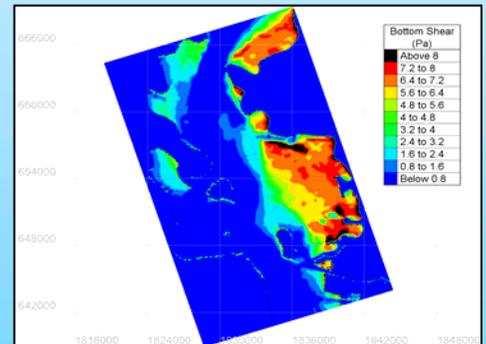


BAYWIDE EELGRASS INVENTORY OF SAN FRANCISCO BAY

October 2004



Funding provided
by Caltrans



Prepared in Cooperation
with NOAA Fisheries



The Baywide Eelgrass Inventory and Habitat Management Research Program is being undertaken as a joint effort of the California Department of Transportation (Caltrans) and National Marine Fisheries Service (NOAA Fisheries). The project is fully funded by Caltrans as one element of the San Francisco-Oakland Bay Bridge East Span Seismic Safety Project environmental mitigation. The purpose of this program is to support the advancement of eelgrass management science and policy within San Francisco Bay by providing essential information on the distribution, abundance, characteristics, and environmental controls of eelgrass within the Bay.

**San Francisco – Oakland Bay Bridge
East Span Seismic Safety Project**

Baywide Eelgrass (*Zostera marina* L.) Inventory in San Francisco Bay



Prepared by

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SAN FRANCISCO BAY EELGRASS INVENTORY

June – October 2003
San Francisco, California

BACKGROUND

Historically, very little has been known about the distribution or characteristics of eelgrass beds within San Francisco Bay (Bay) and within the past decade, the need to establish a baseline of eelgrass (*Zostera marina*) coverage in the Bay has become apparent. While much attention has been paid to the management and restoration of Bay Area marshlands, important subtidal habitats such as eelgrass have generally not received the same management attention and efforts. Much of the blame for the lack of attention to management of these habitats can be traced to a lack of information regarding the status, distribution, and importance of these areas within the San Francisco Bay ecosystem and within a larger coast-wide context.

As an element of the environmental mitigation required to compensate for impacts to eelgrass habitat from the San Francisco-Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project (East Span Project), the California Department of Transportation (Caltrans) has committed to funding a Baywide Eelgrass Inventory and Resource Management Research Program (program). Construction activities for the East Span Project will impact eelgrass habitats as a result of both permanent bridge footprint and shading effects as well as temporary construction activities. In order to mitigate these impacts, and to provide the information necessary to manage eelgrass and other subtidal habitats throughout San Francisco Bay (Bay), Caltrans has been required to undertake a multi-element mitigation program that includes habitat restoration on-site and off-site as well as a commitment to fund the present \$1 million eelgrass inventory and resource management research effort. Caltrans and the National Marine Fisheries Services (NOAA Fisheries) jointly hold the management responsibility over the inventory and research program.

This program is intended to identify and map existing eelgrass beds and identify conditions under which eelgrass can occur throughout San Francisco Bay. In addition, the program is designed to identify current eelgrass stressors and opportunities for enhancement of eelgrass communities within the Bay. The results of the program will facilitate management of eelgrass habitat resources throughout the Bay by providing additional information on the status, distribution, growth-limiting factors, and ecological benefits of eelgrass within this highly dynamic system.

A large-scale survey of the known and potential occurrence of eelgrass throughout San Francisco Bay was completed over 15 years ago (Wyllie-Echeverria and Rutten 1989) and, due to the advances in survey technology over the past few years, more accurate maps are now possible. In addition, while previous studies have addressed environmental factors such as light on the growth of eelgrass in the Bay (Zimmerman *et al.*, 1991 and 1995), the multiple and complex environmental factors that influence eelgrass distribution are not well known. For these reasons, the current program will fill in the information gap



Figure 1. Eelgrass growing near the shore at Keil Cove, Marin County

much-needed to preserve this critical biological resource. The results of the eelgrass inventory are presented on the individual map sheets of this Eelgrass Atlas.

EELGRASS RESOURCES

Eelgrass (*Zostera marina* L.) (Figure 1) is the most widely distributed marine angiosperm in the Northern Hemisphere (den Hartog 1970). It is a native plant indigenous to the soft-bottom bays and estuaries of the Northern Hemisphere and occurs along the Pacific coast of North America from the Bering Straits down to lower Baja California. Eelgrass is considered to be a habitat forming species that creates unique biological environments when it occurs in the forms of submerged or intertidal aquatic beds or larger meadows. As submerged aquatic beds, eelgrass is given special status under the Clean Water Act, 1972 (as amended), Section 404(b)(1), "Guidelines for Specification of Disposal Sites for Dredged or Fill Material," Subpart E, "Potential Impacts on Special Aquatic Sites."

Eelgrass abundance has declined worldwide over the past 20 – 30 years due to increased anthropogenic effects (Short and Wyllie-Echeverria 1996). In the late 1920s eelgrass was reported as an abundant species along the shores of the Bay (Setchell 1929). In 1987, about 60 years later, a survey of the Bay revealed only 128 hectares (316 acres) (0.1 percent total bay bottom coverage) of eelgrass throughout the Bay, with much of the existing habitat exhibiting conditions of environmental stress (Wyllie-Echeverria and Rutten 1989, Wyllie-Echeverria 1990). A decade later, surveys of the San Pablo Peninsula, documented over 162 hectares (400 acres) of eelgrass, suggesting either extremely dynamic conditions within the existing beds, or an underestimation in the 1987 studies resulting from limited survey techniques (SAIC and Merkel & Associates 1997a, 1997b).

As documented in the San Francisco Bay Area Wetlands Ecosystem Goals Project (1999) approximately 8,100 hectares (20,000 acres) of deep and shallow bay habitats have been lost since the 1800's as a result of bay fill and sediment deposition. Considering that almost all of the habitat losses have resulted

along the shallow Bay margins, it is unlikely that eelgrass escaped impact from these historic losses. However, as a point of fact, the historic status of eelgrass in San Francisco Bay is not well known and it cannot be fully determined whether eelgrass habitat has been substantively reduced from prior levels. Because Setchell's early work did not include comprehensive maps and most of the sites referenced in 1929 remain today, it is not possible to fully determine if significant declines in eelgrass within the Bay have occurred between 1929 and present. While, there is some reason to believe significant declines have occurred, even today there are many places on the Bay where eelgrass can be described as "an abundant species along the shores".

Notwithstanding the difficulty in assessing historic trends for a system as large as San Francisco Bay, eelgrass is highly limited compared to other west coast bays and estuaries. In addition to a general paucity of eelgrass, the beds that do exist in San Francisco Bay are extremely dynamic. In repeated surveys of eelgrass beds at Point Molate, the Richmond Harbor training wall, and the Emeryville Flats, eelgrass density and abundance was noted to fluctuate significantly from year to year (Merkel 1997, 2001). This annual variability in eelgrass appears to relate to fluctuations in the turbidity or even average climatic conditions within marginally suited environments. While there has not been a significant amount of rigorous monitoring of eelgrass in the Bay, at least some of the high variability appears to be related to large-scale episodic events that influence the distribution of freshwater and sediments in the Bay (Merkel 2000 and additional unpublished data). Recent studies have demonstrated that dynamism in eelgrass beds is common in many areas. For example, eelgrass above-ground biomass and shoot density can vary by as much as 500% over two years at the same site in Willapa Bay, Washington as a result of environmental fluctuations and human disturbance (Thom et al. 2003). Similarly, El Niño Southern Oscillation (ENSO) events can cause considerable declines in eelgrass within Southern California (Merkel & Associates 2000).

SURVEY AND ANALYSIS METHODS

Pre-survey Screening Model

San Francisco Bay consists of approximately 100,000 hectares (250,000 acres) of subtidal and intertidal habitat. The intent of the current program was to provide a complete overview of all eelgrass resources within the Bay at a single point in time in order to establish a baseline inventory of eelgrass resources. To accomplish this goal, a pre-survey screening model was developed to identify those portions of the Bay with potential to support eelgrass. Using this model, it was possible to reduce the survey area to a size that could be effectively and efficiently surveyed within the 2003 summer/early fall when eelgrass abundance is at its peak.

The pre-survey screening made use of existing physical data in a probabilistic model in order to determine the potentially suitable areas for eelgrass growth within the Bay. Through this pre-survey screening, the study area for the field surveys was

reduced to approximately 15,400 hectares (38,000 acres). The areas identified by the model as suitable for eelgrass growth were the focus areas for field surveys.

Field Surveys

Eelgrass surveys were conducted from June to October 2003 using both acoustic and aerial survey methods. In order to manage eelgrass survey areas, the Bay was divided into one-square kilometer (247-acre) cells oriented in a Universal Transverse Mercator (UTM) coordinate grid. The study area for the program encompassed San Francisco Bay and the waters of Suisun Bay. However, only limited surveying was conducted in Suisun Bay once it was determined that eelgrass had been fully replaced by Widgeon Grass (*Ruppia maritima*) east of the Carquinez Bridge.

Aerial Surveys

Aerial eelgrass surveys were conducted on June 3, 16, and 17, 2003 and October 23, 2003. Aerial surveys were performed from a helicopter during daylight low tides and eelgrass was located and roughly mapped using visual surveys, photography, and a differential global positioning system (dGPS) to mark coordinates of existing eelgrass beds. The outlines of eelgrass beds that were mapped during the aerial surveys provided information helpful in completing more comprehensive acoustic surveys. These surveys were primarily used to exclude large areas of intertidal mudflats from the requirements of in-water acoustic surveys by confirming the absence of eelgrass in these areas. The aerial surveys also provided a large-scale perspective on eelgrass abundance and distribution throughout the Bay.

Helicopter overflights were typically flown between 150 and 60 meters (500 and 200 feet), but surveys occasionally were conducted as high as 1,500 meters (5,000 feet) to photograph large beds and were flown as low as 6 meters (20 feet) in order to distinguish *Zostera* from dense *Ruppia* beds in Suisun Bay. Three days of aerial surveys were completed before the in-water surveys were initiated to eliminate large areas of the Bay from the in-water eelgrass surveys and to review and document navigation hazards in the shallow waters surveyed at high tides.

Acoustic Surveys

M&A conducted sixty-five days of acoustic eelgrass surveys between June 4 and October 12, 2003. The timing of survey work was dependent on factors such as tides, depth of the survey areas, and weather. Most survey work was conducted at high tides whenever possible in order to avoid submerged obstructions and to survey as close to shore as possible. Windy conditions on the Bay frequently prevented work from being conducted in the late afternoon and evening and sidescan operators often found that the calmest waters with the highest tides occurred in the middle of the night. As such, considerable work was conducted during night surveys.

Acoustic survey techniques utilized a combination of side-scan sonar and single-beam sonar combined with diver groundtruthing to search for and document eelgrass beds.

Acoustic surveys were conducted aboard the 7.3-meter (24-foot) R/V Merkel Johnson-150 and made use of side-scan and single beam sonar integrated with a dGPS. Side-scan data were collected using a Marine Sonics side-scan sonar operating at 600 kHz. The side-scan towfish was positioned approximately 0.5 to 2.0 meters (1.6 to 6.6 feet) below the water surface, depending on the amount of water between the surface and the Bay bottom. To obtain good coverage and resolution, the side-scan was configured to provide a display range of 20 meters (66 feet) per channel (port and starboard). Transects were spaced 38 meters (125 feet) apart, which allowed for a trackline overlap of one meter (3.3 feet) between parallel tracklines.

The dGPS receiver (Leica MX400) utilized the U.S. Coast Guard FM correction beacon and collected navigation and positioning data for the surveys. Navigational fixes were collected every second during data collection. Vessel position was maintained along predetermined transect lines using an on-board, real-time GPS display. Sidescan and fathometer data were collected and analyzed digitally using Marine Sonics Sea-Scan PC side-scan data collection software and Oceanic Imaging Consultants GeoDAS analysis software. The horizontal system resolution was approximately ± 2 meters (± 6.5 feet) as a combined error of the navigation system and side-scan equipment. All data were collected in decimal degrees latitude and longitude using the North American Datum of 1983 in meters (NAD 83) and subsequently converted and plotted on a coordinate grid using UTM coordinates in meters (NAD 27).

Bathymetry

Bathymetric data were collected using a Furuno FCV-600L single-beam fathometer operating at a frequency of 200 kHz with the 15% beam width. The echo-sounder was mounted on the stern of the vessel and the transducer was located approximately 0.2 meters (0.5 feet) below the water surface. Fathometer data were recorded with the side-scan data and stored with time and xyz coordinate data. Bathymetric data were post-corrected for tide stage using the time stamp and NOAA gauging station data.

Ground-Truthing

Acoustic records of eelgrass beds were ground-truthed by SCUBA divers who confirmed the presence of eelgrass in mapped beds. Diver ground-truthing was conducted at Bayfarm Island, Emeryville Flats, Crown Beach, Oakland Middle Harbor, Clipper Cove, Richmond Training Wall, Pt. Molate, Pt. San Pablo, Pt. San Quentin, Angel Island, Keil Cove, Richardson Bay, and Coyote Point. Diver ground-truthing was conducted from 6.7-meter (22-foot) and 7.3-meter (24-foot) research vessels operated by Merkel & Associates.

DATA INTERPRETATION AND EELGRASS MAPPING

Digital maps of the distribution of eelgrass throughout the Bay were created from the 2003 survey data. Following completion of the surveys, sonar traces were downloaded, processed, and geographically registered using ESRI ArcView Version 3.2a[®].

All plots were generated based on California State Plane Zone 3 (NAD 83). Two themes were created in the Arcview program, eelgrass habitat from the 2003 survey and a “maximum documented eelgrass extents” layer that combined data from all spatially documented sources including such sources as Wyllie-Echeverria and Rutten (1989), SAIC & Merkel (1997a and b), Merkel & Associates (1997, 1999, 2001, 2003b, unpublished data), and Kitting (1993, 1998). In order to present these results on a scale that would be useful to resource managers, the San Francisco Bay Eelgrass Atlas was created. Each page of this atlas presents a 25-square kilometer (9.7-square mile) section of the Bay at a scale of 1:36,000. Bathymetry is presented in feet below mean lower low water (MLLW).

Mapping techniques and areal coverage determination made use of a mix of analytical techniques developed and employed in prior large-scale eelgrass surveys (SAIC and Merkel & Associates 1997a and b, Merkel 1988, 1992, 2003a, U.S. Navy SWDIV 1994, 2000). Eelgrass beds in San Francisco Bay generally consist of clustered patches of eelgrass as opposed to continuous carpets, such as those observed in most other systems. For the purpose of this survey, a given eelgrass bed included many clustered eelgrass patches and the edges were determined by locating the greatest extent of the eelgrass patches within the survey area. Within the boundaries of the bed, eelgrass was subdivided into four cover categories defined by the percentage of total bottom coverage within the mapped bed. The cover classes used were >5%, 5%-20%, 20%-40%, and greater than 40% cover (Figure 2). Where individual plants were too far apart to be aggregated into beds, the individual plants were considered to define the boundaries of discrete beds. These patches, like many of the patches that occurred within the beds, were typically comprised of single plants with only a few turions.

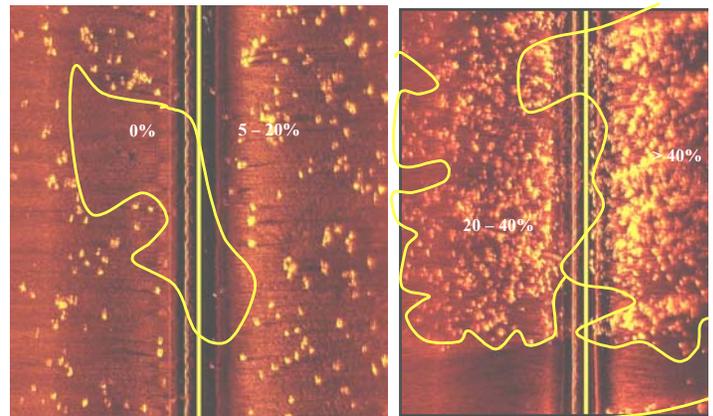


Figure 2. Examples of mapped eelgrass coverage classes.

SURVEY RESULTS

Eelgrass Distribution

The Baywide Eelgrass Inventory mapped 1,165.7 hectares (2,880.5 acres) of eelgrass within San Francisco Bay during the summer of 2003 (Table 1, Figure 3). The coverage of eelgrass observed during the current survey was approximately 900%

greater than the eelgrass extent mapped during the previous baywide eelgrass survey (Wyllie-Echeverria and Rutten 1989). The major differences observed between the 1987 and 2003 surveys is attributed at least in part to an actual increase in eelgrass coverage and in part to recent advances in mapping technology. Given results of prior surveys conducted throughout the 1990's, it is clear that mapping technologies play a major role in detecting low-density eelgrass beds in the turbid waters of San Francisco Bay (Thompson *et al.* 1997).

In order to compare survey results and mapping technologies between the 1987 and 2003 surveys, it is helpful to compare eelgrass coverage between the same beds. Twenty-two eelgrass beds were mapped in 1987, and all of these were located and mapped during the 2003 survey (Table 1). In addition to those beds mapped in 1987, eight major beds (e.g., Emeryville Flats) and several smaller eelgrass beds and individual patches were mapped during the current survey. The total coverage of the major beds was 1,129.2 hectares (2,790.3 acres) and the coverage of additional small eelgrass patches was 36.5 hectares (90.2 acres). Both the increased coverage of the major beds and the addition of the smaller patches contributed to the higher coverage in 2003 than was reported in 1987 surveys.

Table 1. Location and acreage of major eelgrass beds in San Francisco Bay during the 1987 (Wyllie-Echeverria and Rutten 1989) and current 2003 surveys.

LOCATION	1987 (ac.)	2003 (ac.)	ATLAS PAGE
San Pablo Bay	124	1,504.5	21, 34
Point Orient	3	2.3	21
Naval Supply Depot	12	77.0	21
Point Molate Beach	26	32.0	22
Toll Plaza West	0.5	0.0	22
Toll Plaza East	0.5	2.5	22
Point Richmond, North	7	24.0	22
Point Richmond, South	4	65.6	22
Richmond Breakwater, North	18	19.0	22, 35
Richmond Breakwater, South	7	86.3	23, 36
Brickyard Cove	-	17.7	22
Emeryville (breakwater)	13	28.7	47
Emeryville Flats	-	21.6	37
Yerba Buena Island	-	1.7	37
Treasure Island	-	5.1	37
Alameda	55	269.9	49, 56
Bayfarm, North	2	4.4	49, 56
Bayfarm, South	4	127.9	49, 56
Coyote Point	1	0.6	42
Richardson Bay	13	436.7	6, 14
Angel Island West	3	1.6	14
Angel Island South	-	0.7	15, 24
Angel Island East	-	2.8	23
Belvedere Cove	5	21.8	14
Point Tiburon	1	0.2	14
Keil Cove	10	20.4	14
Paradise Cove, North	4	13.0	13
Paradise Cove, South	3	0.2	14
Pt. San Quentin	-	0.5	13
Pt. San Pedro	-	1.6	12
Minor Beds and Patches	-	90.2	various
TOTAL	316	2,880.5	

The majority of the eelgrass in the Bay was located on the east shoreline between Point Pinole and Bayfarm Island (Table 1). A few solitary plants were recorded north of Point Pinole near Wilson Point and several individual plants and two small patches were observed south of the San Mateo Bridge along the Alameda shoreline. On the west shoreline, eelgrass was mapped from Point San Quentin in Marin County to Coyote Point south of the San Francisco Airport, but was primarily located along the Marin County shoreline. The range of eelgrass distribution during the current survey was similar to the 1989 survey.

By far the largest eelgrass bed in the Bay is the Point San Pablo bed, which was located between Point Pinole and Point San Pablo north of the Richmond-San Rafael Bridge (Figure 4, Atlas Pages 20, 21, 33, and 34). This bed was approximately 608.9 hectares (1,504.5 acres) during 2003, and comprised 52.2% of the total eelgrass coverage in the Bay. The Point San Pablo eelgrass bed occurs on a shallow depositional shoal (approximately -1.5 to -0.5 meters [-4.9 to -1.6 feet] MLLW). In 1987, the Point San Pablo eelgrass bed was also mapped as the largest bed in the Bay, although during this survey it was mapped as an order of magnitude smaller than during the current surveys (Wyllie-Echeverria and Rutten 1989).

The second largest eelgrass bed in the Bay is found in Richardson Bay near Sausalito in Marin County (Figure 3 and Atlas Pages 6 and 14). This bed was approximately 176.7 hectares (436.7 acres) during the 2003 survey, the densest part of which was located among the boat moorings and near the marinas on the western side of the Bay. Eelgrass in Richardson Bay occurred between -3.0 and -0.5 meters (9.8 and -1.6 feet) MLLW in 2003.

HISTORICAL DISTRIBUTION RANGE

Eelgrass coverage within San Francisco Bay is in a constant state of flux. Thus, understanding the potential eelgrass habitat areas in addition to the beds that were mapped during the 2003 survey is crucial to determining the extent and distribution of areas within the Bay that are potentially suited to supporting eelgrass under various conditions. While it is not possible to exclude many shallow areas of the Bay as unsuitable for supporting eelgrass, many areas that did not support eelgrass during the present survey have been previously documented to support eelgrass. For this reason a map layer has been prepared of the maximum documented extent of eelgrass. This has been done in anticipation of future updates as additional survey data becomes available in future years. The maximum documented eelgrass extent is a combination of all known eelgrass surveys in the Bay where credible and accurate spatial data exist. At the time this map was produced, the maximum historical extent of eelgrass was documented to be 1,392.4 hectares (3,440.6 acres).

BATHYMETRY

Bathymetry for the Bay has been derived from numerous survey sources that date over extended periods. In most instances, the bathymetry has been collected on larger survey vessels that have avoided the extreme shallows of the Bay margins. As a result, bathymetric survey data are sparse in areas that support eelgrass beds. To improve upon this condition, bathymetric data from the present survey has been used to supplement prior survey data and provide a more accurate bathymetry range for eelgrass.

Using the bathymetric data, it has been possible to determine the elevation range distribution of eelgrass within the Bay (Figure 5). The depth distribution of eelgrass is extremely narrow and is indicative of the turbid nature of the Bay.

The most likely explanation for restricted eelgrass coverage in the Bay is the low-light levels available to eelgrass in the North and South Bay regions. More than 4.5 million cubic meters (6 million cubic yards) of sediment enter the Estuary per year from approximately 20 major freshwater streams and rivers (Goals Project 1999). In addition to the sources of sedimentation from freshwater flows, there is additional suspended sediment resulting from tidal currents and wind-driven waves. The Central Bay region has the clearest water, followed by the South Bay and North Bay, and lastly Suisun Bay. The Suisun and North Bay regions are by far the most turbid of any area in the Estuary due to freshwater input of the Delta. In addition to the presence of a substantial amount of sedimentation in the Bay, this sediment is also retained within the regions of the Estuary that are far from the mouth of the Bay. Although the San Pablo

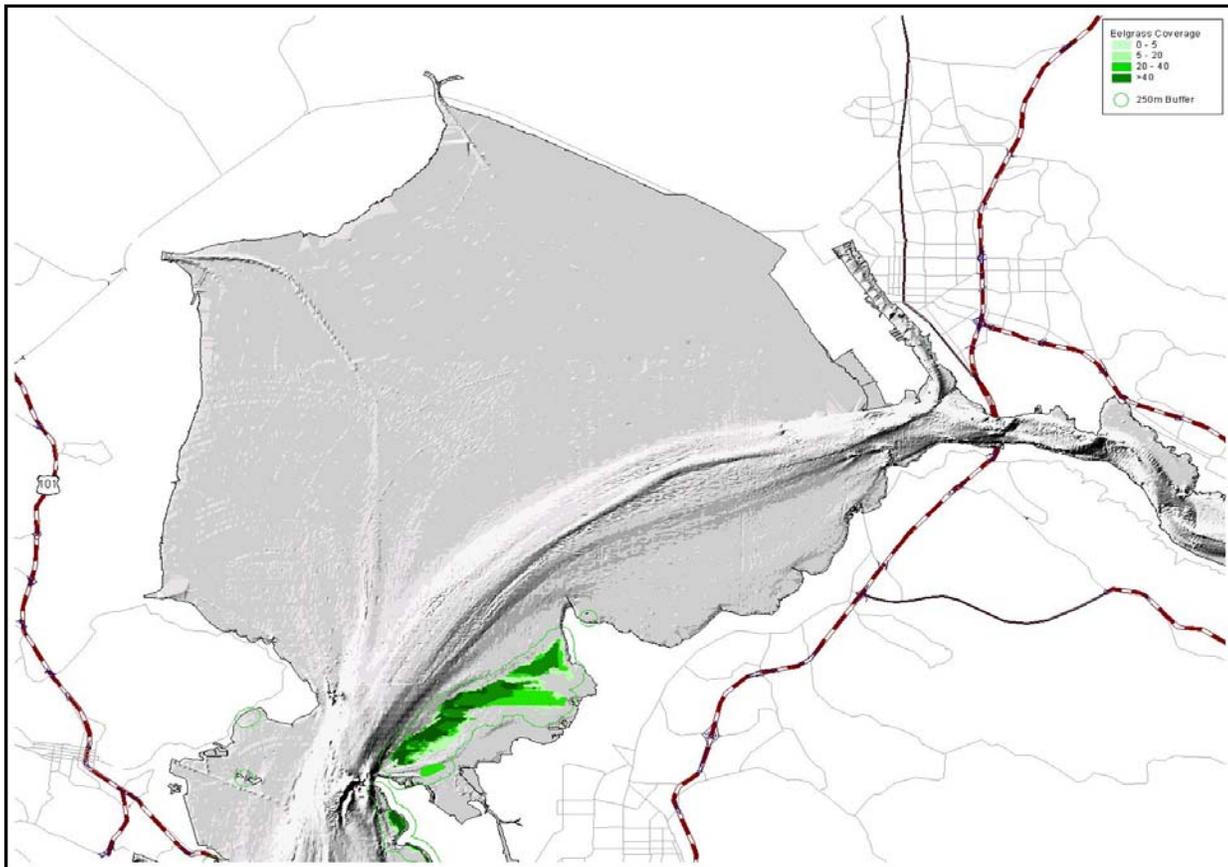


Figure 3. Northern San Francisco Bay eelgrass distribution, including the Pt. San Pablo eelgrass bed

REGIONAL COMPARISON

Existing eelgrass beds cover approximately 1% of San Francisco Bay, which is at least an order of magnitude less than other large California estuarine systems (Table 2). However, due to the large size of the Bay, even a minor proportional representation amounts to substantial eelgrass resources on a statewide basis and the importance of this resource should not be undervalued in resource management decisions.

eelgrass bed is technically in the North Bay region, this area of North Bay is well flushed by clearer waters of the deep channel around Point San Pablo. Conversely, the western portions of San Pablo Bay receive little ocean water influence and while these areas support salinities levels that could support eelgrass, the sediment-laden surface waters in this region probably restrict adequate light levels.

