Soils Classification Map - San Juan Metropolitan Area

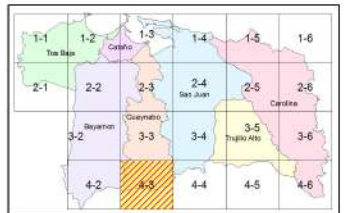
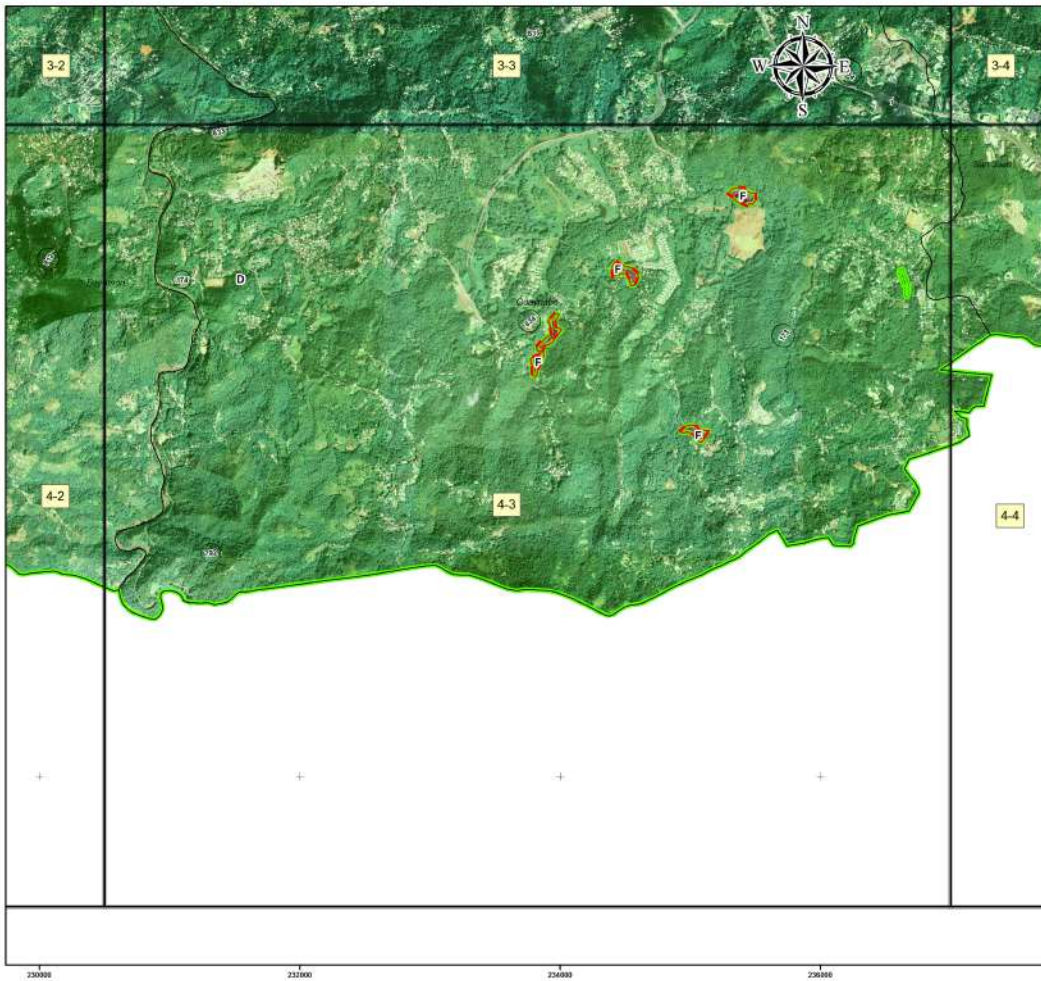


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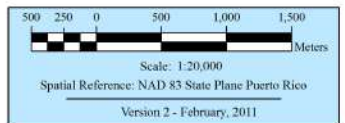


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Soils Classification Map - San Juan Metropolitan Area

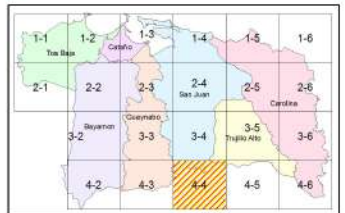
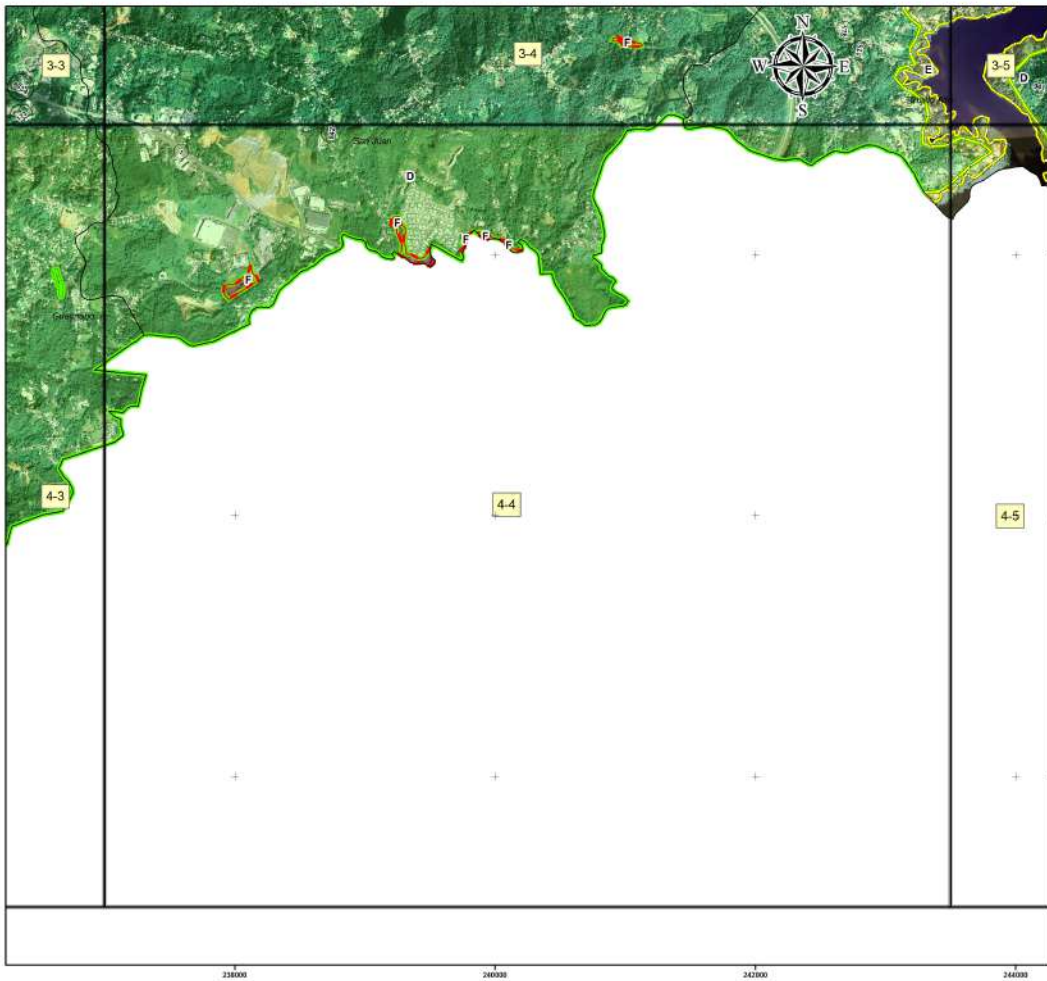


Site Class (NEHRP)			
C	D	E	F
Blue	Green	Yellow	Red

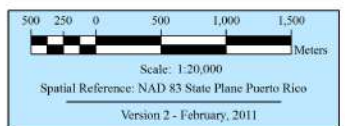


DISCLAIMER:
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Soils Classification Map - San Juan Metropolitan Area