Table 2. Comparison of eelgrass coverage in California bays and estuarine systems.

System	Eelgrass (acres)	% Coverage
Mission Bay ¹	1,210	54%
San Diego Bay ²	1,626	14%
Humboldt Bay ³	4,821	10%
Tomales Bay ⁴	965	13%
San Francisco Bay	2,881	1%

¹Merkel & Associates 2003

²U.S. Navy 2000

³McBride et al., unpublished data

⁴Wyllie-Echeverria and Rutten 1989

CONCLUSIONS

The Baywide Eelgrass Inventory and Resource Management Program will provide a unique tool for developing the subtidal habitat goals for San Francisco Bay. This 2003 Eelgrass Atlas provides a snapshot of the distribution of eelgrass during a single year and, along with the maximum documented eelgrass extent, this survey alludes to the tremendously dynamic nature of eelgrass beds in the Bay. As a resource management tool, the current survey provides the first comprehensive mapping of eelgrass habitat resources in the Bay. However, this atlas serves only as a planning and large-scale resource management tool and is not intended to replace site specific and up-to-date

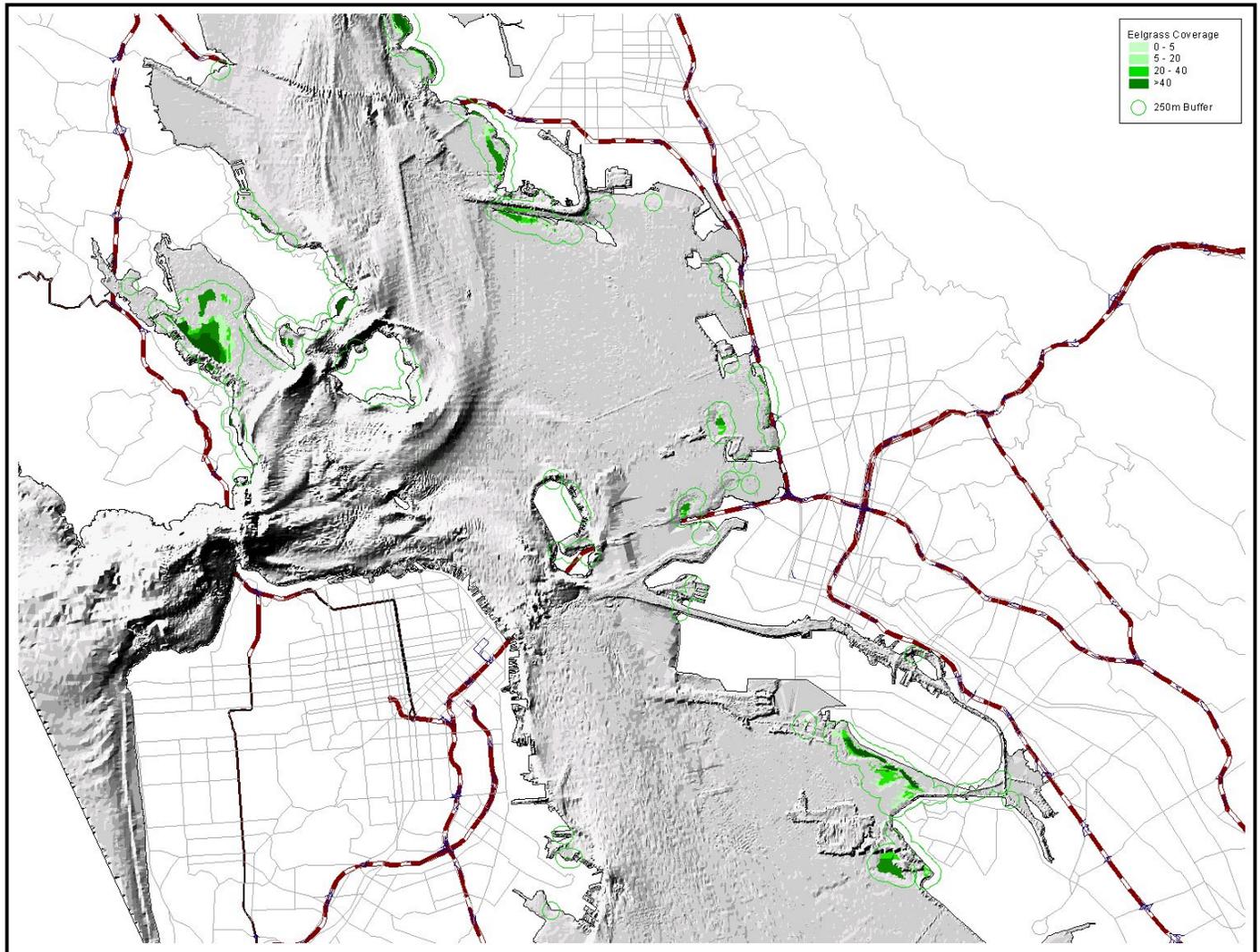


Figure 4. Central San Francisco Bay eelgrass distribution during 2003.

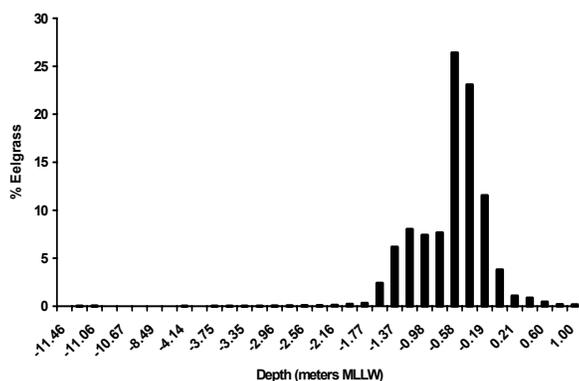
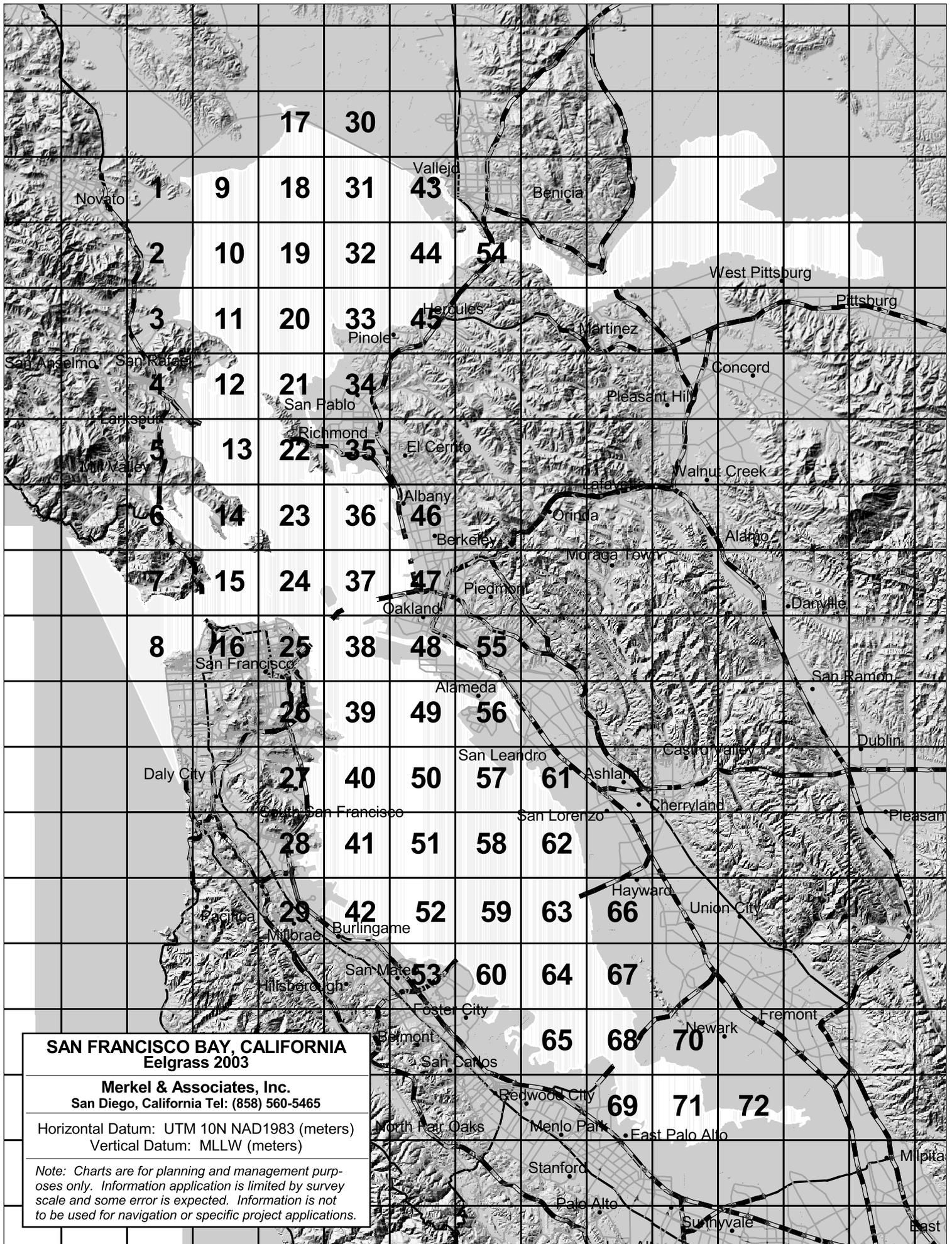


Figure 5. Depth distribution of eelgrass within mapped beds in San Francisco Bay

surveys and analyses where potential impacts to eelgrass habitat are contemplated. Resource managers are cautioned regarding the inapplicability of the present data for completing impact assessments. While these data provide a useful tool for planning and evaluating management needs, they are not adequate to meet the needs of specific project assessments.

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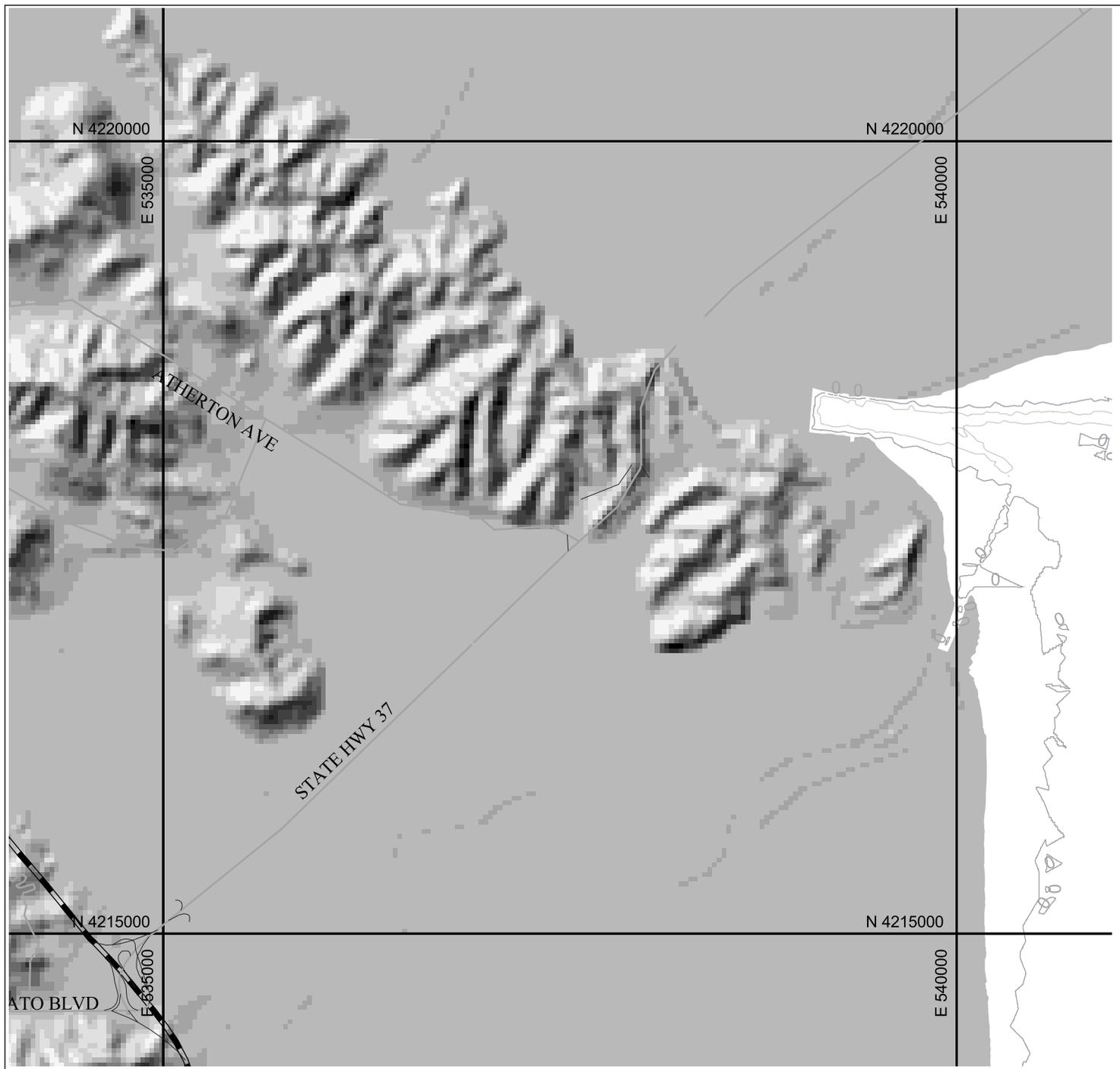


SAN FRANCISCO BAY, CALIFORNIA
Eelgrass 2003

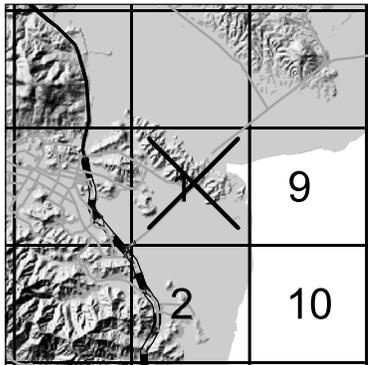
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 San Diego, California Tel: (858) 560-5465

Horizontal Datum: UTM 10N NAD1983 (meters)
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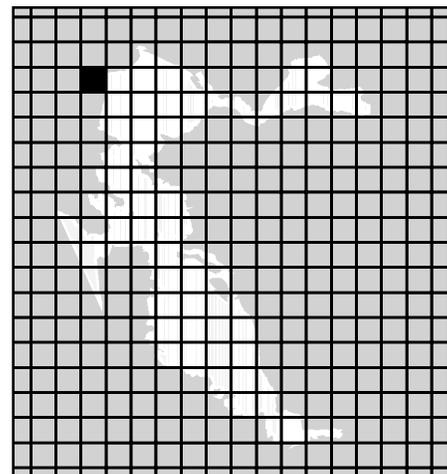
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SHEET VICINITY



SHEET LOCATOR



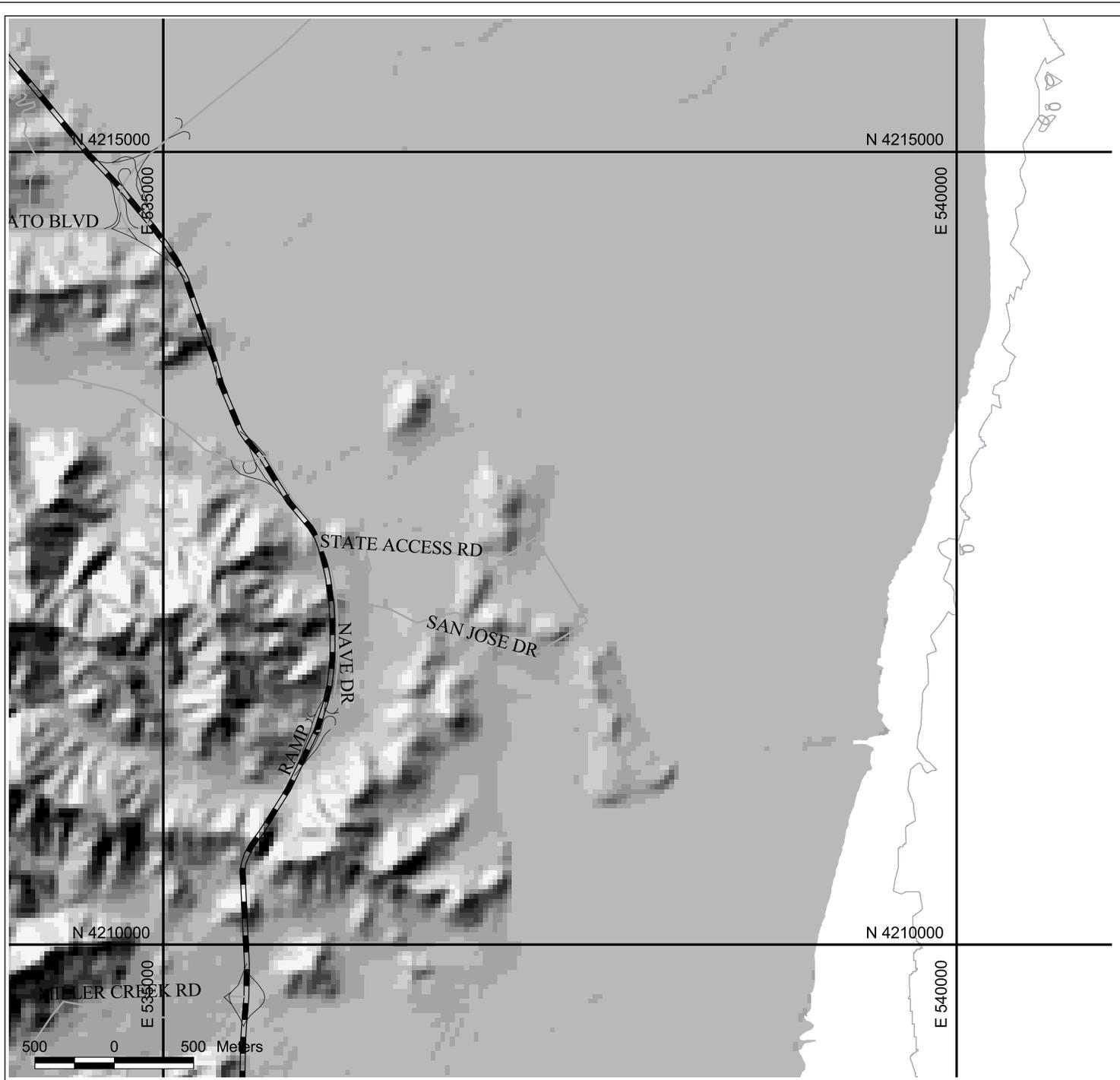
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Eelgrass 2003**

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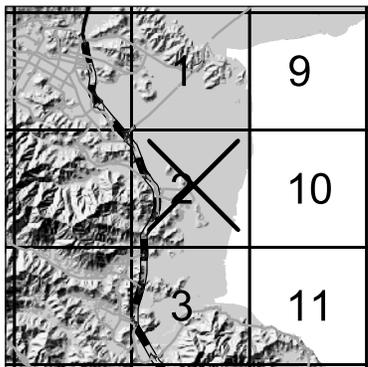
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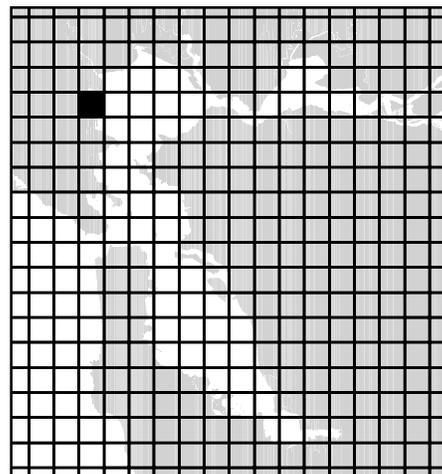




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Eelgrass 2003**

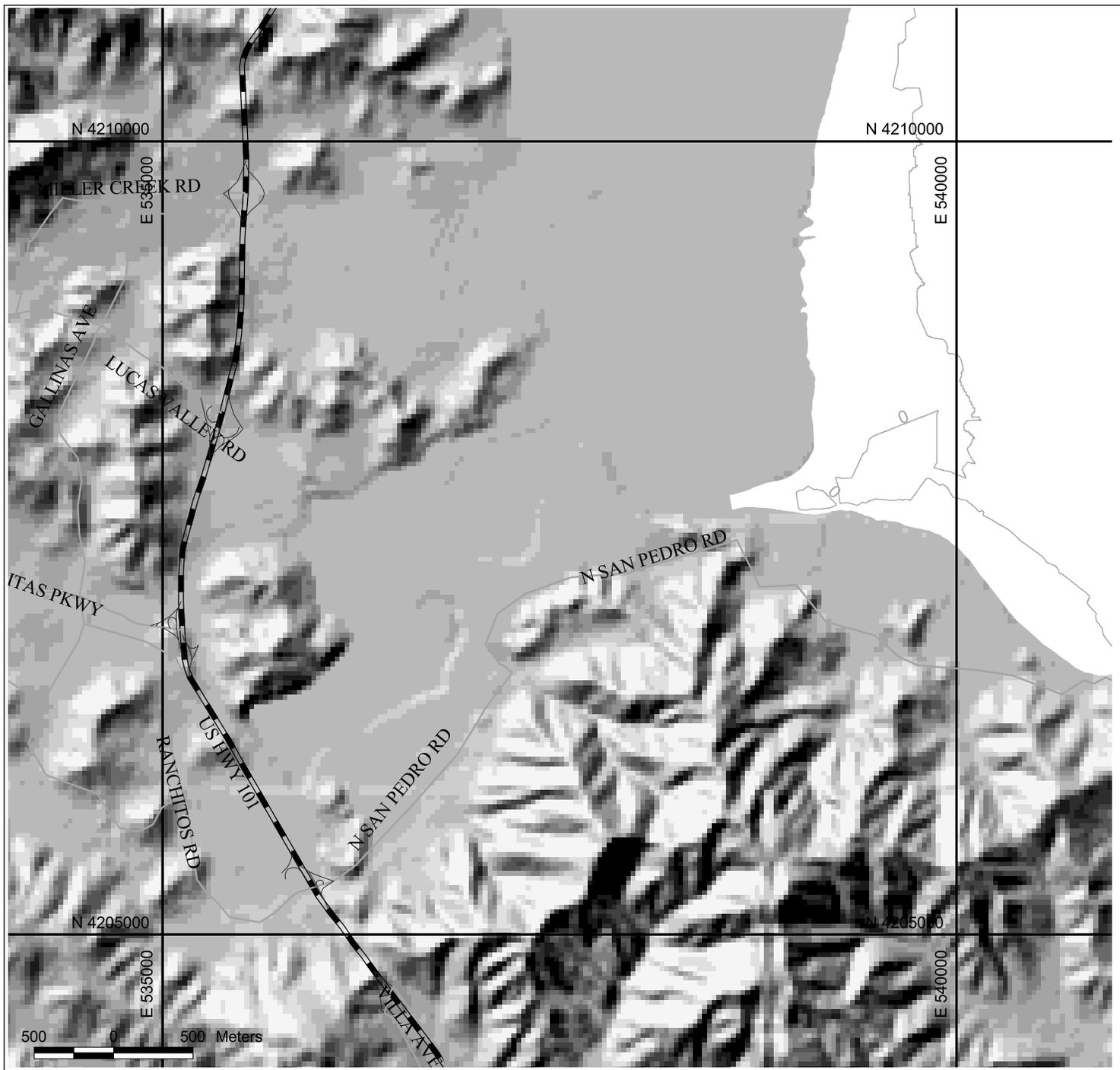
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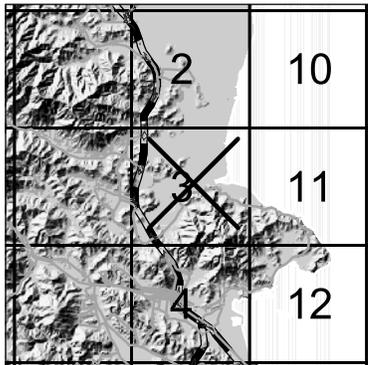
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- 0 - 5 % Density
- 5 - 20 % Density
- 20 - 40 % Density
- >40 % Density
- Maximum Documented Eelgrass Extents
- 250m Buffer of Maximum Documented Eelgrass Extents

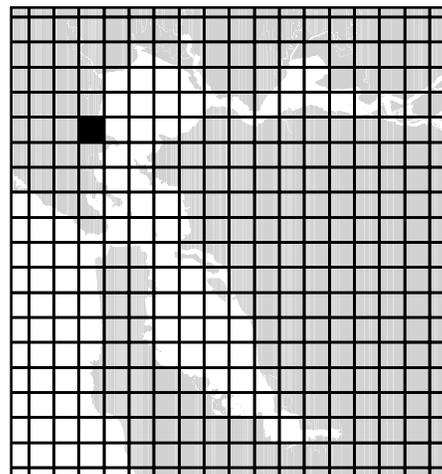




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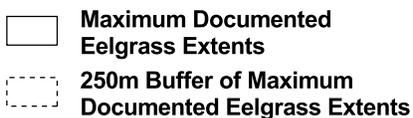