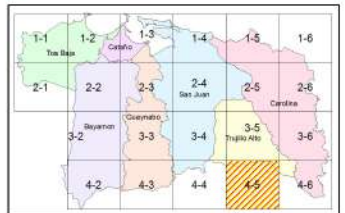
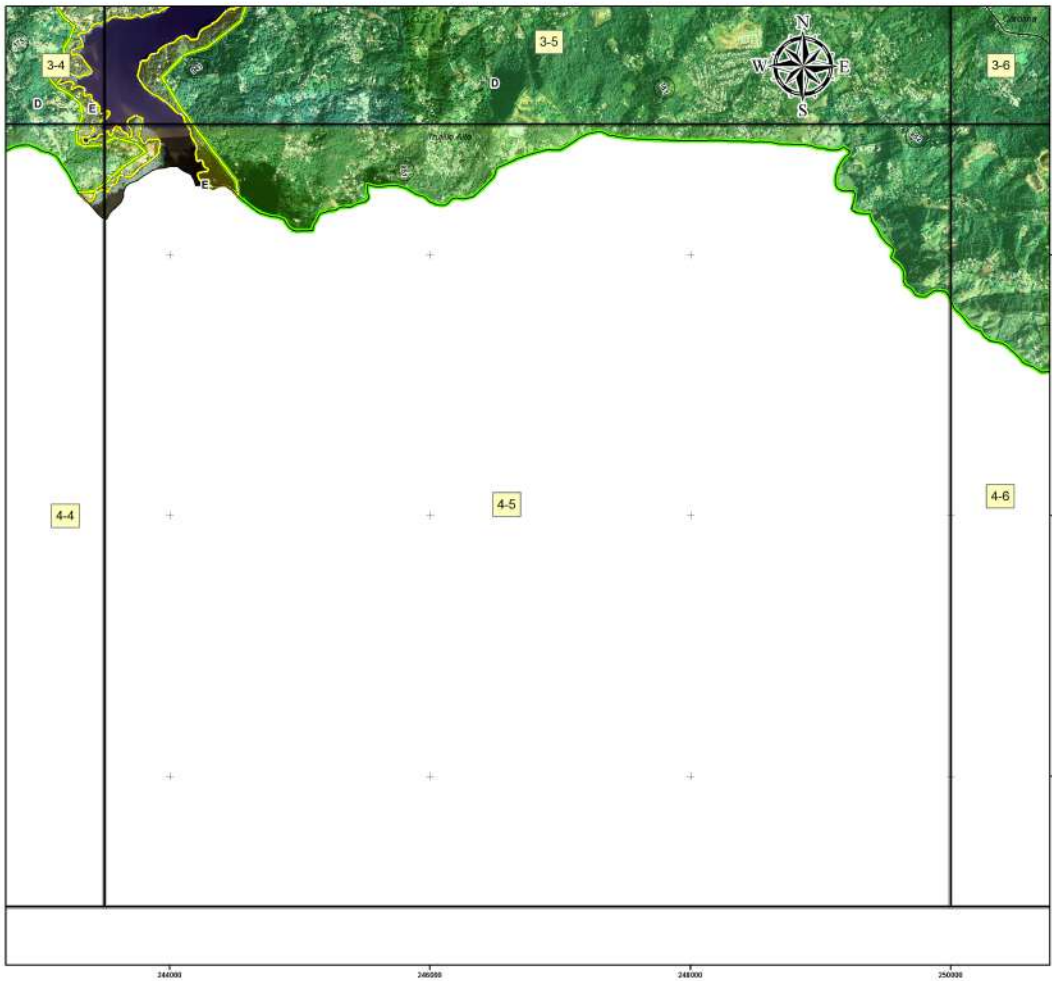


Site Class (NEHRP)			
C	D	E	F
Blue	Green	Yellow	Red

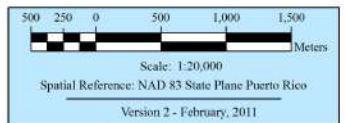


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Soils Classification Map - San Juan Metropolitan Area