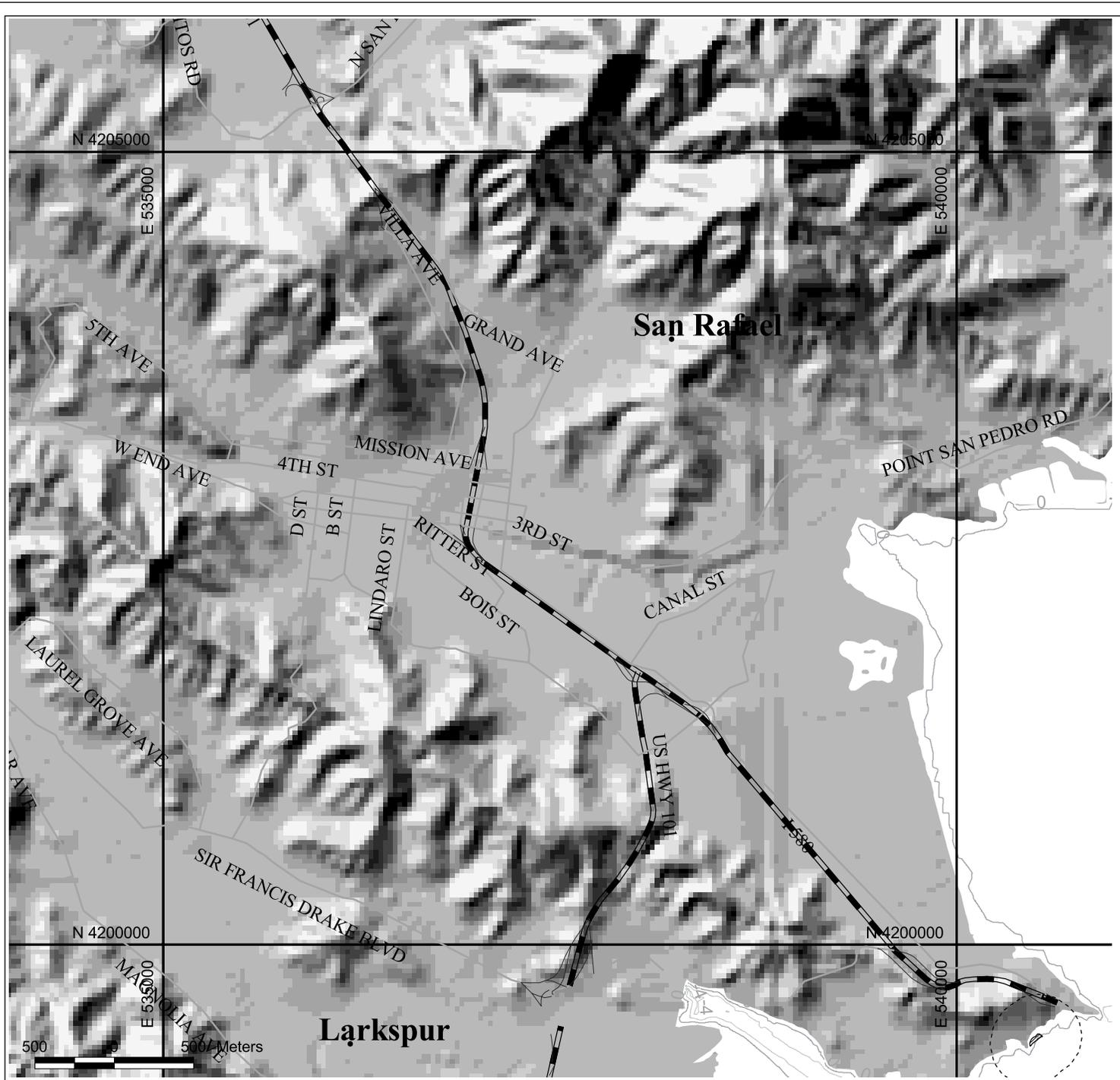
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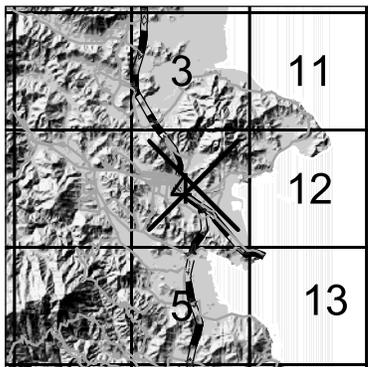
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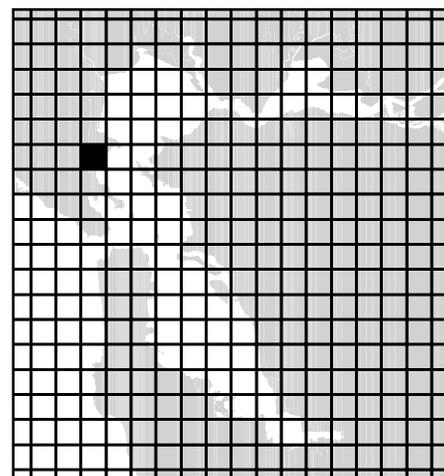




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SHEET LOCATOR



**SAN FRANCISCO BAY, CALIFORNIA
Eelgrass 2003**

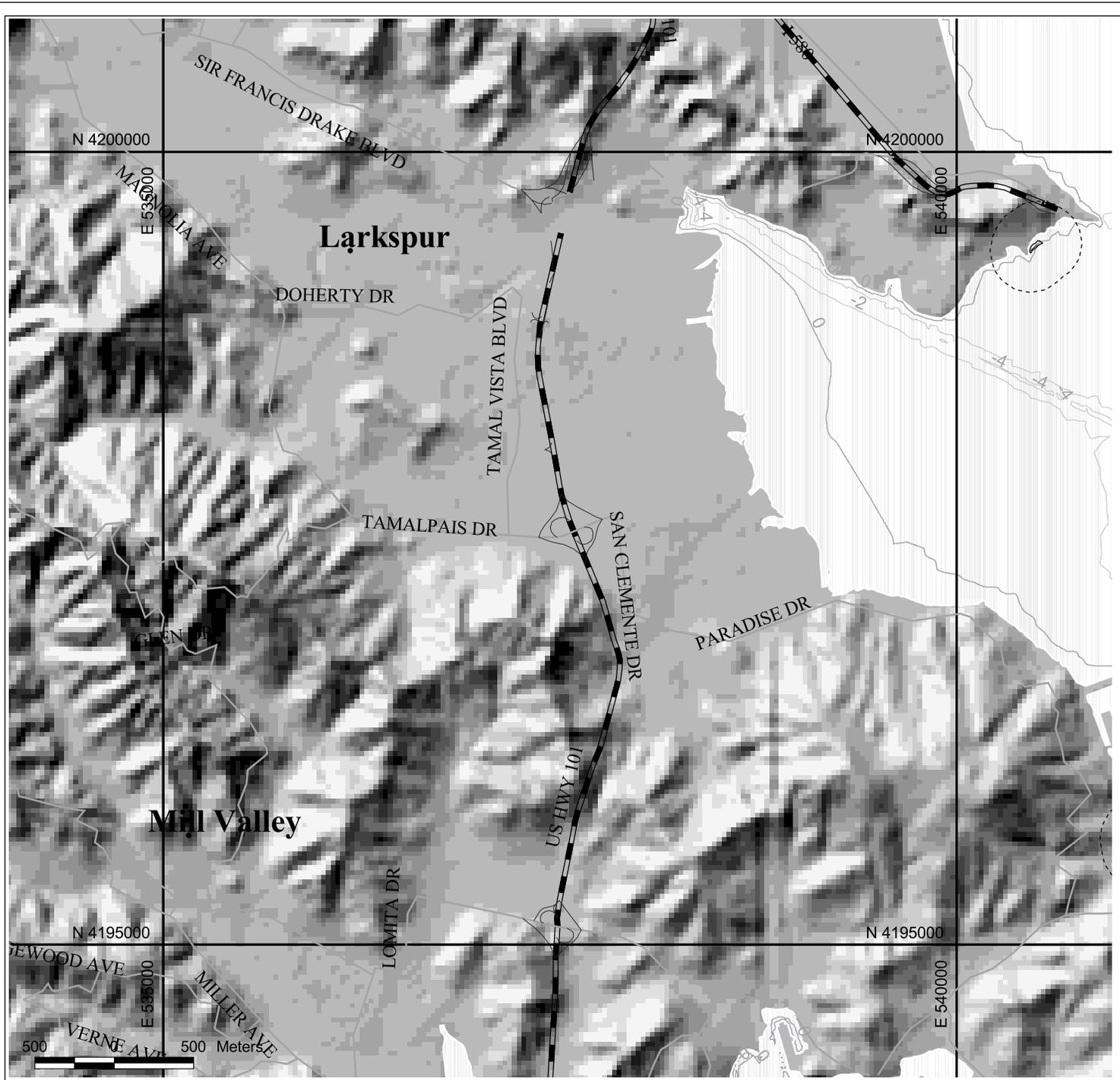
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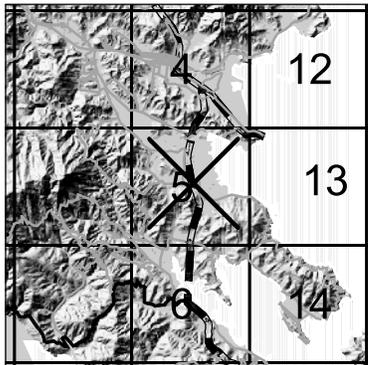
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-  0 - 5 % Density
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-  20 - 40 % Density
-  >40 % Density
-  Maximum Documented Eelgrass Extents
-  250m Buffer of Maximum Documented Eelgrass Extents

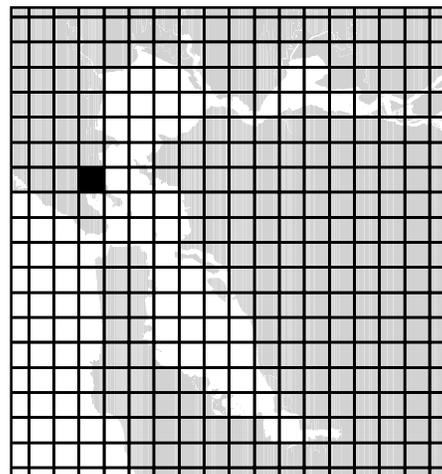




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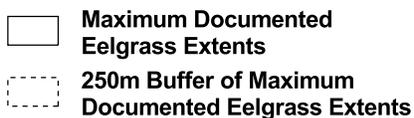
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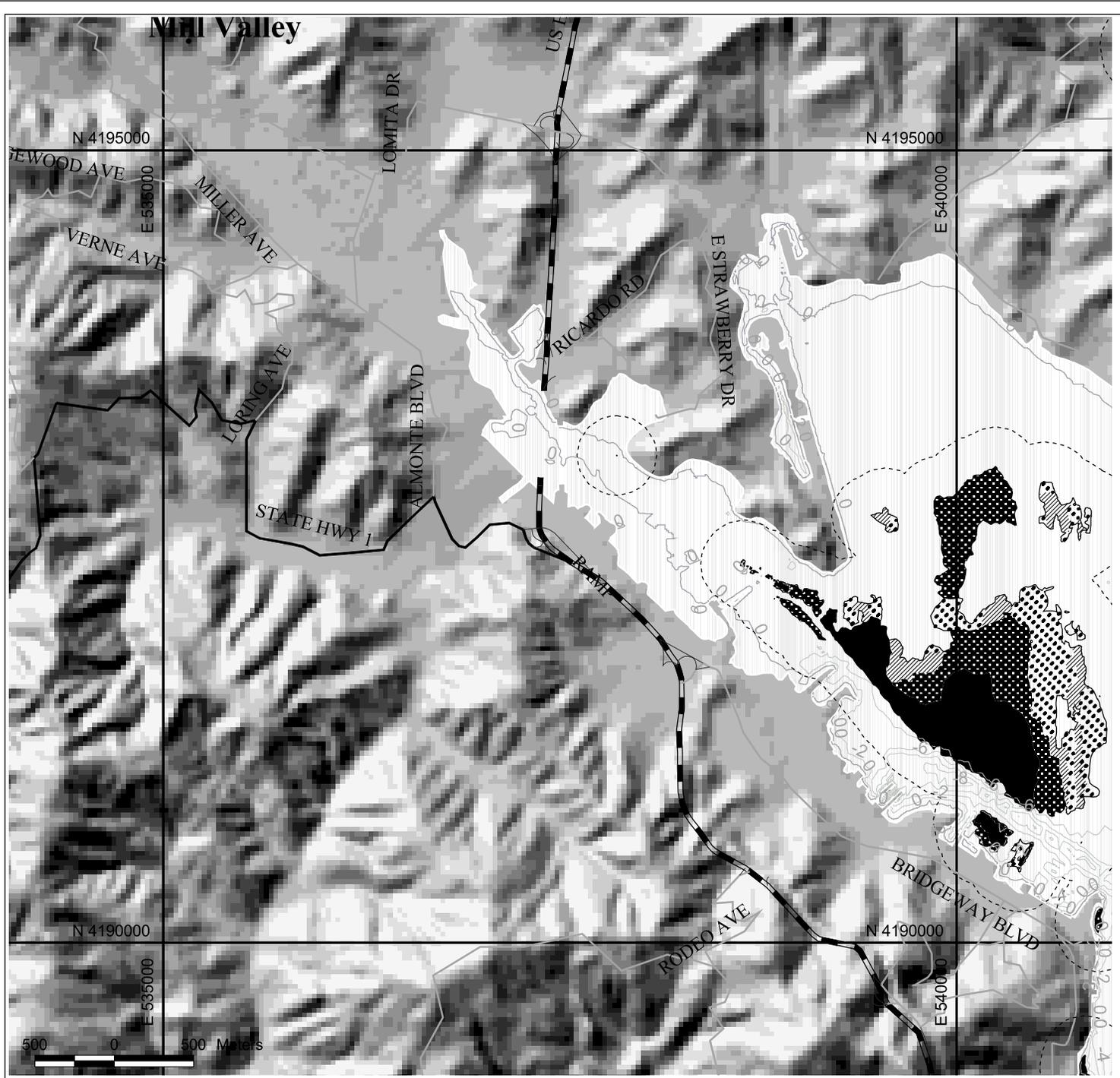
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Eelgrass 2003**

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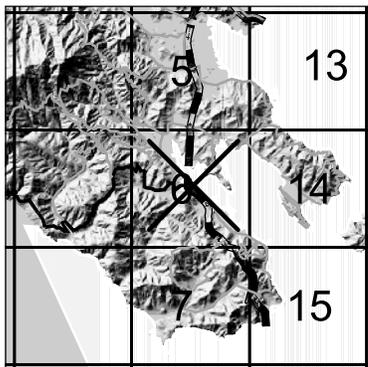
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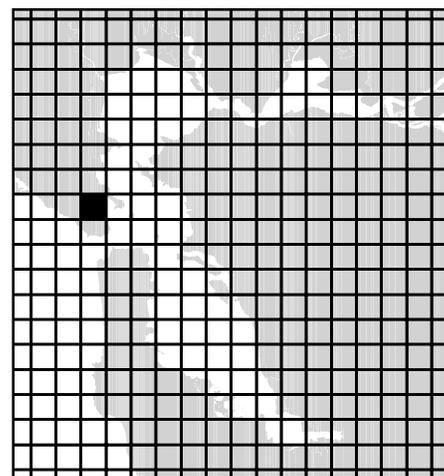




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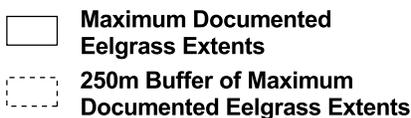


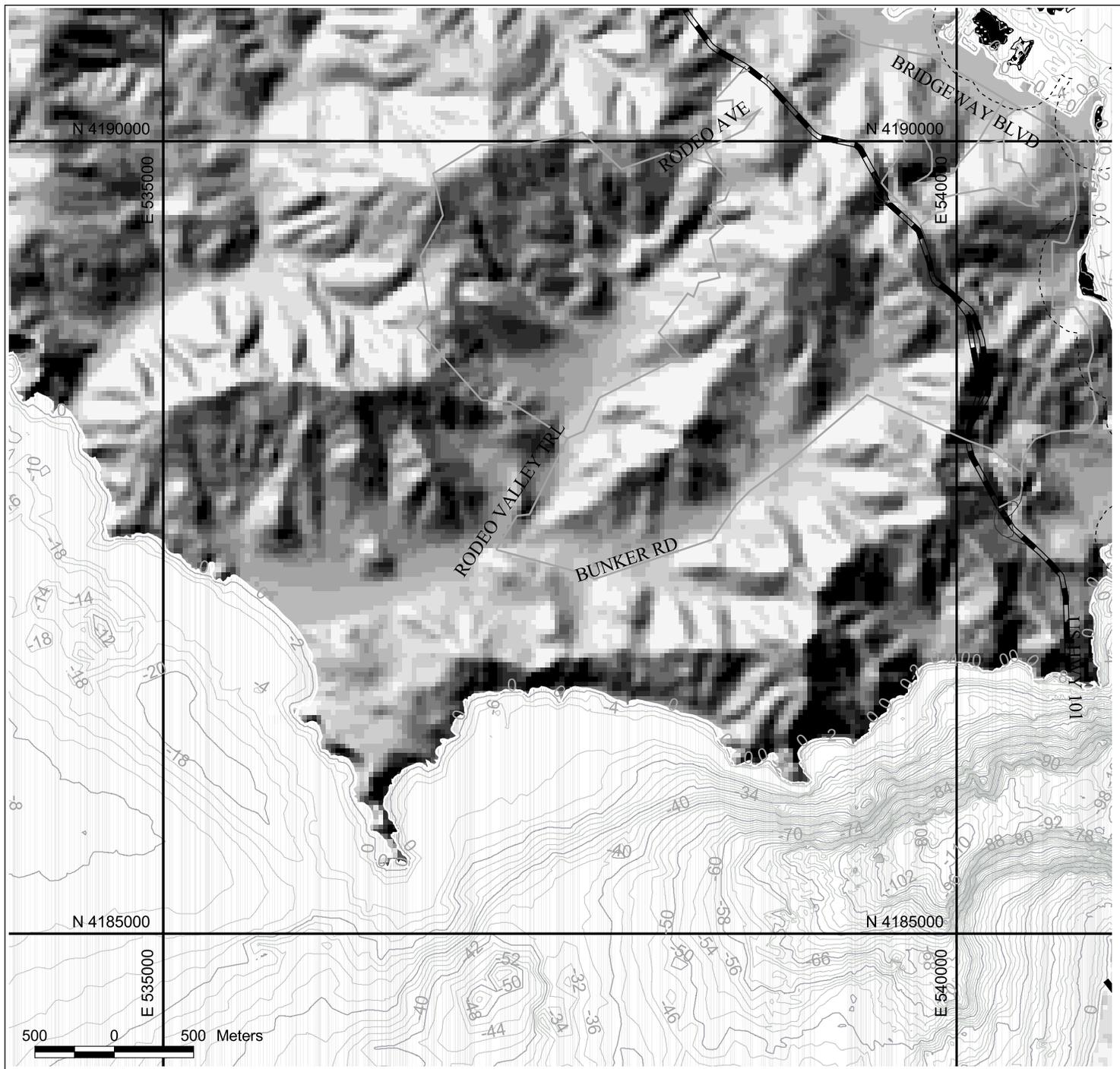
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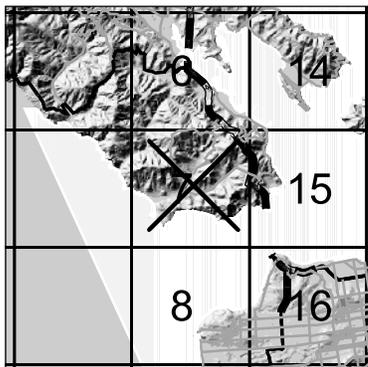
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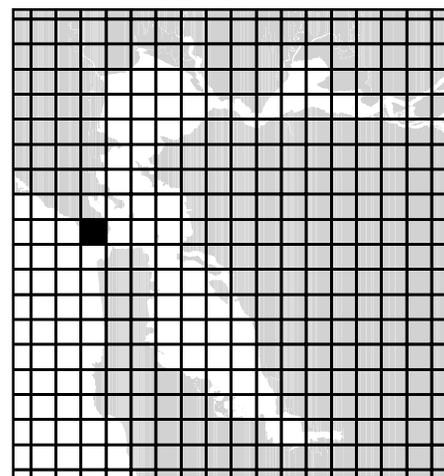




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SHEET LOCATOR



SHEET 7 OF 72

**SAN FRANCISCO BAY, CALIFORNIA
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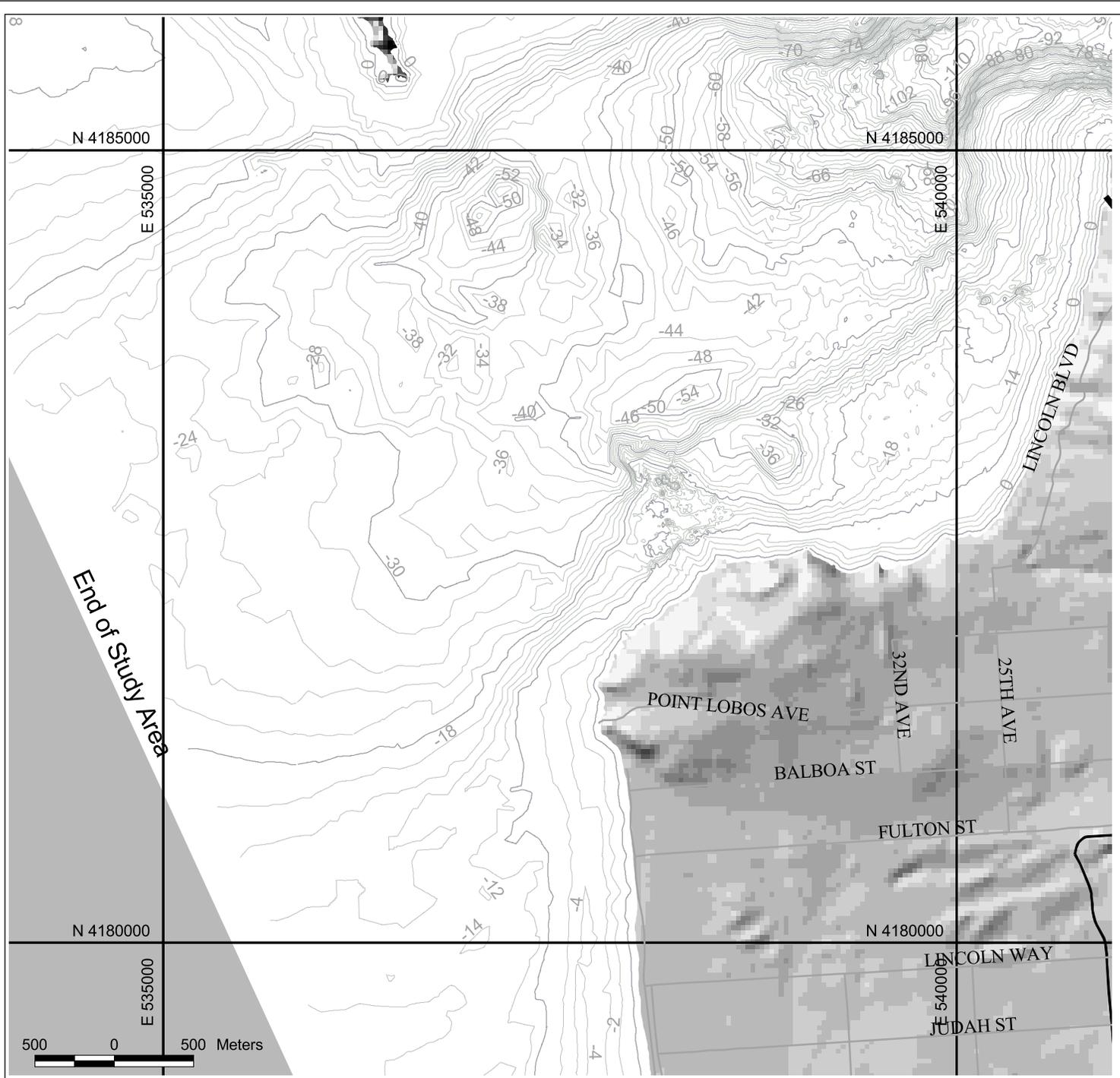
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San Diego, California Tel: (858) 560-5465

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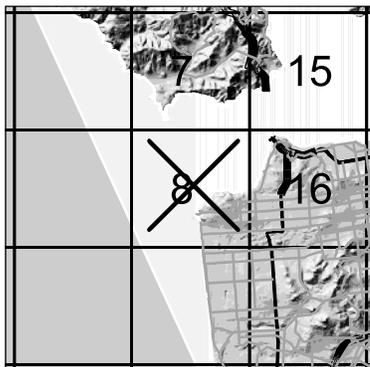
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- | | | | |
|---|--------------------------|---|---|
|  | 0 - 5 % Density |  | Maximum Documented Eelgrass Extents |
|  | 5 - 20 % Density |  | 250m Buffer of Maximum Documented Eelgrass Extents |
|  | 20 - 40 % Density | | |
|  | >40 % Density | | |

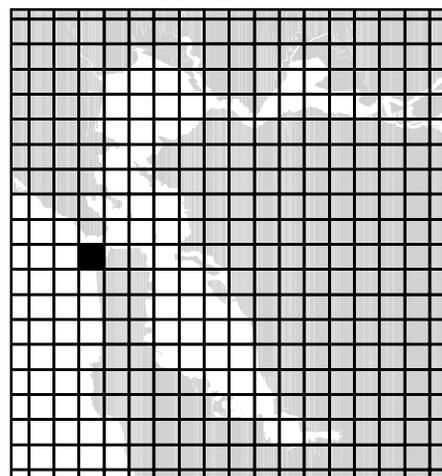




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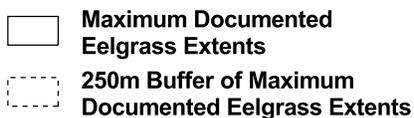
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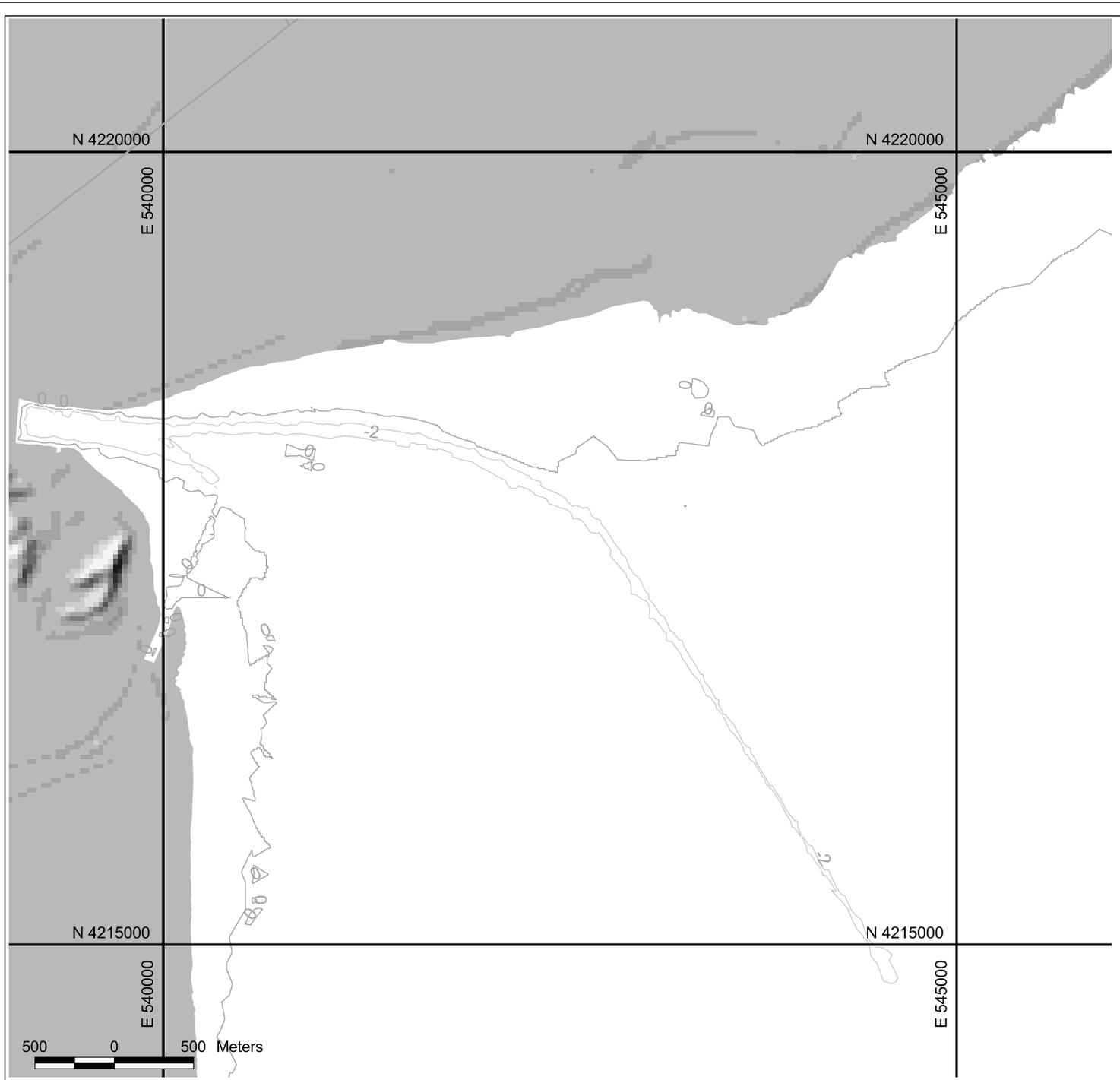
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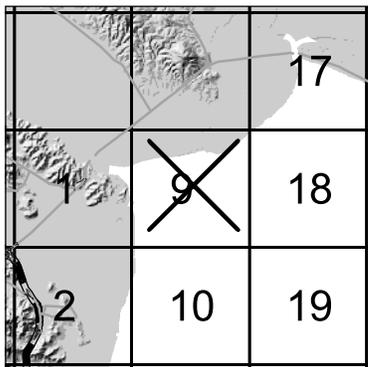
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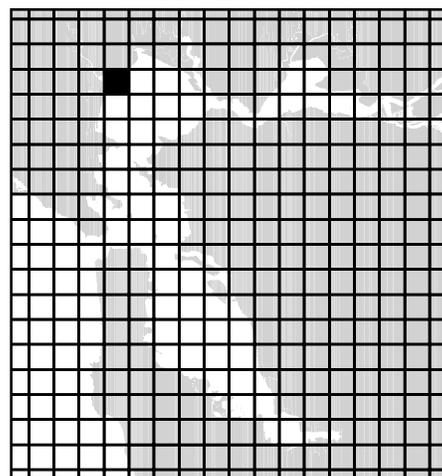




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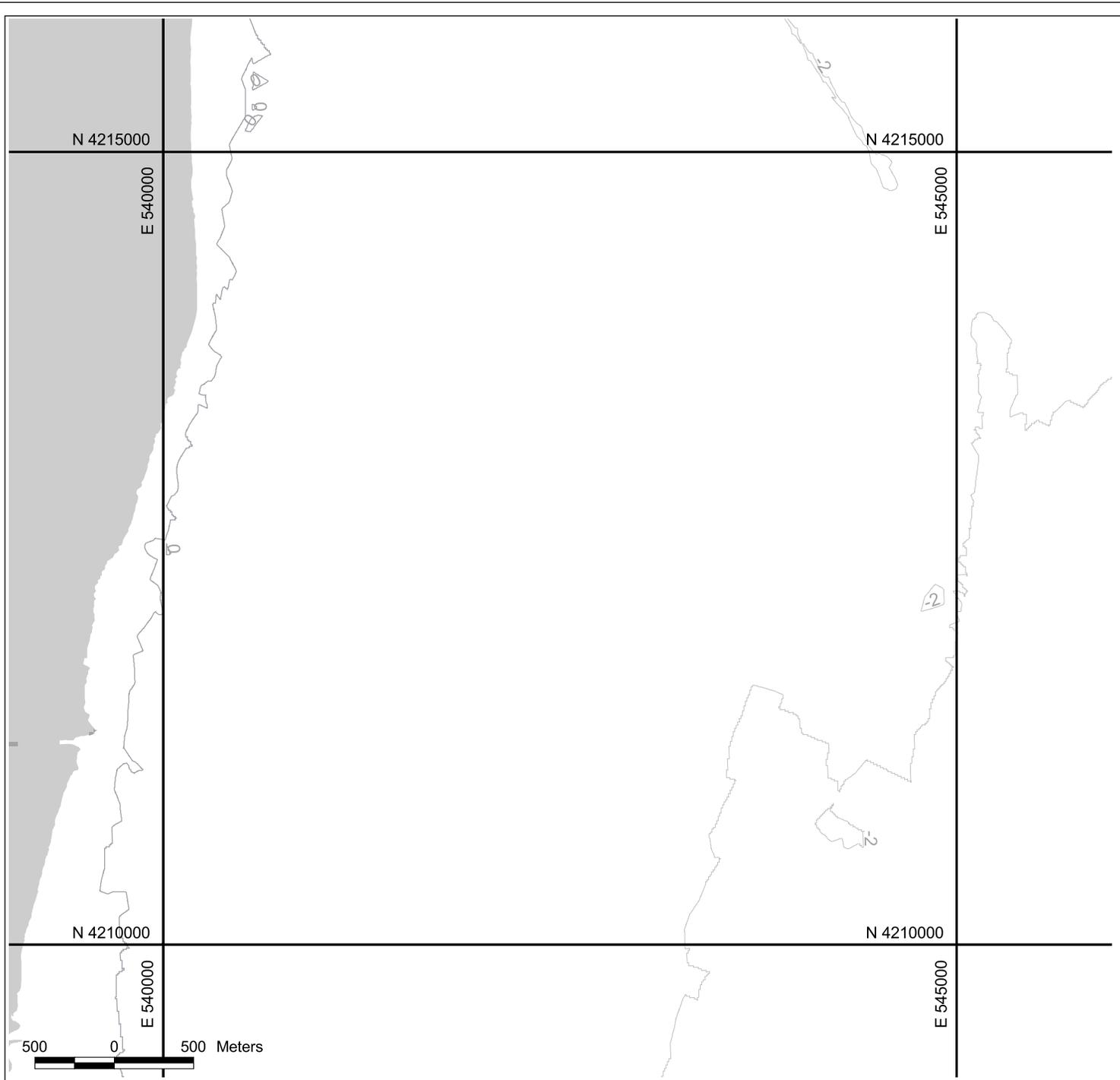
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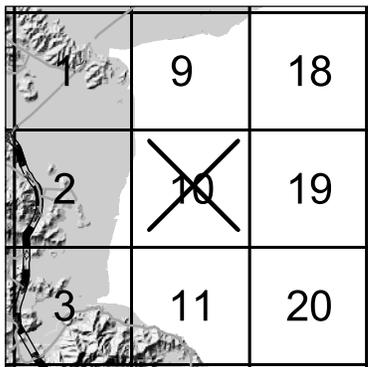
-  0 - 5 % Density
-  5 - 20 % Density
-  20 - 40 % Density
-  >40 % Density

-  Maximum Documented Eelgrass Extents
-  250m Buffer of Maximum Documented Eelgrass Extents

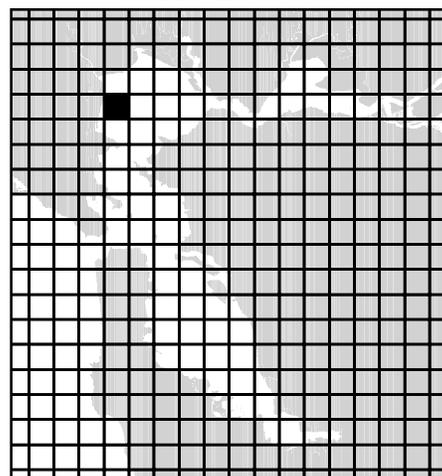




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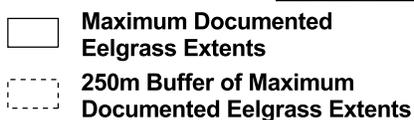


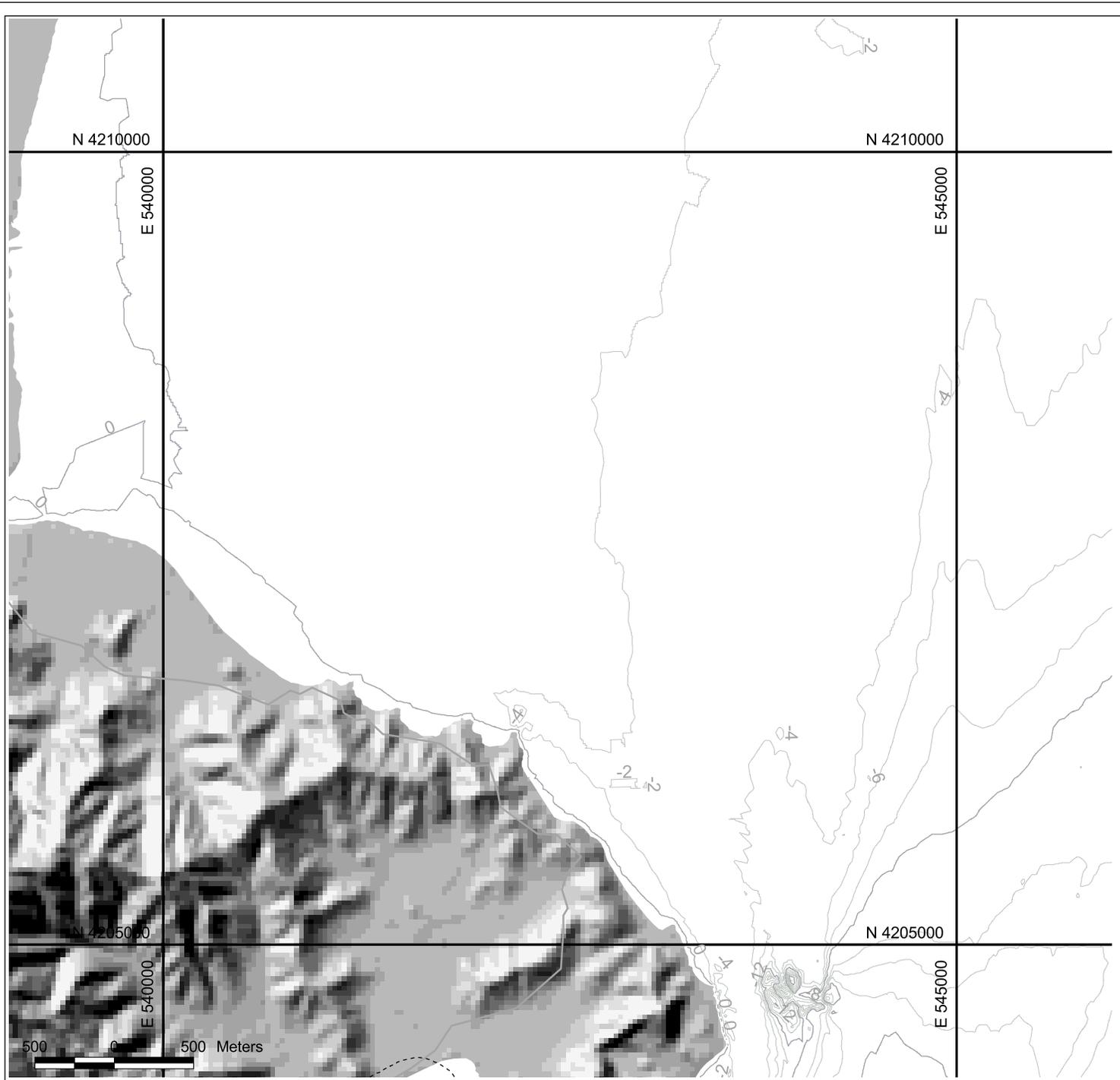
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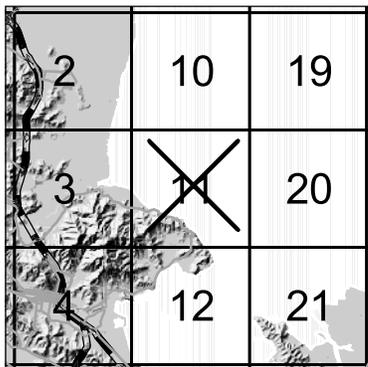
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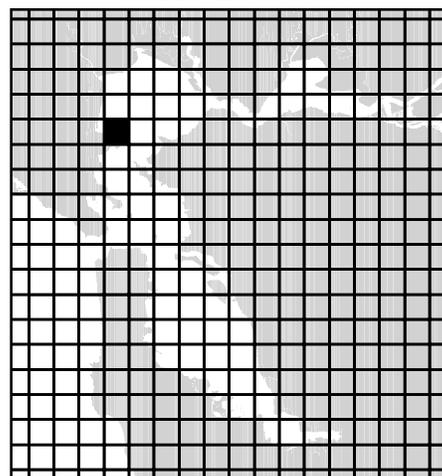




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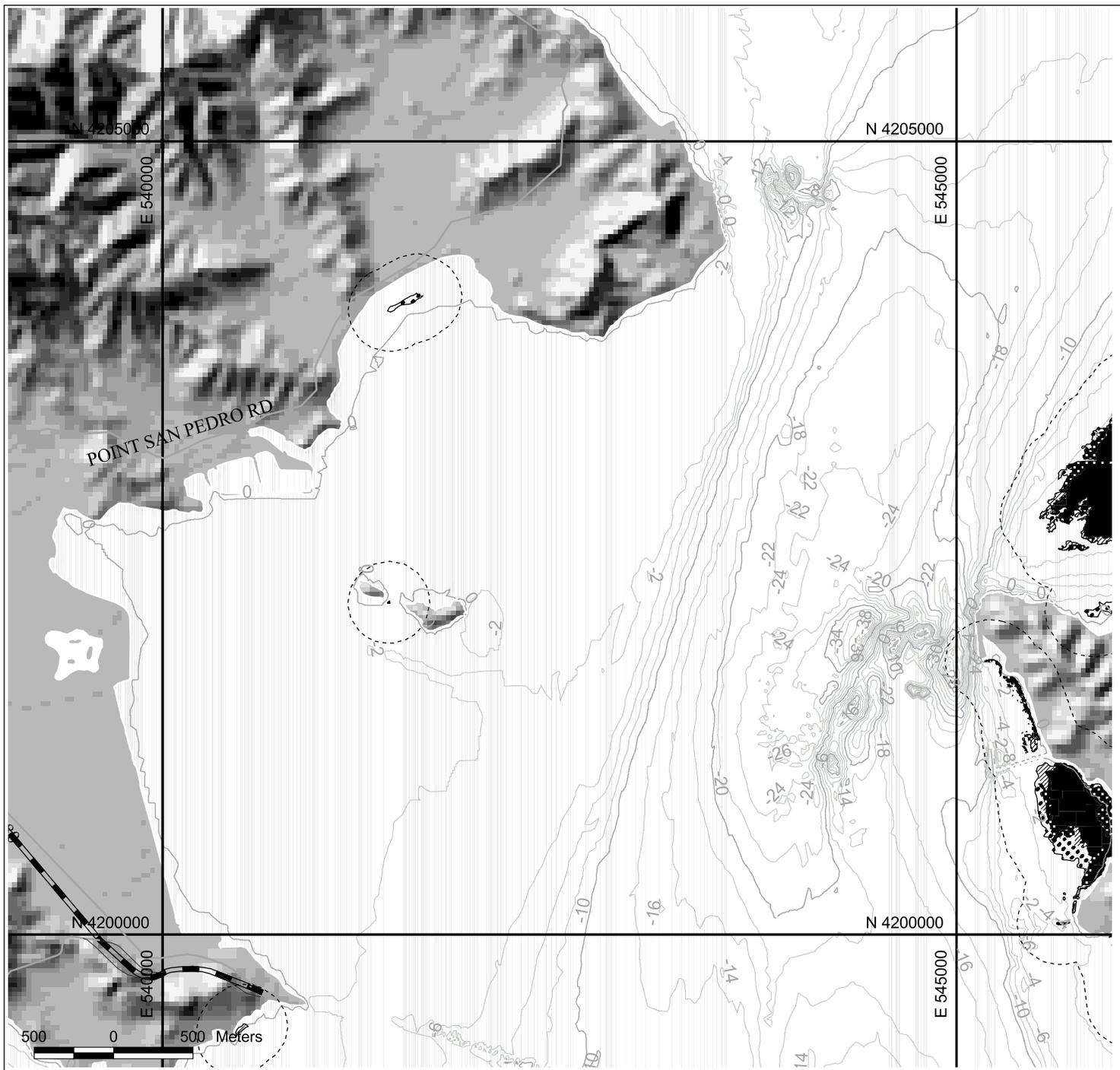
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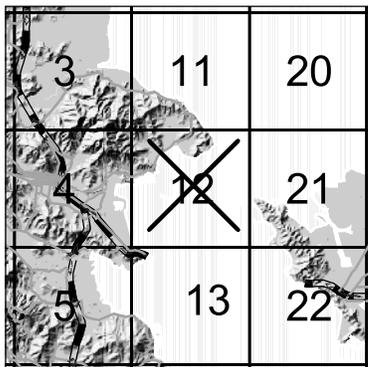
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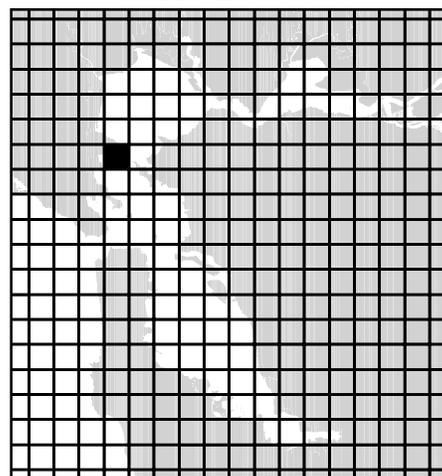




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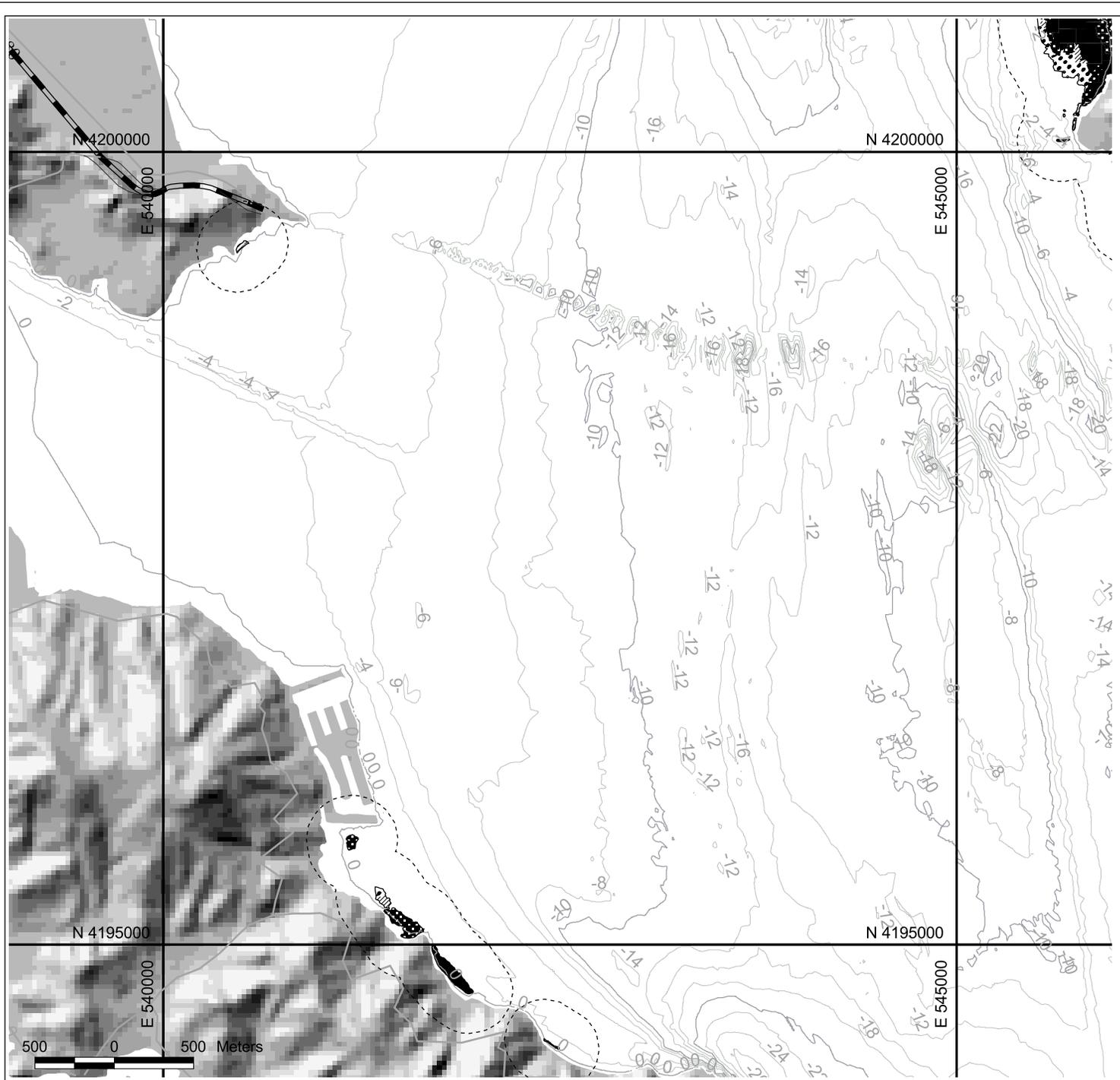
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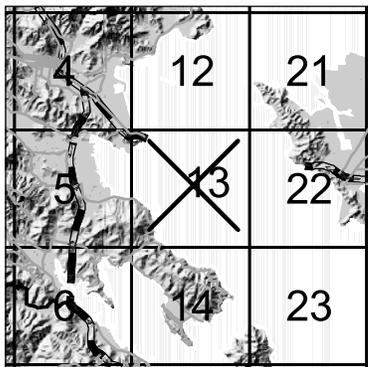
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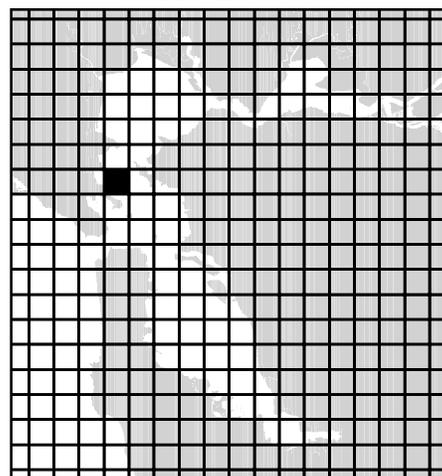




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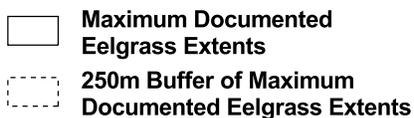


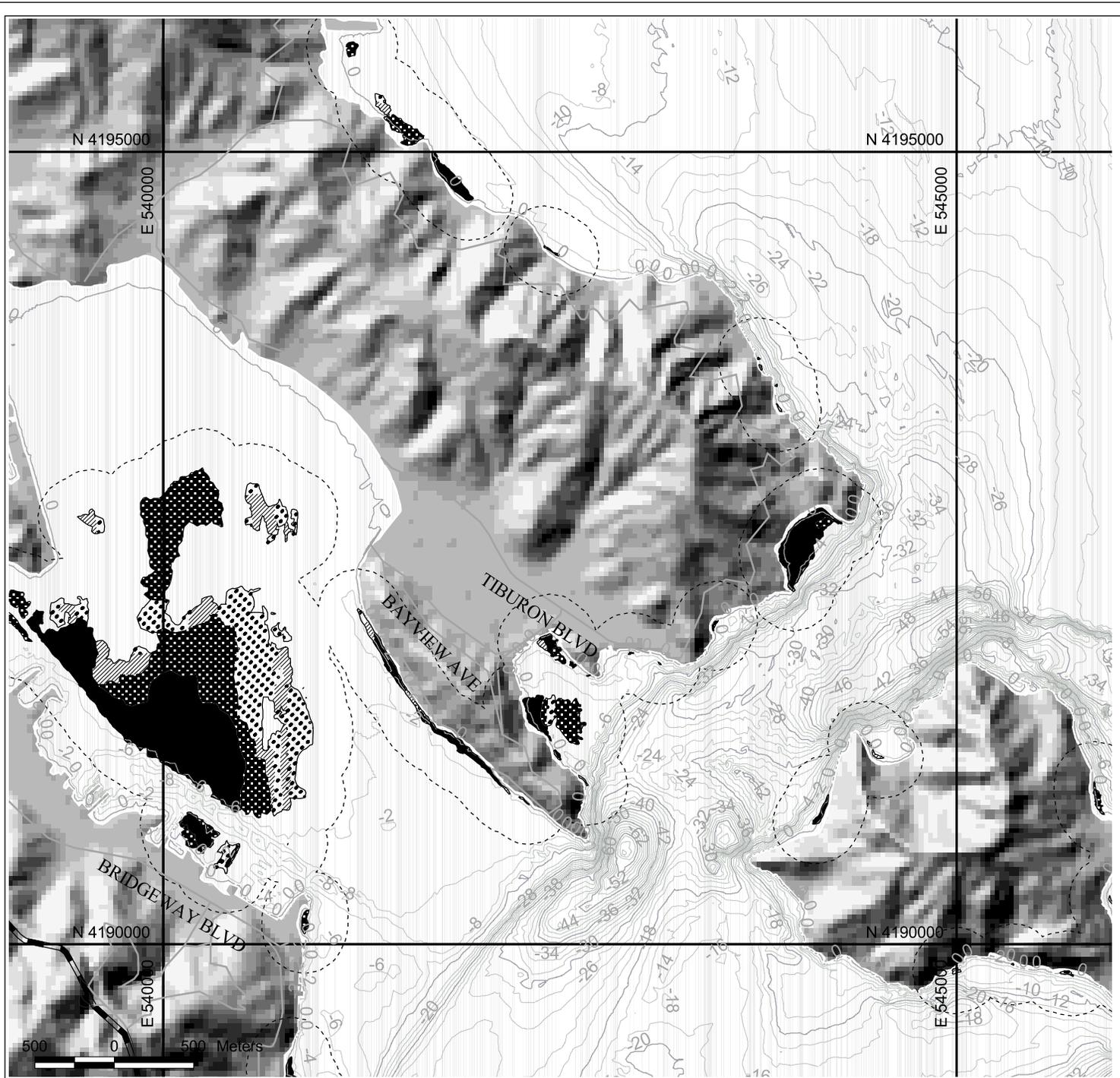
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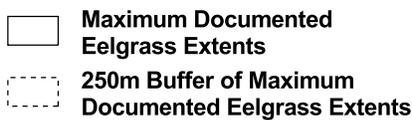