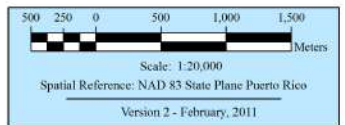
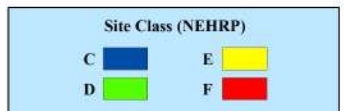
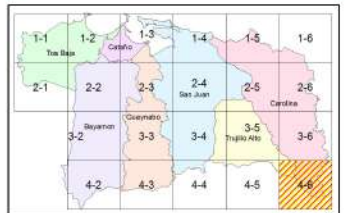
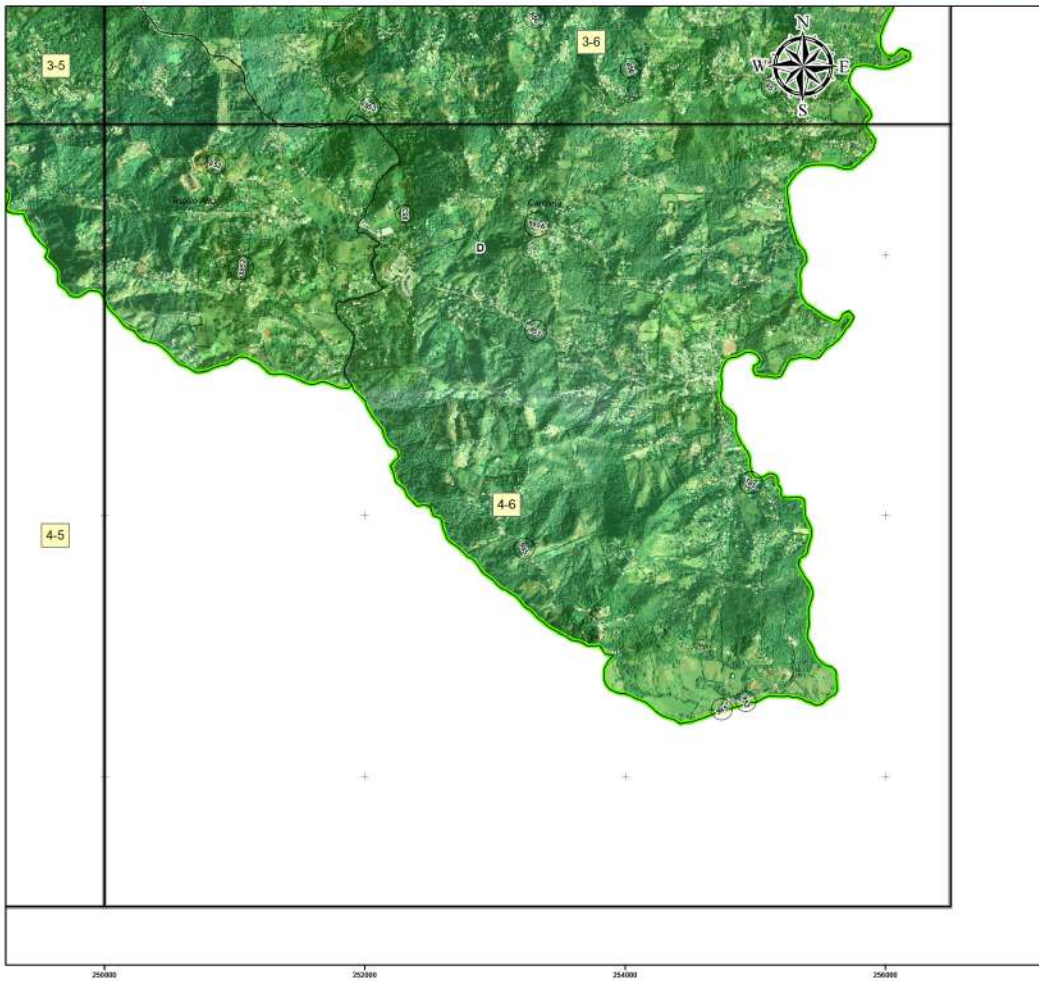


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