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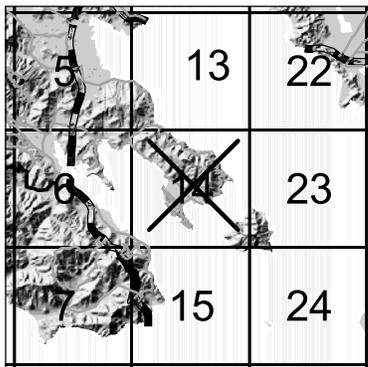
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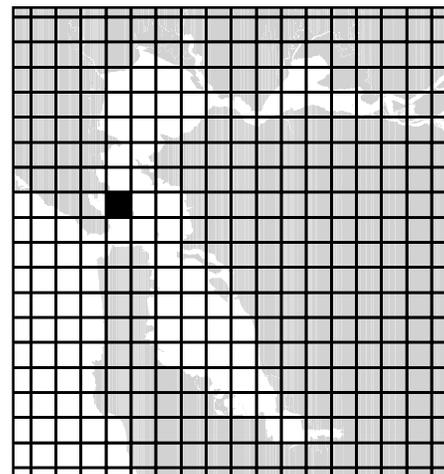
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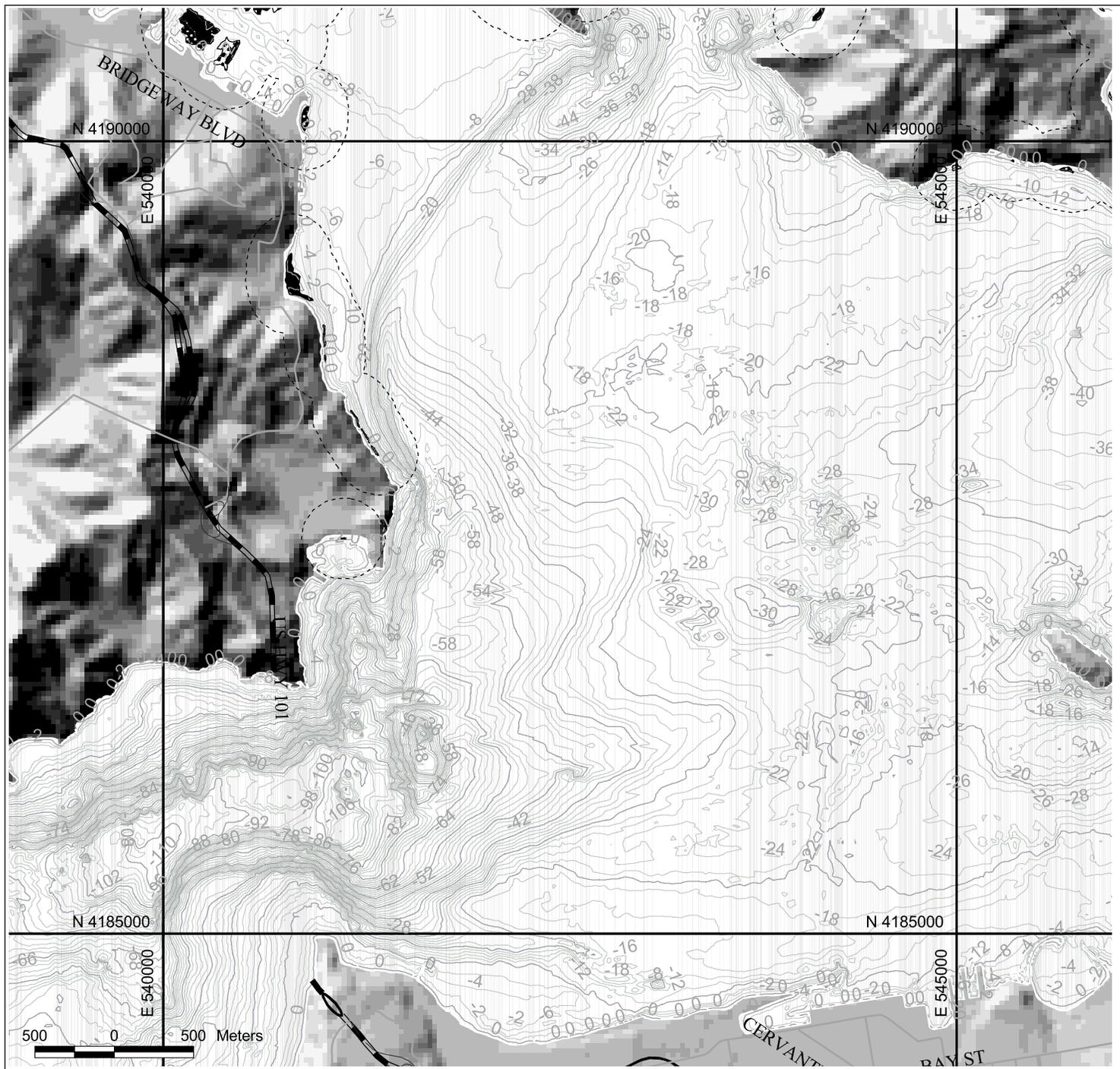


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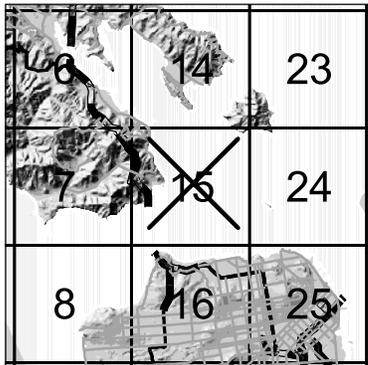


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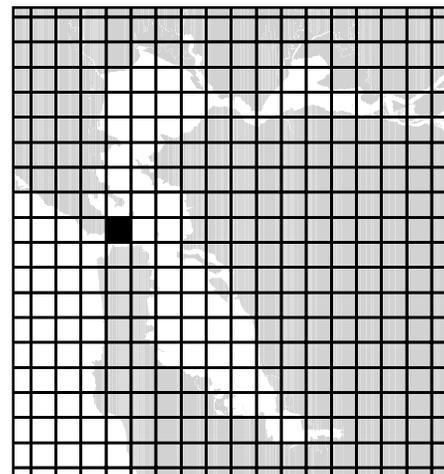




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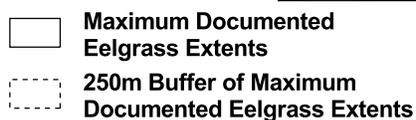


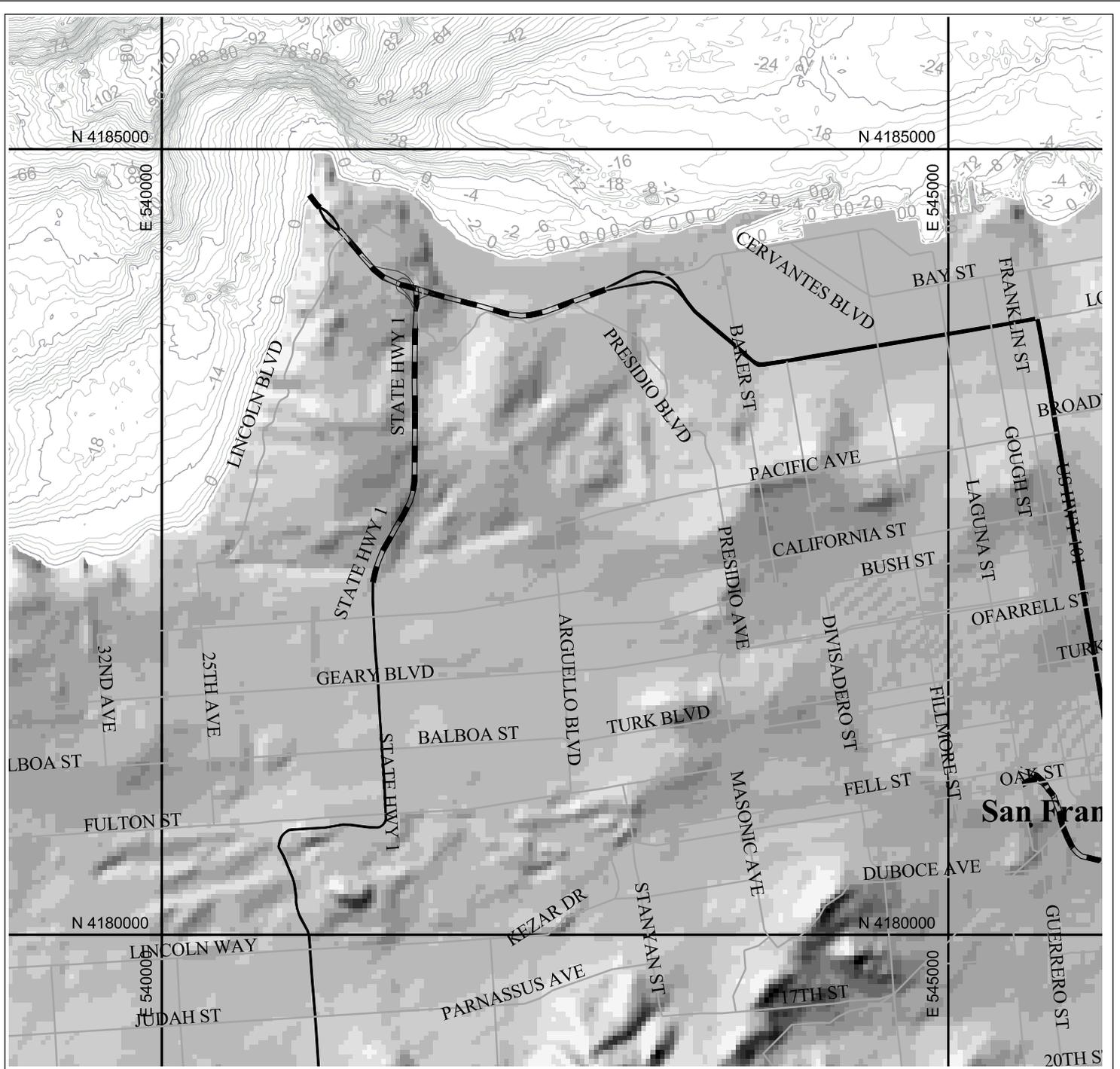
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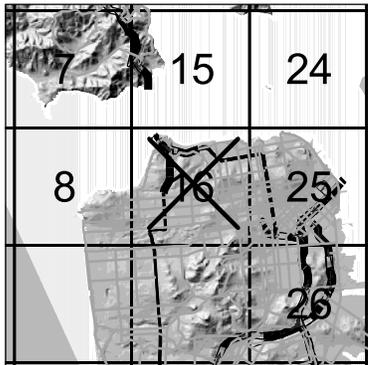
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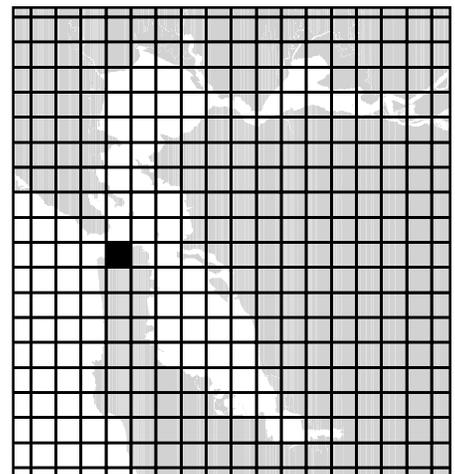




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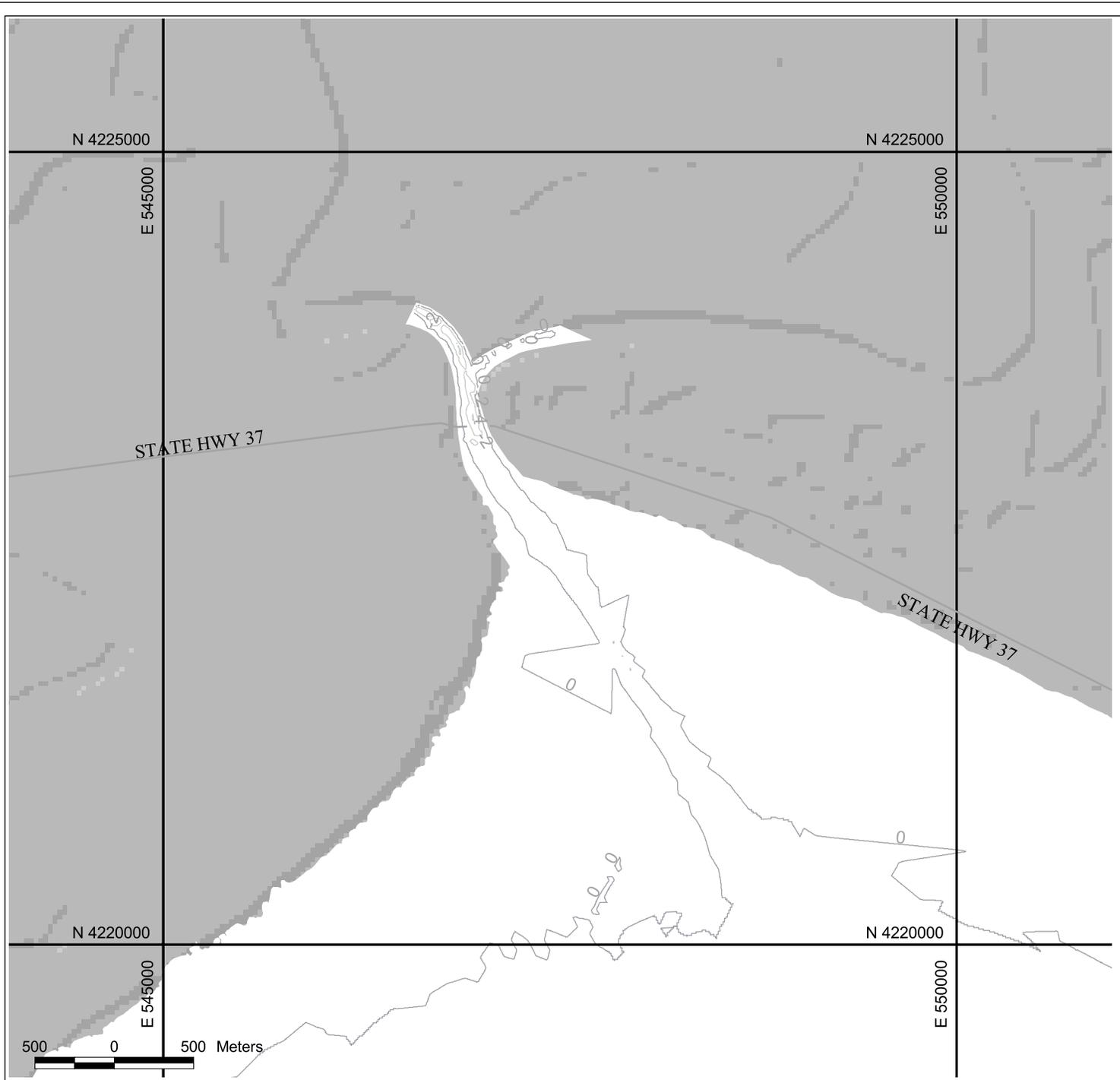
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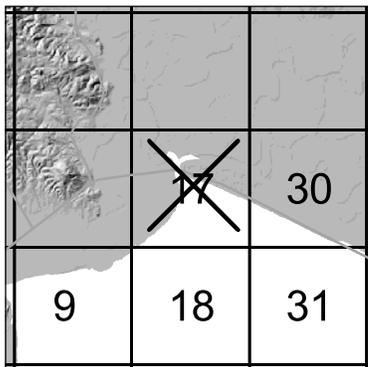
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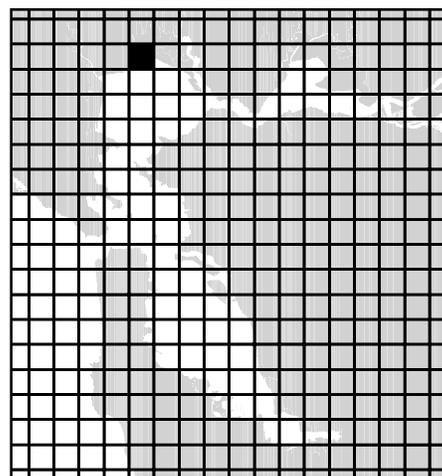




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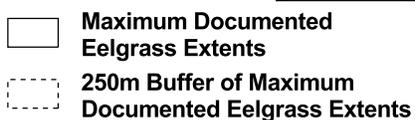


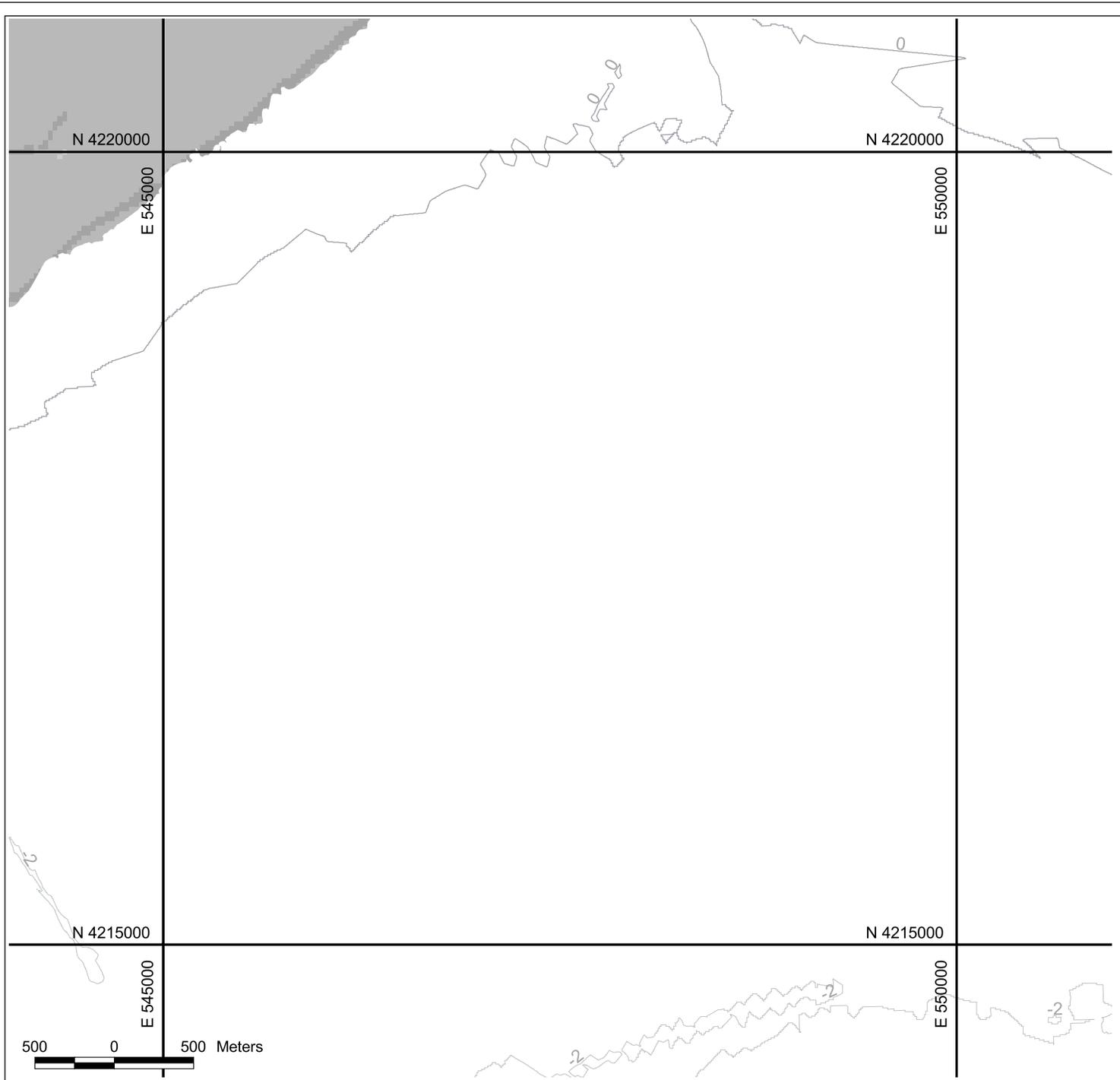
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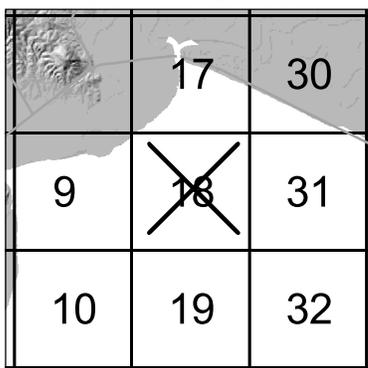
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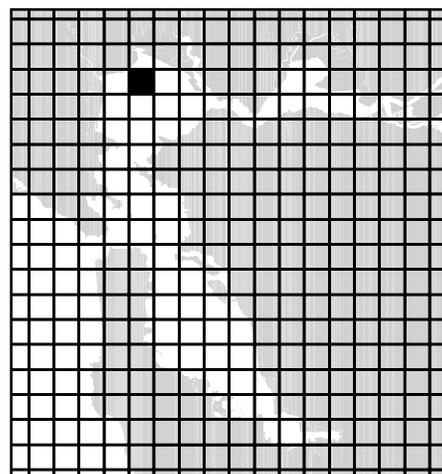




SHEET VICINITY



SHEET LOCATOR

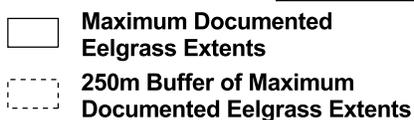


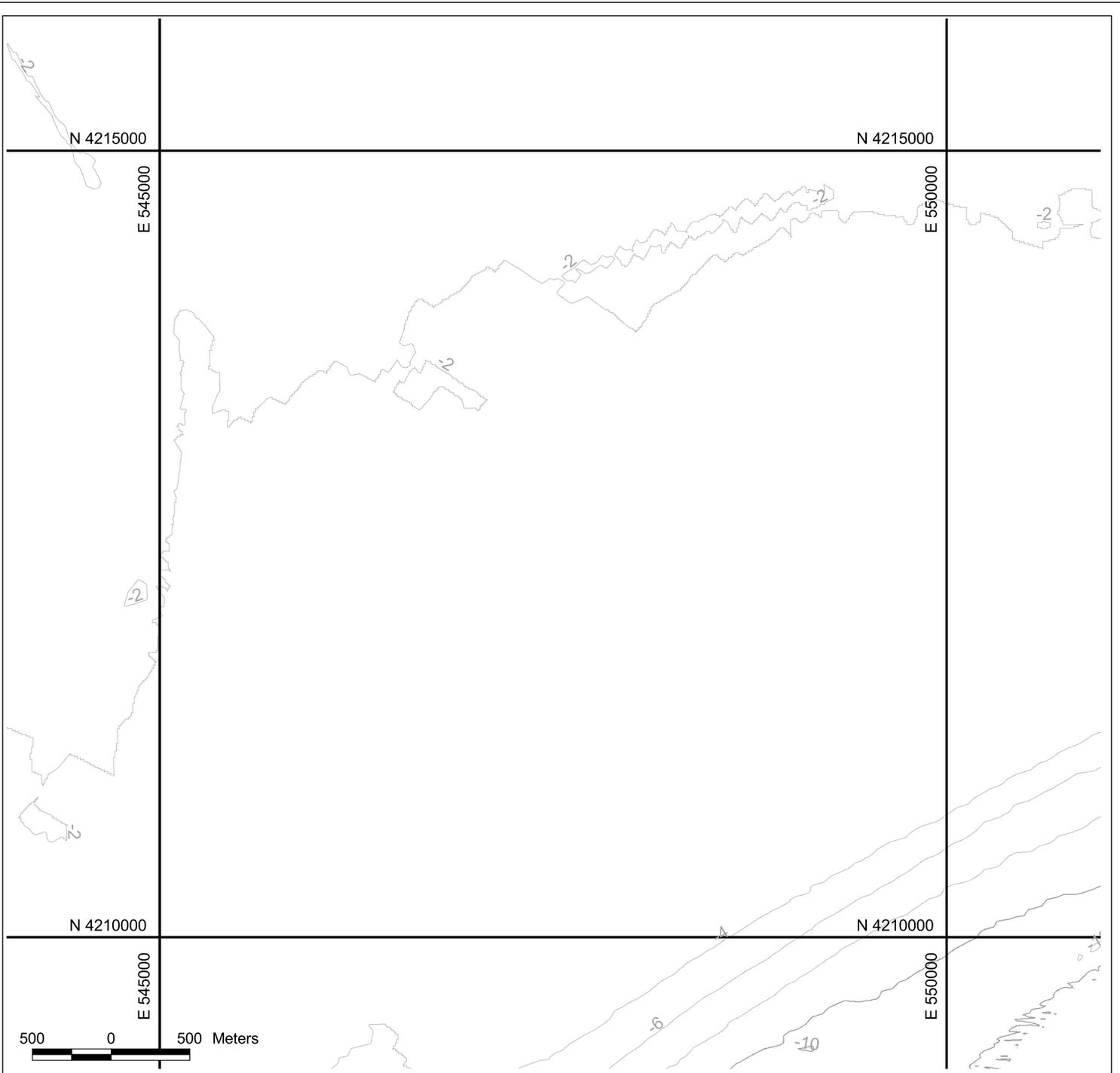
**SAN FRANCISCO BAY, CALIFORNIA
Eelgrass 2003**

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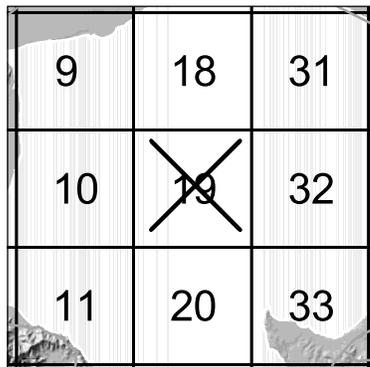
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Vertical Datum: MLLW (meters)

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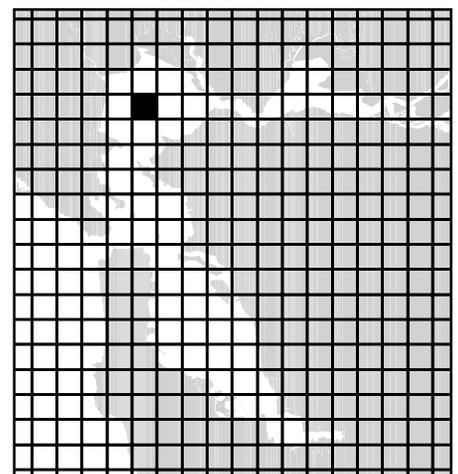




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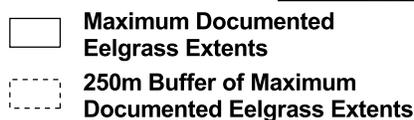


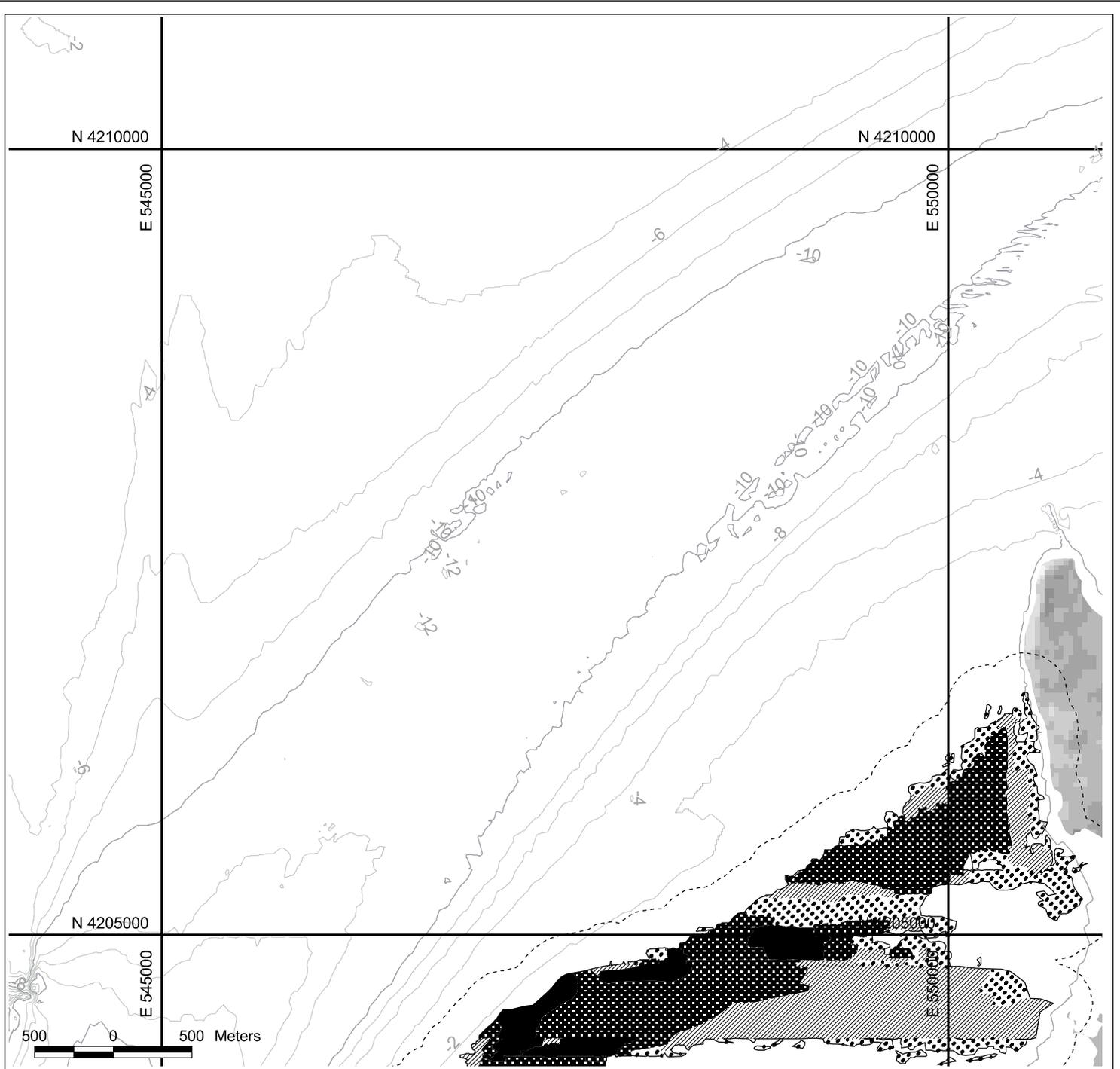
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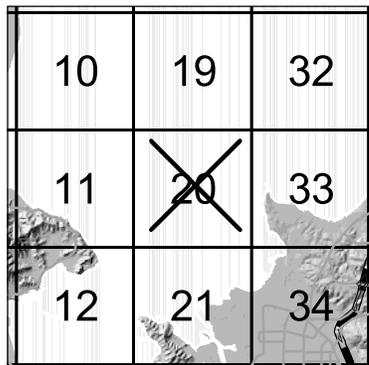
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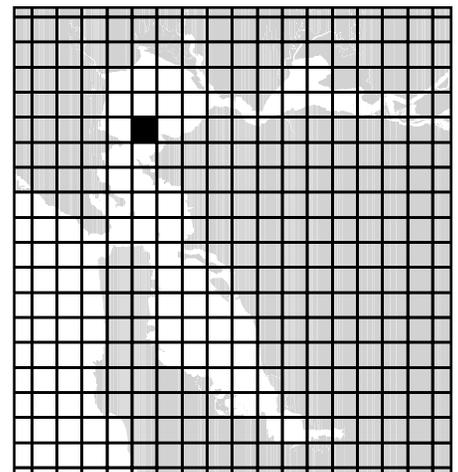




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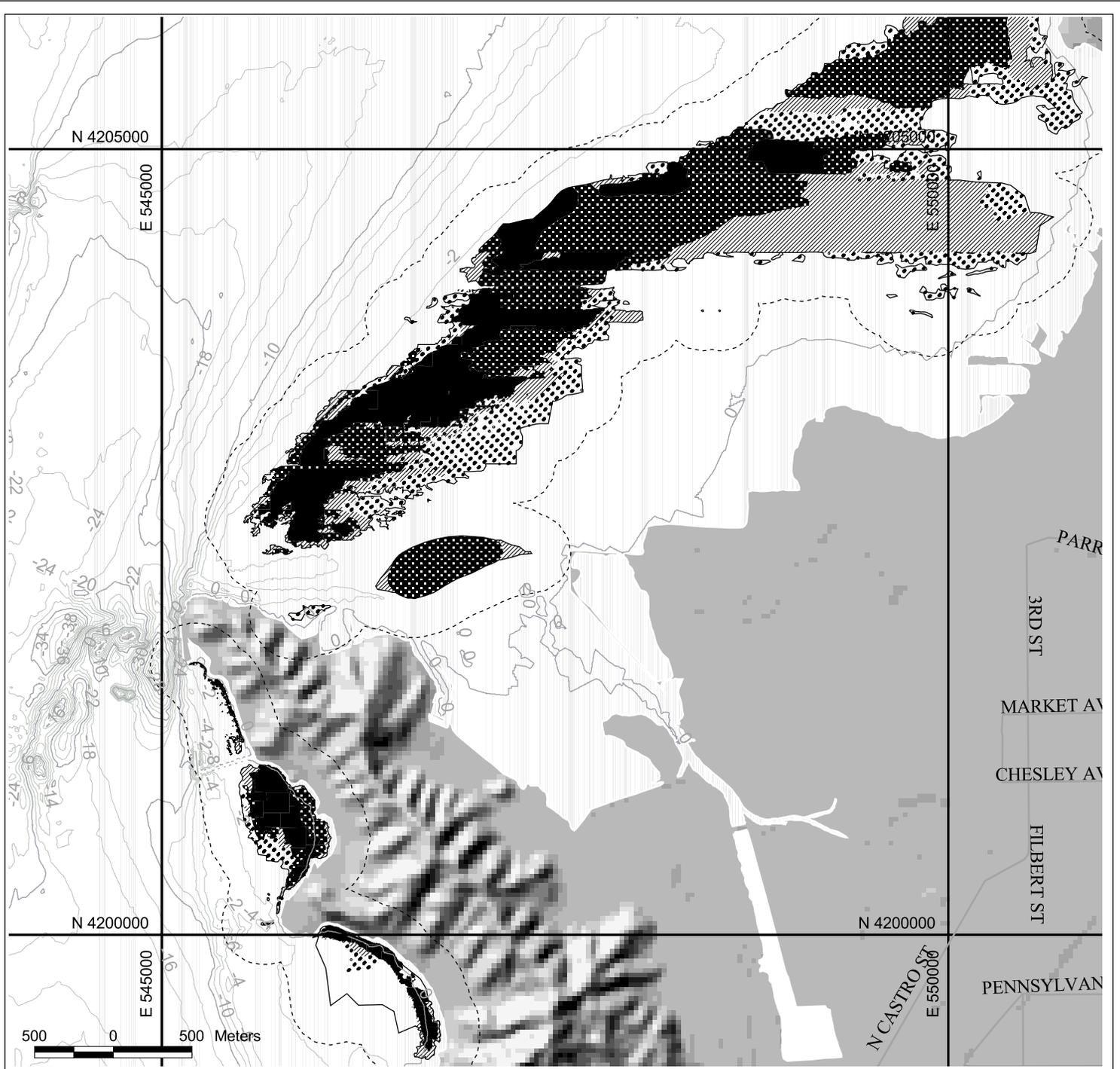
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Horizontal Datum: UTM 10N NAD1983 (meters)
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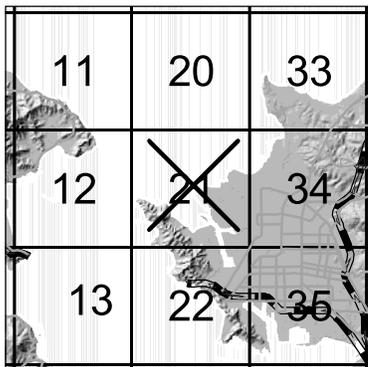
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-  0 - 5 % Density
-  5 - 20 % Density
-  20 - 40 % Density
-  >40 % Density
-  Maximum Documented Eelgrass Extents
-  250m Buffer of Maximum Documented Eelgrass Extents

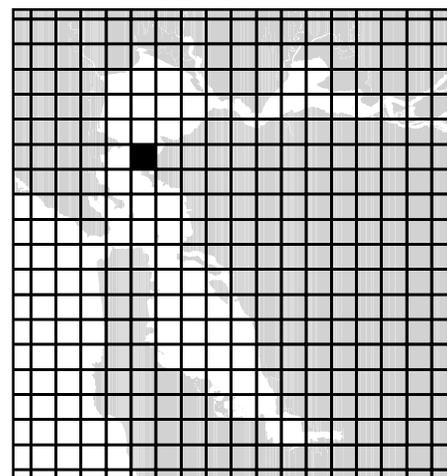




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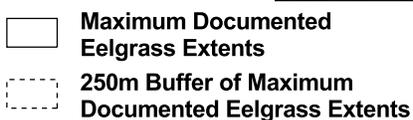


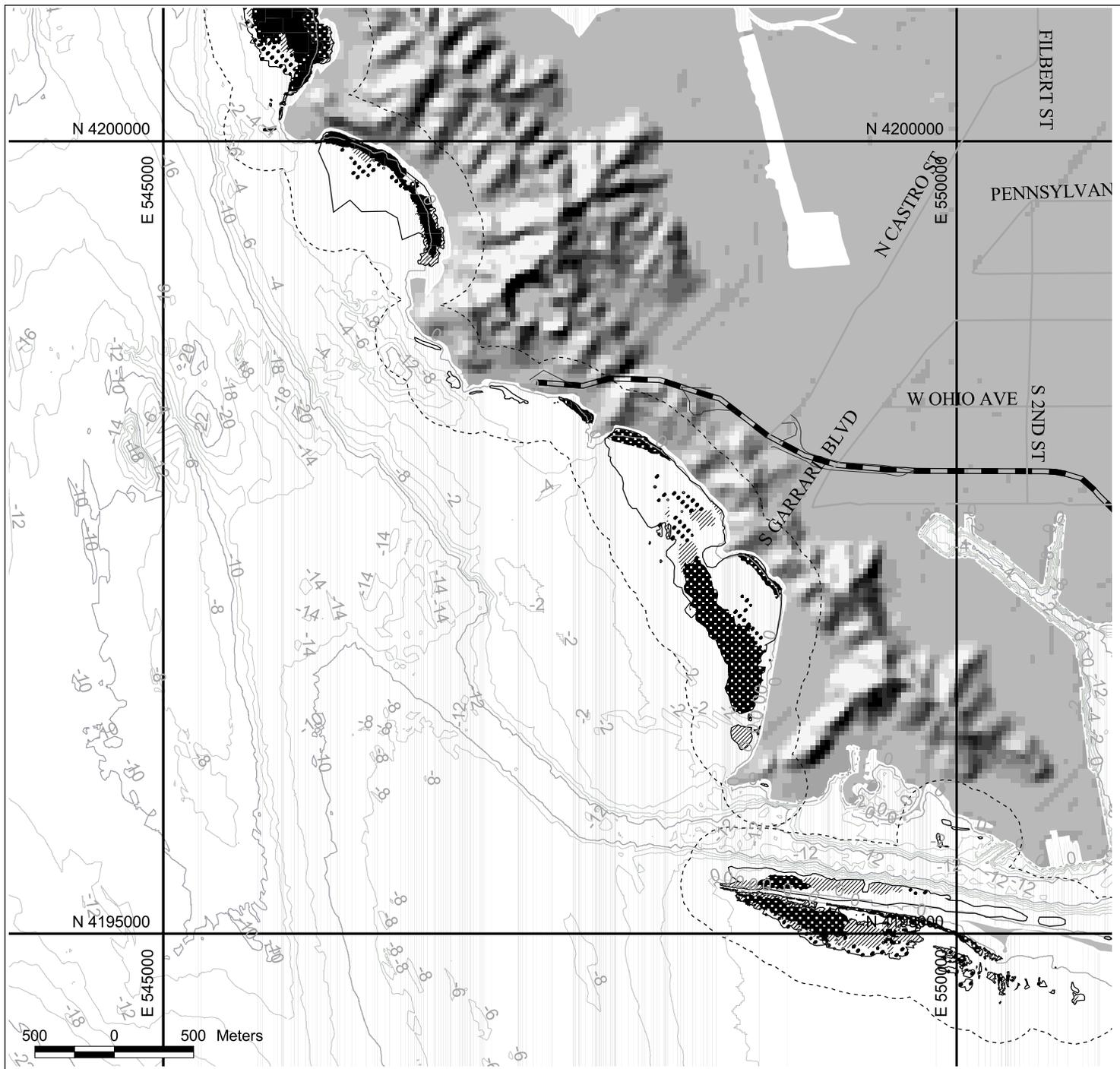
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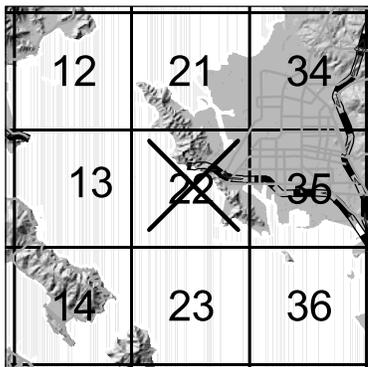
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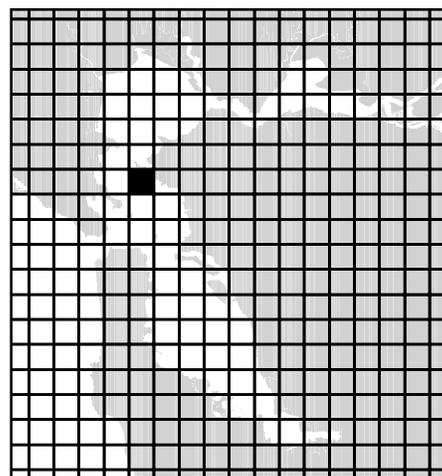




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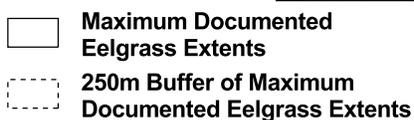


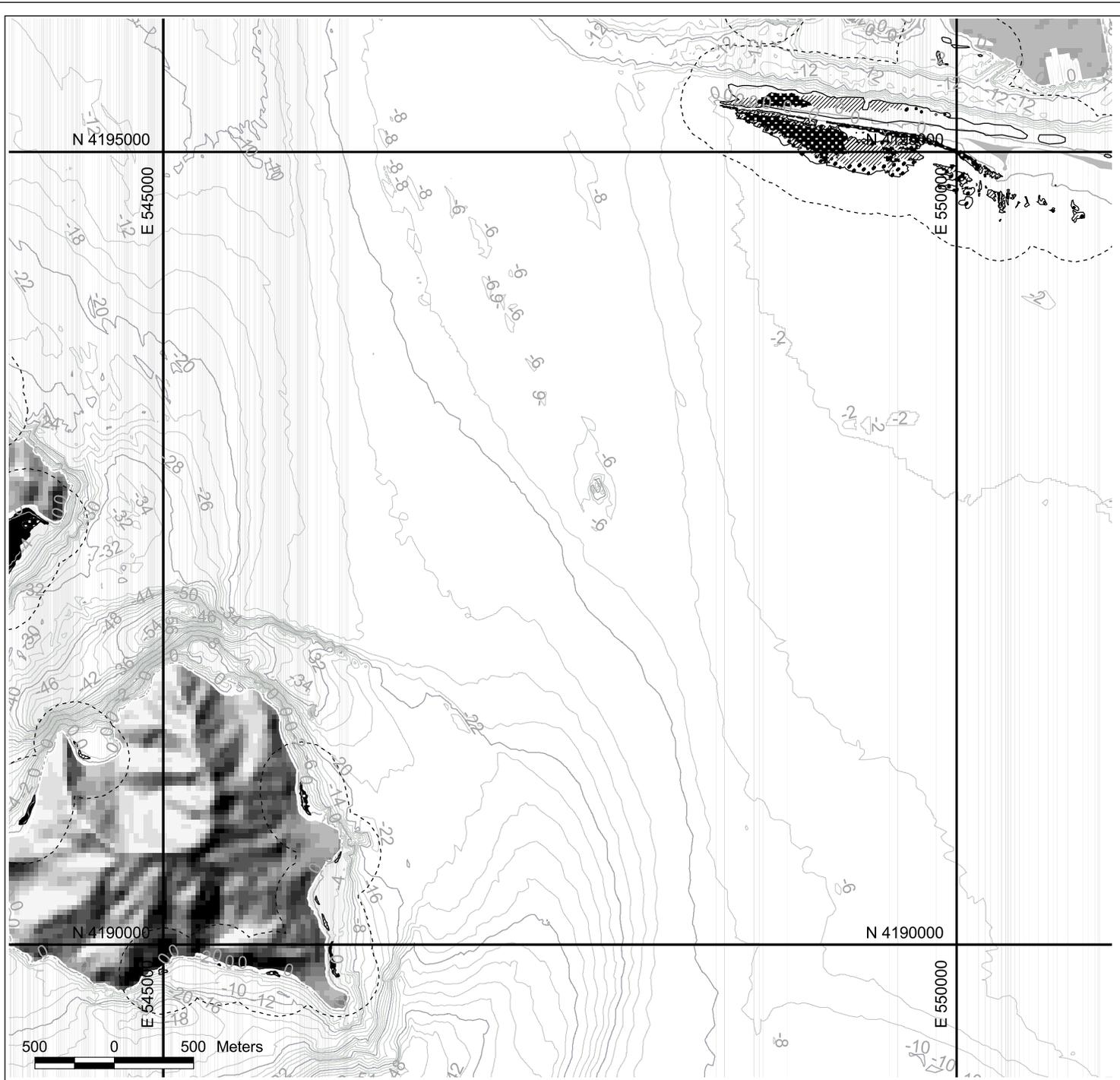
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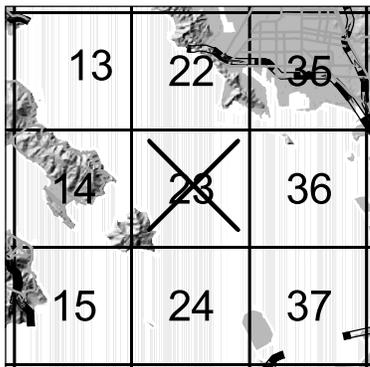
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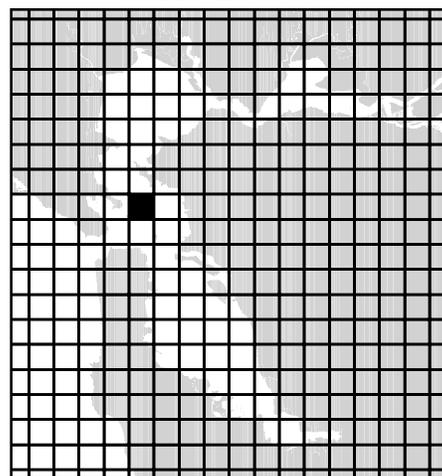




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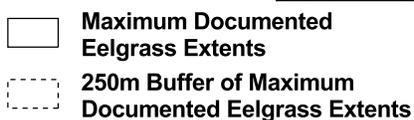


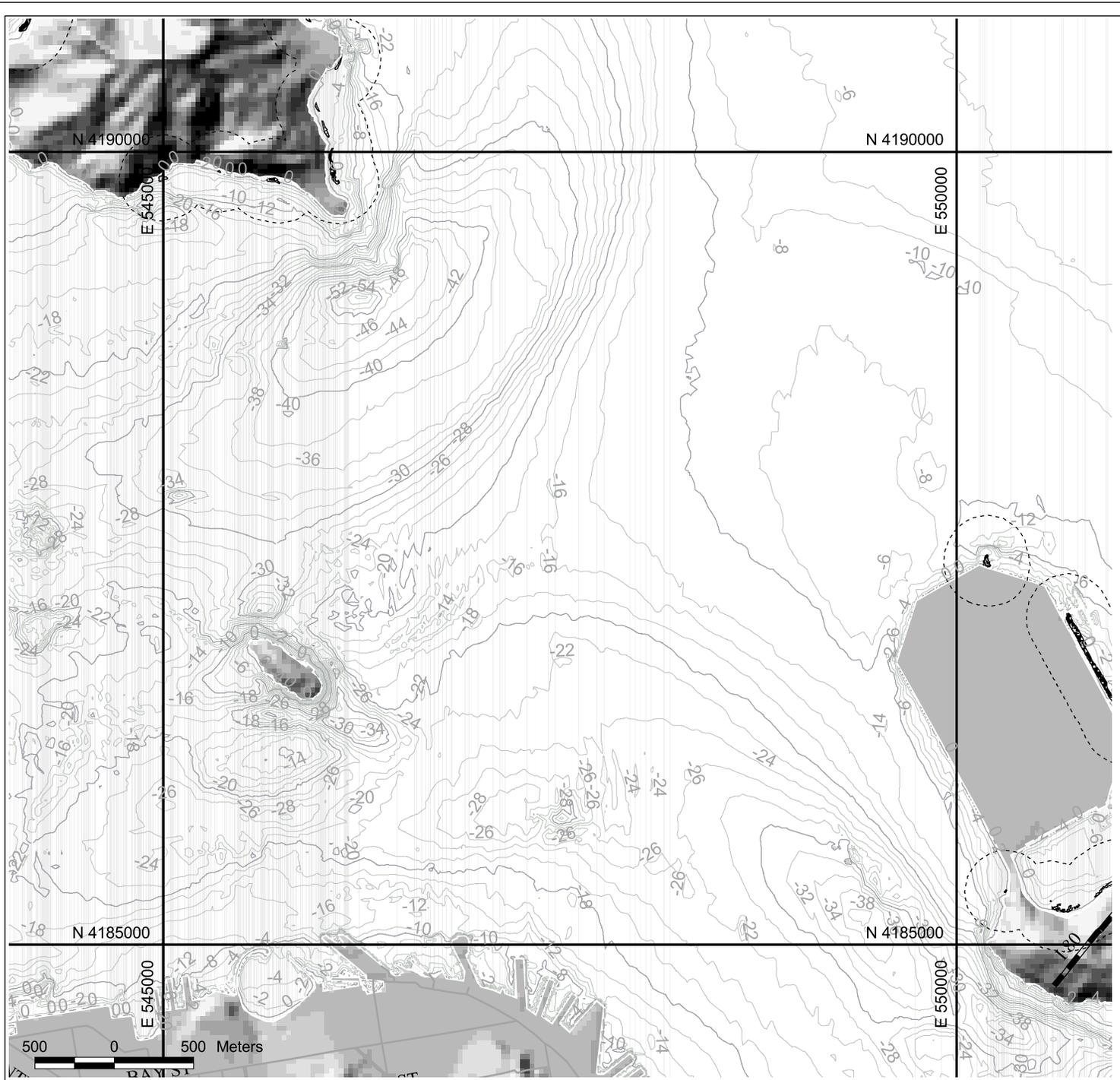
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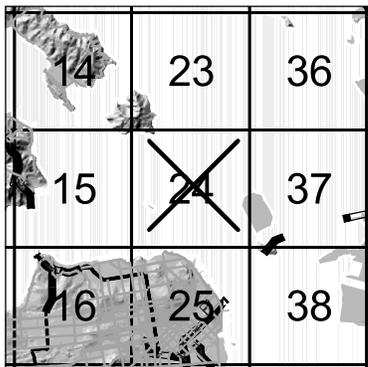
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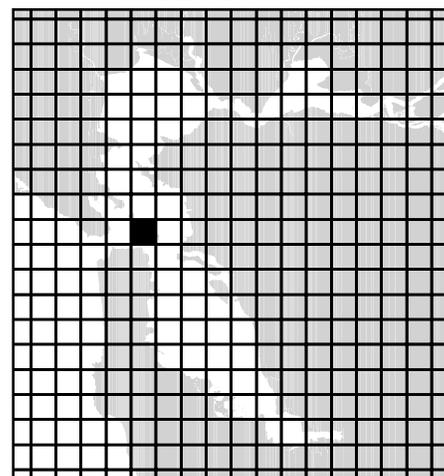




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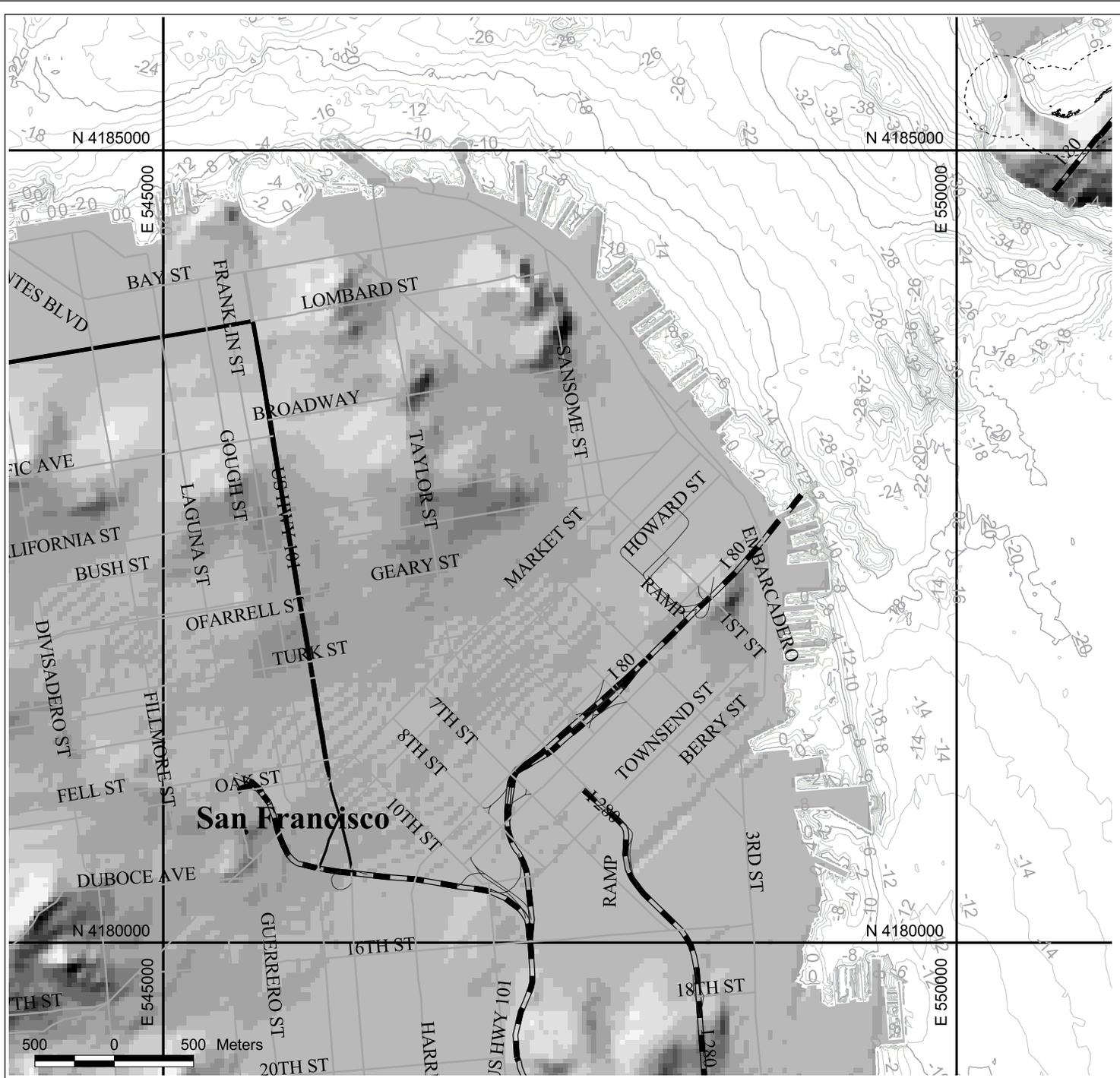
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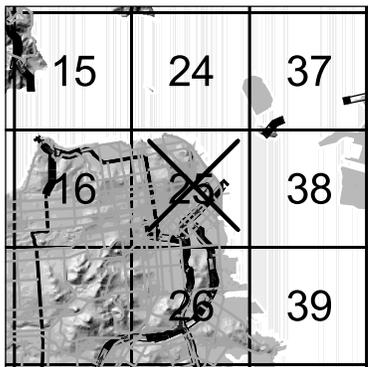
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-  >40 % Density
-  Maximum Documented Eelgrass Extents
-  250m Buffer of Maximum Documented Eelgrass Extents

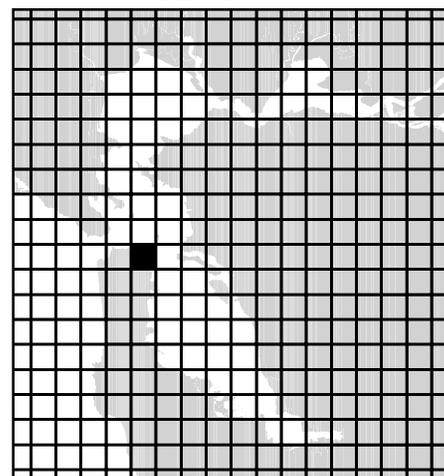




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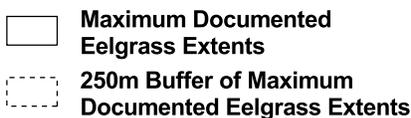


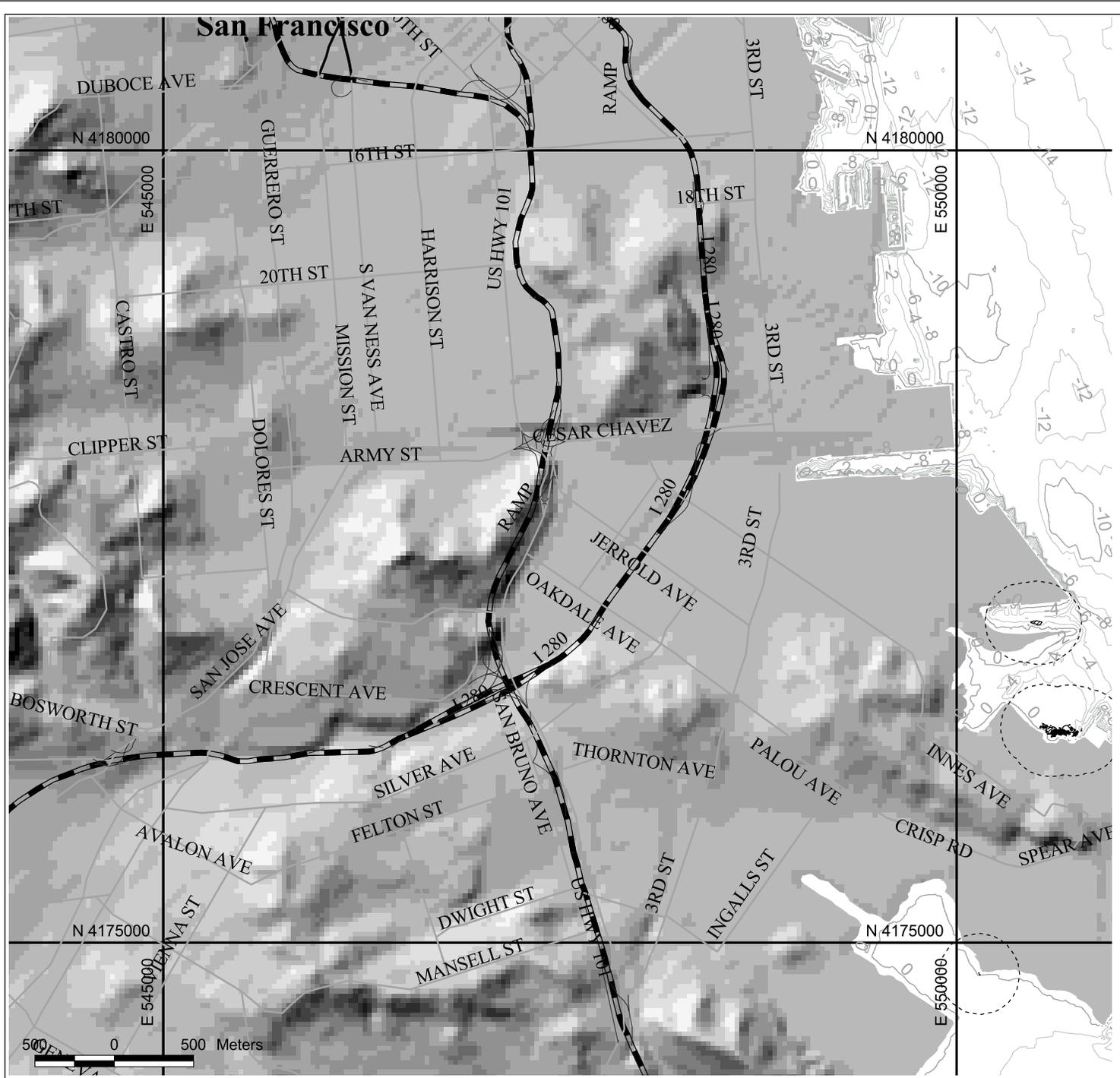
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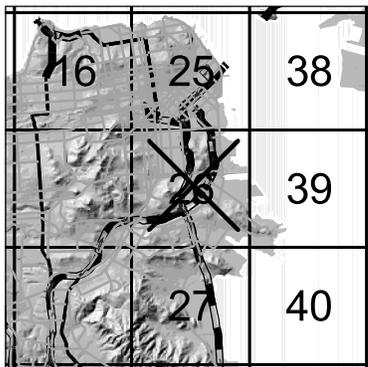
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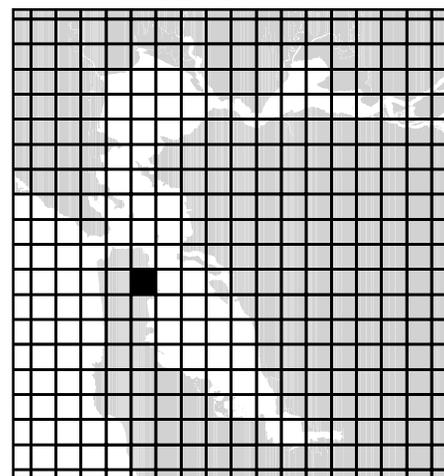




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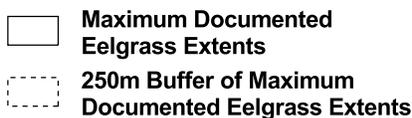


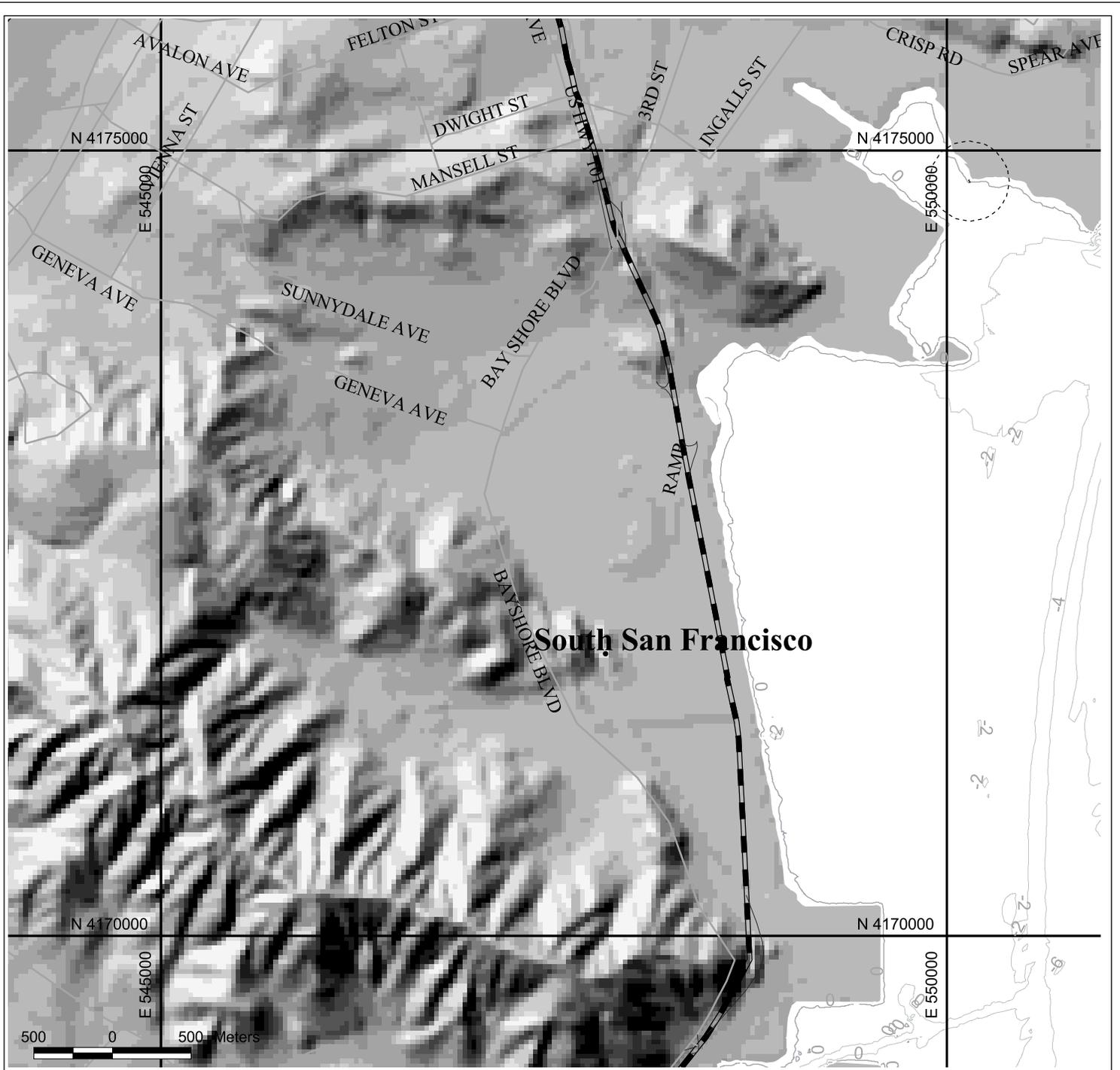
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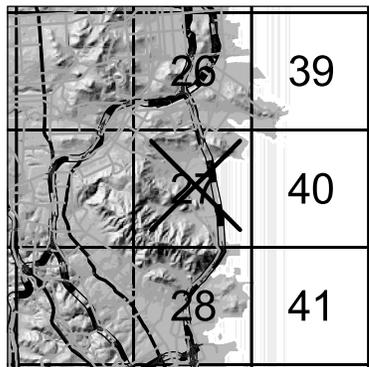
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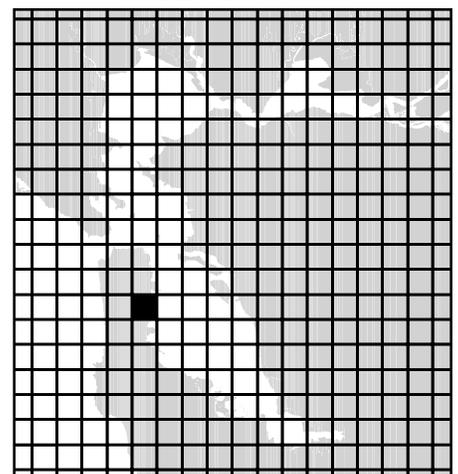




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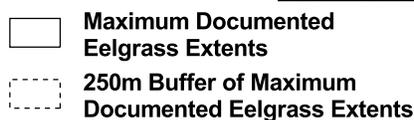


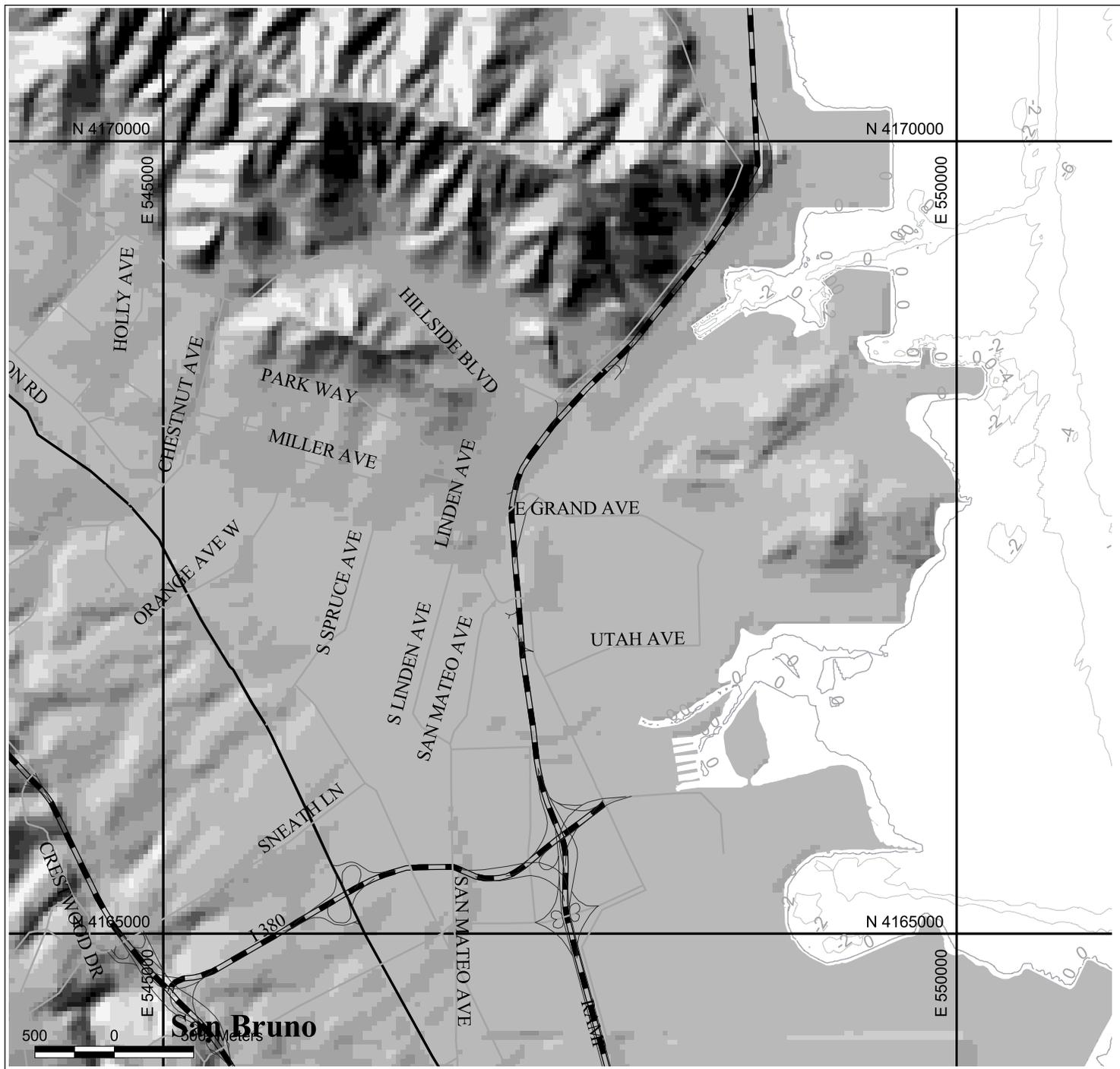
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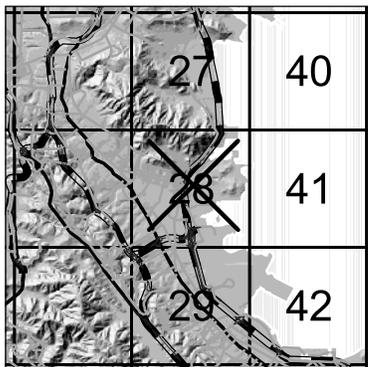
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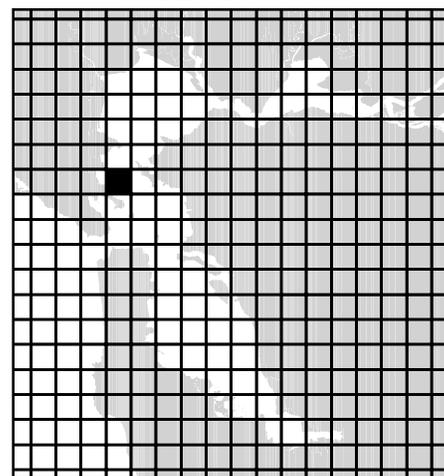




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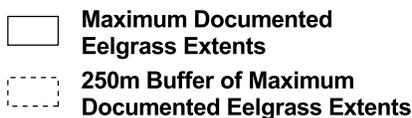


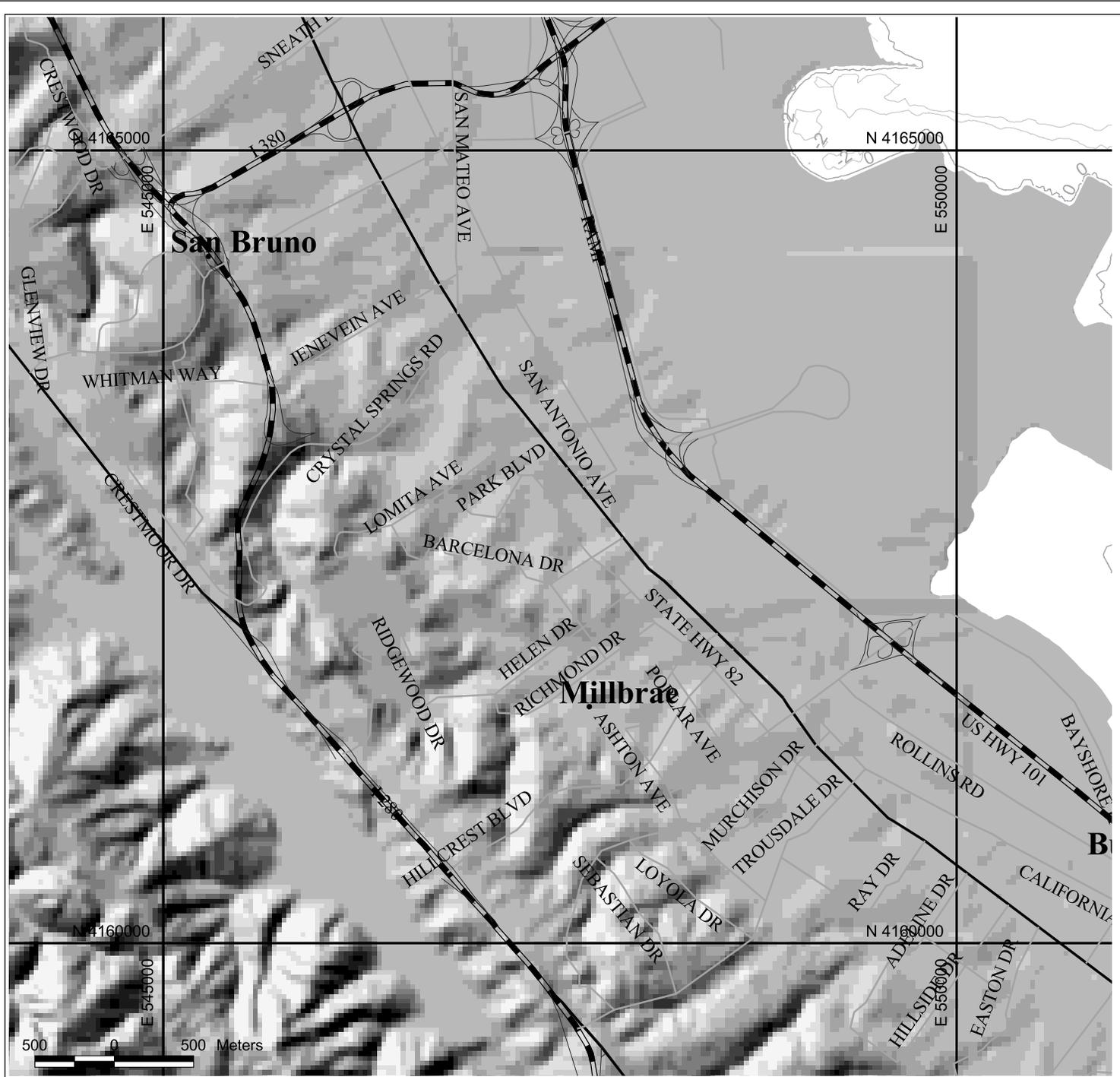
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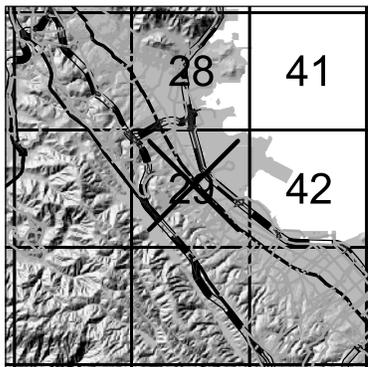
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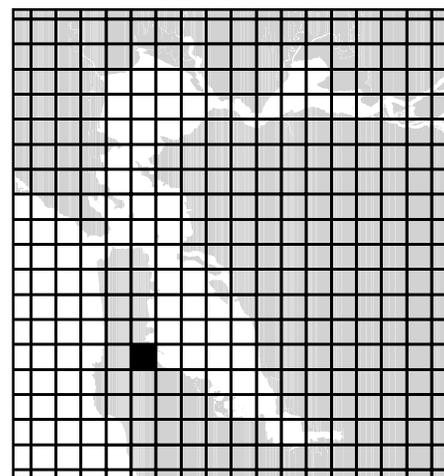




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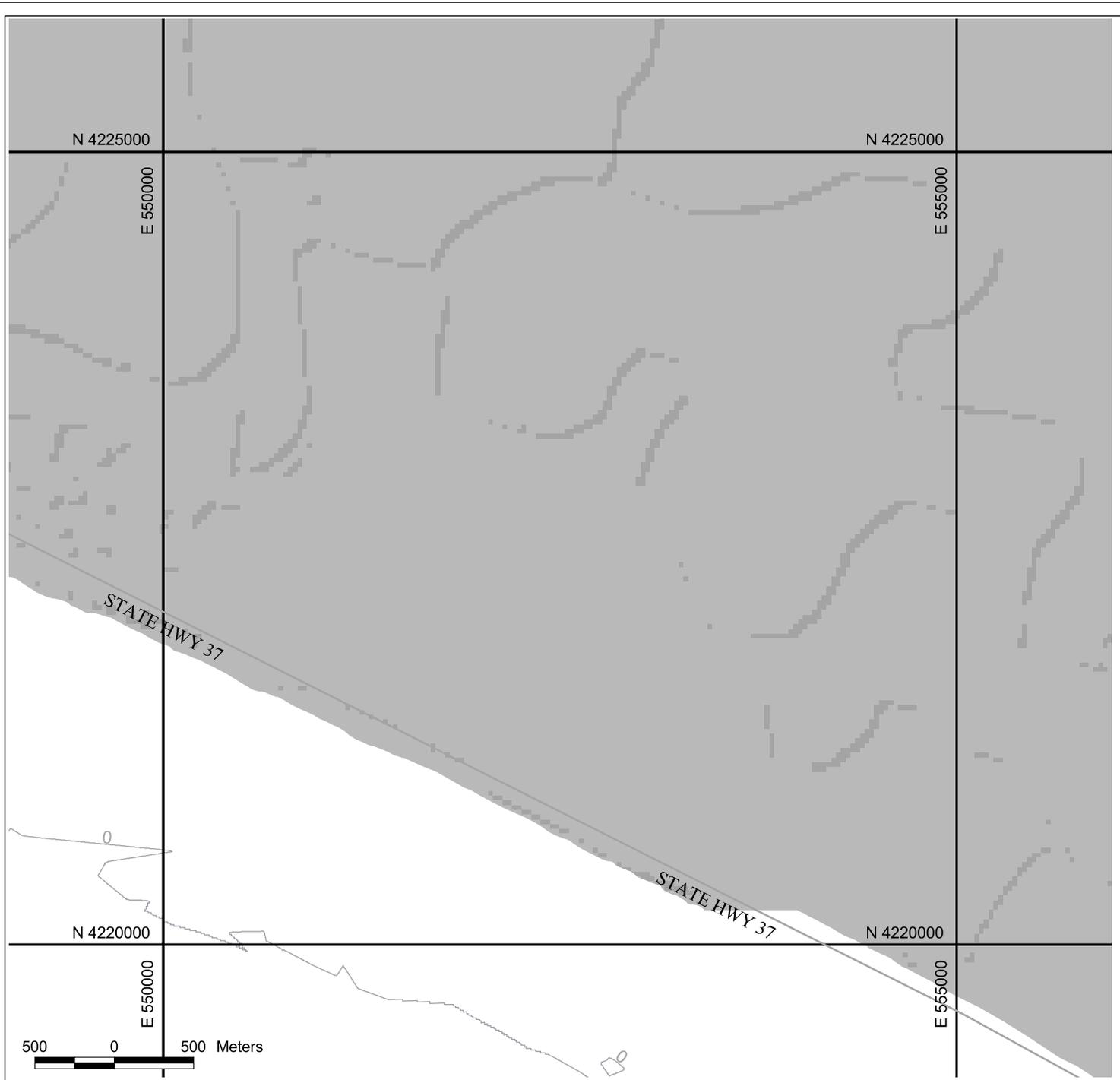
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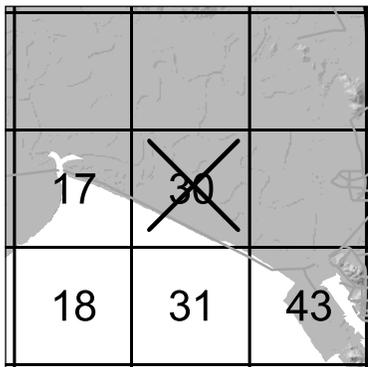
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- 0 - 5 % Density
- 5 - 20 % Density
- 20 - 40 % Density
- >40 % Density
- Maximum Documented Eelgrass Extents
- 250m Buffer of Maximum Documented Eelgrass Extents

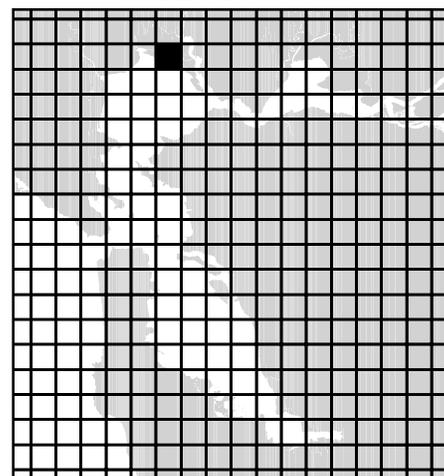




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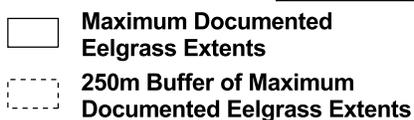


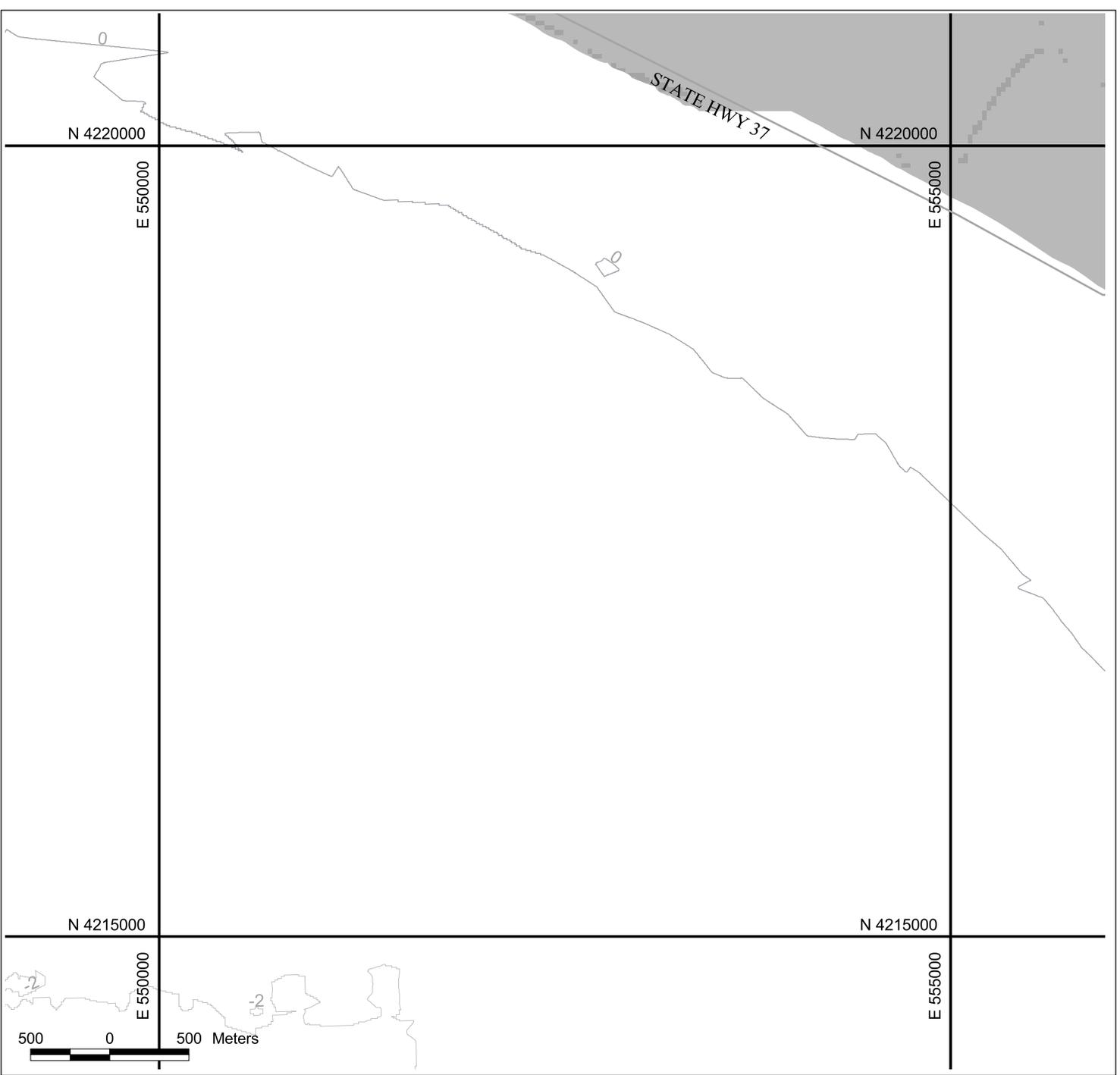
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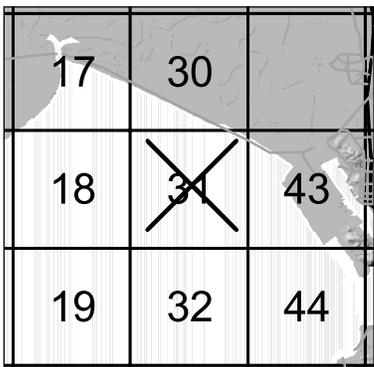
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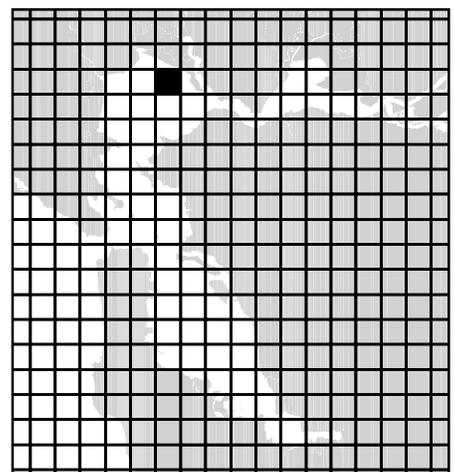




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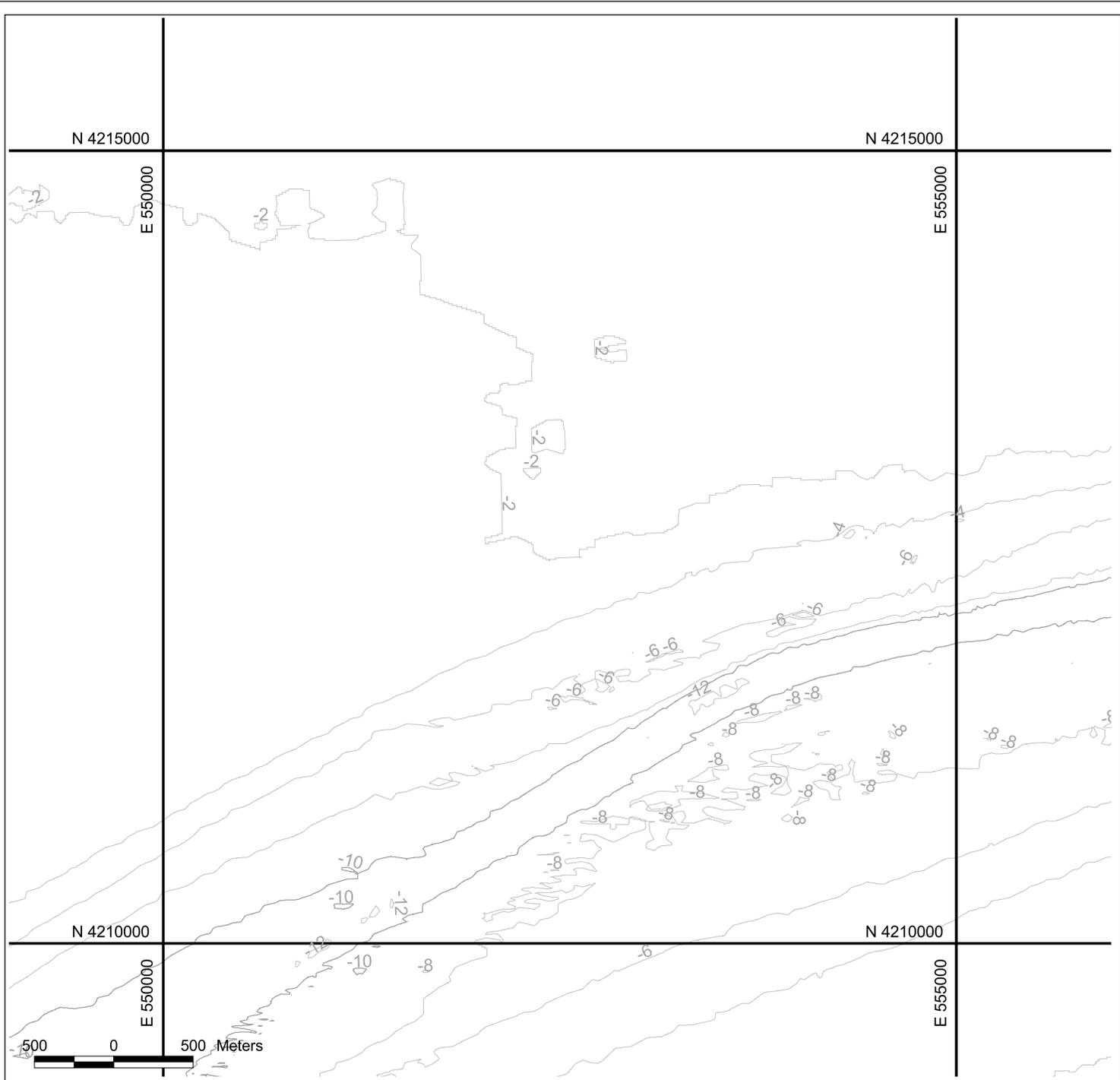
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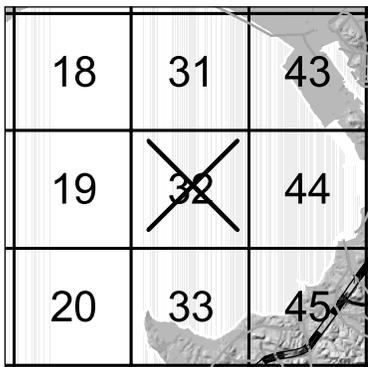
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-  0 - 5 % Density
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-  20 - 40 % Density
-  >40 % Density
-  Maximum Documented Eelgrass Extents
-  250m Buffer of Maximum Documented Eelgrass Extents

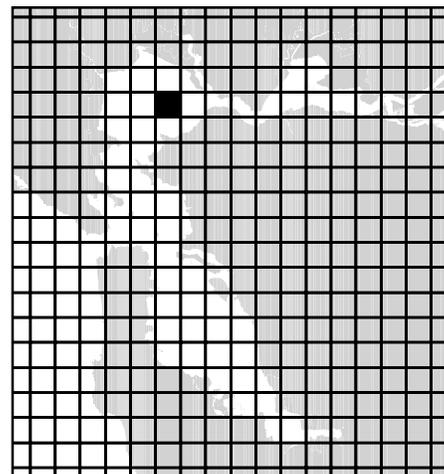




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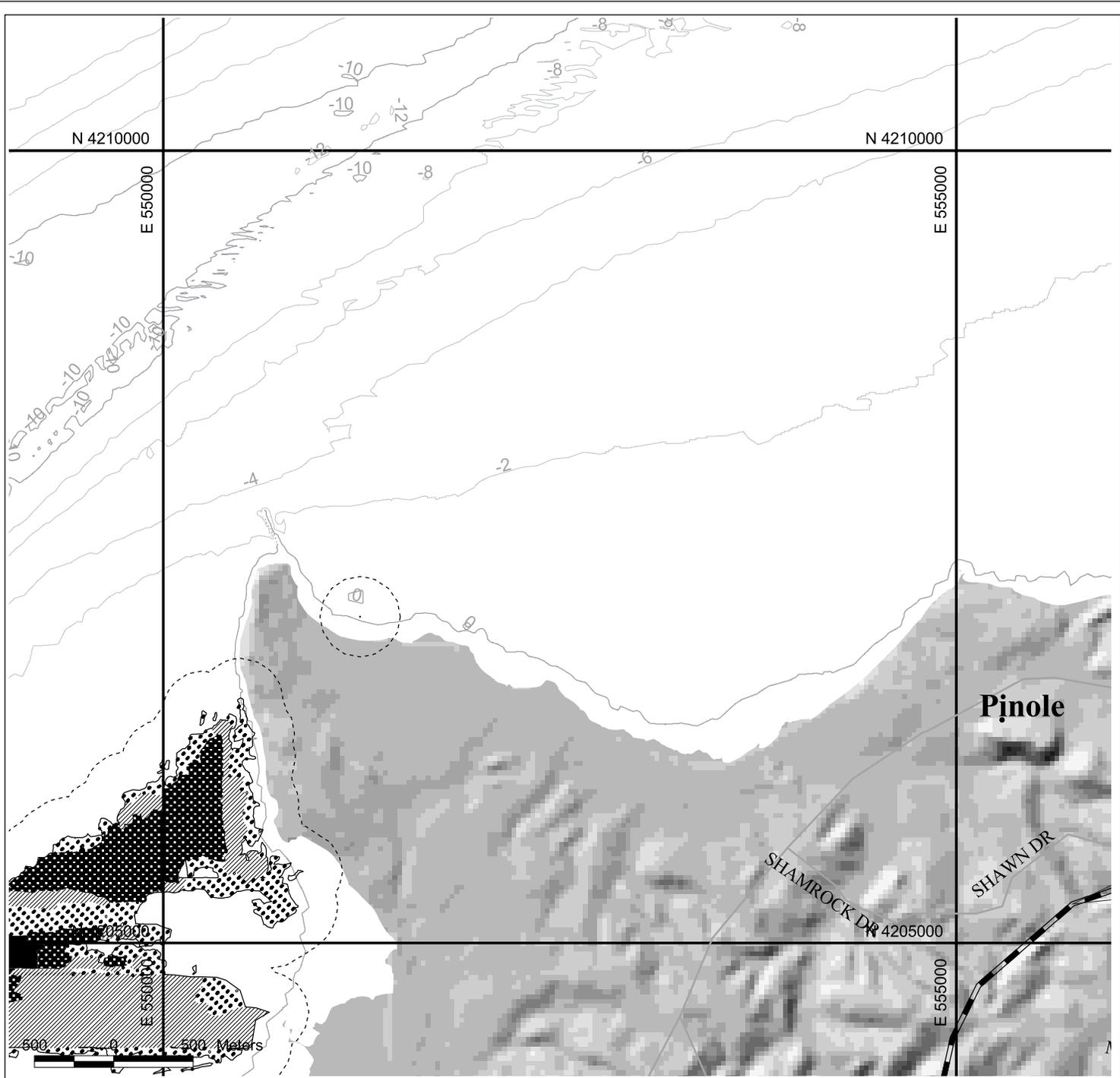
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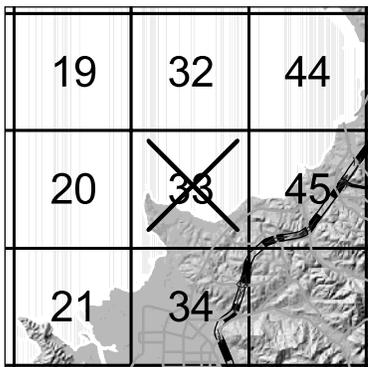
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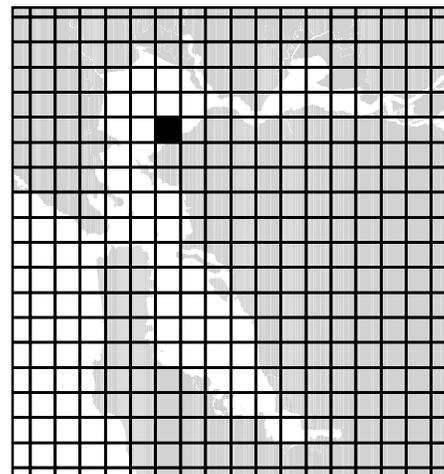




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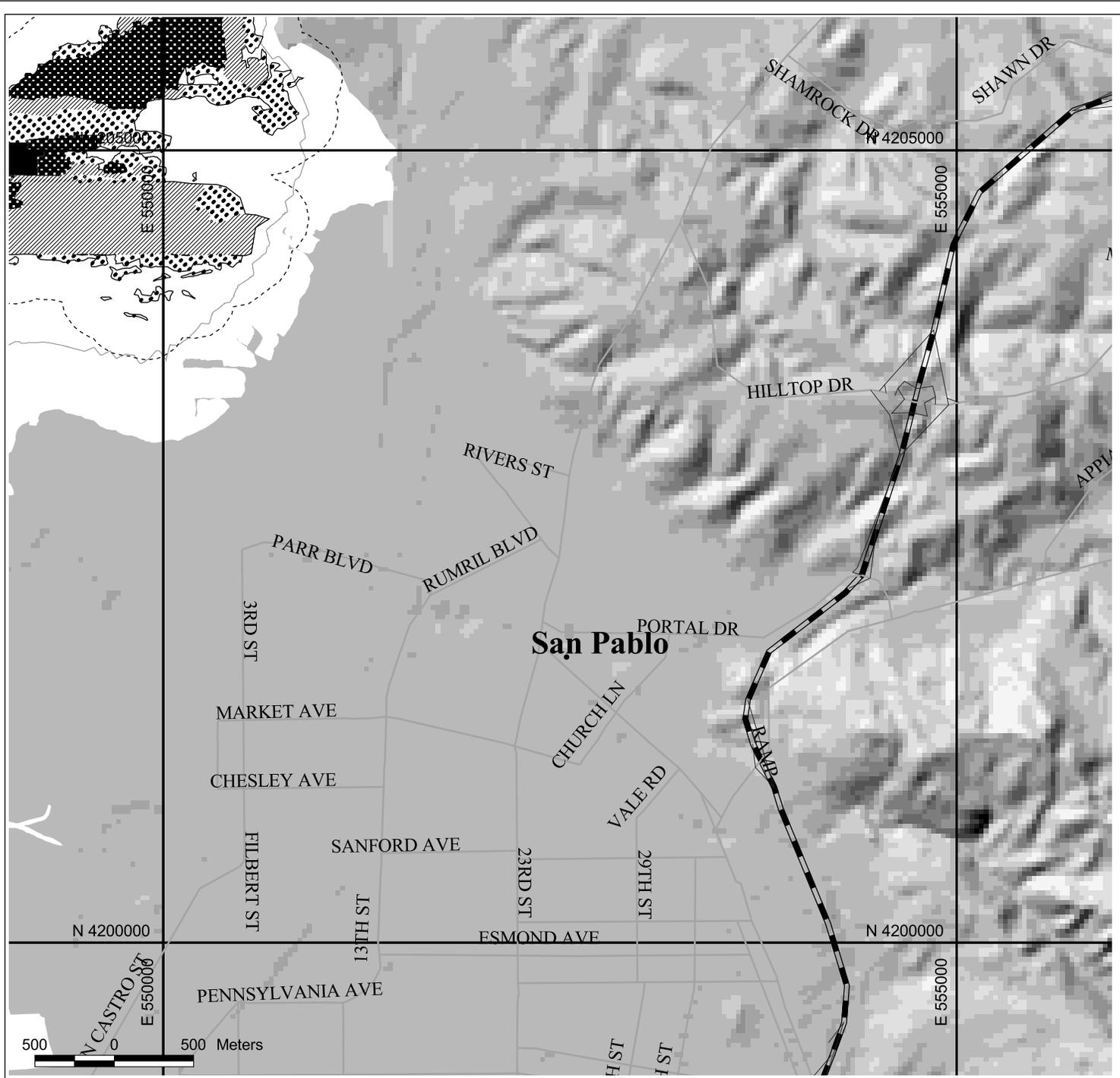
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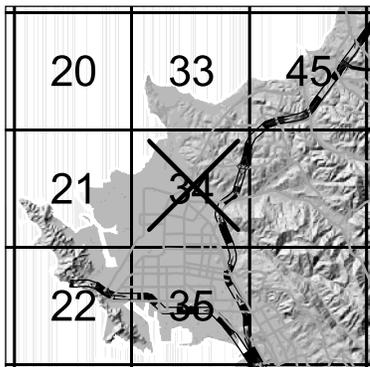
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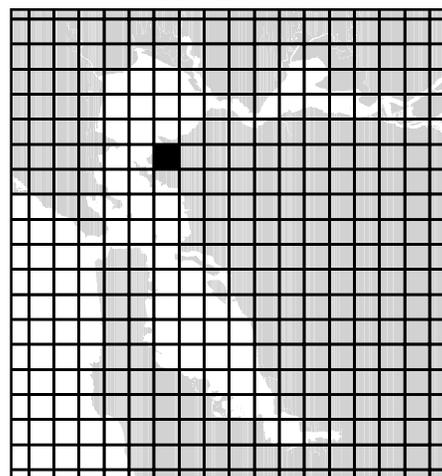




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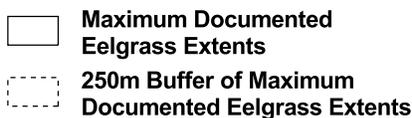


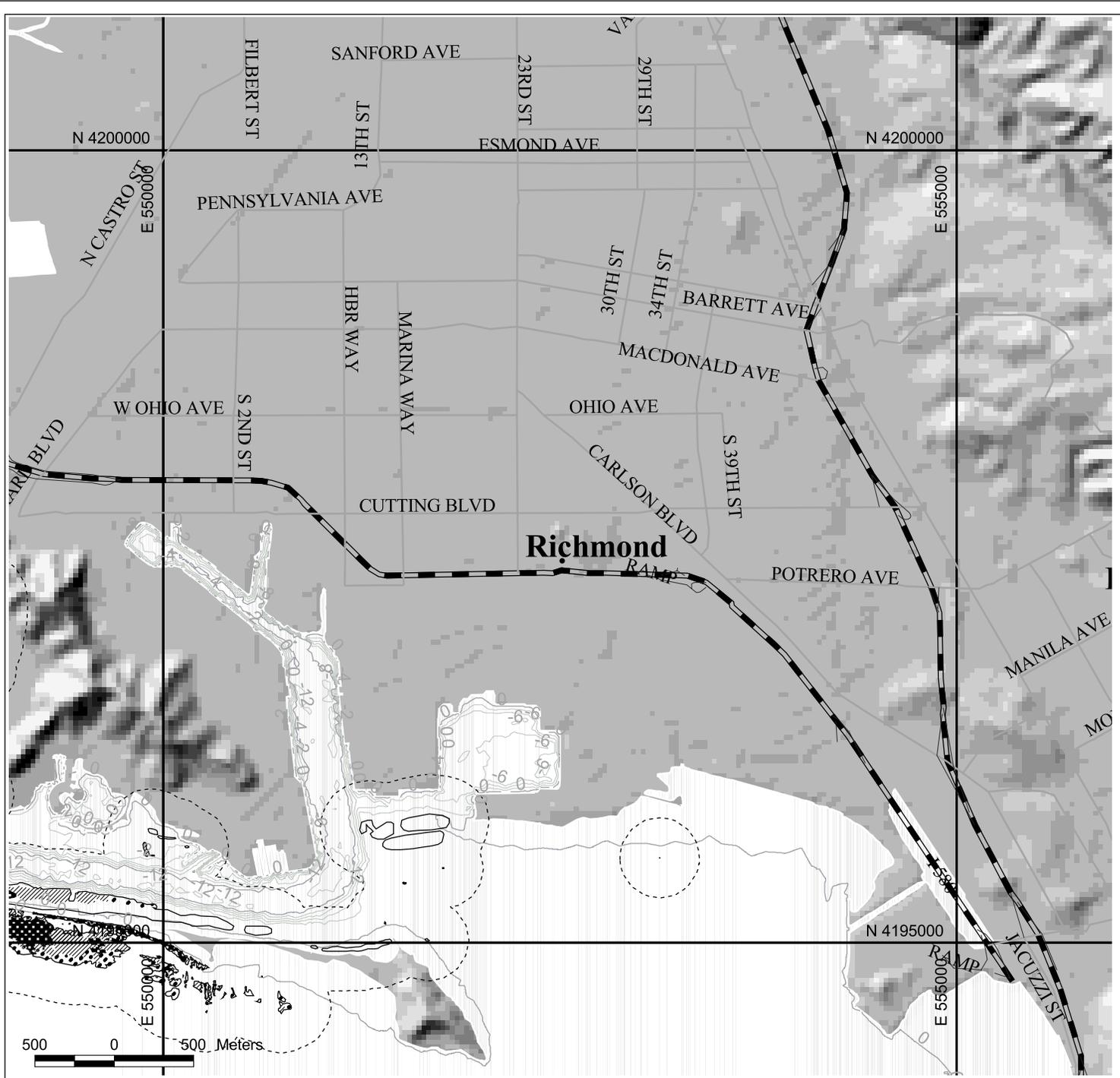
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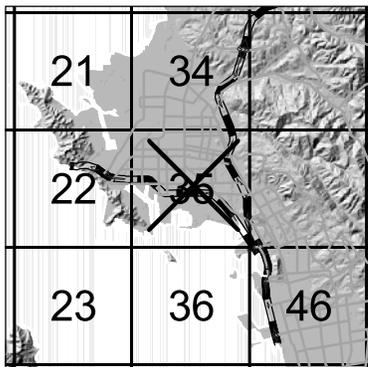
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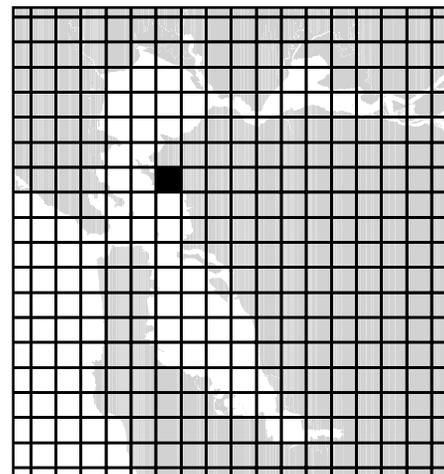




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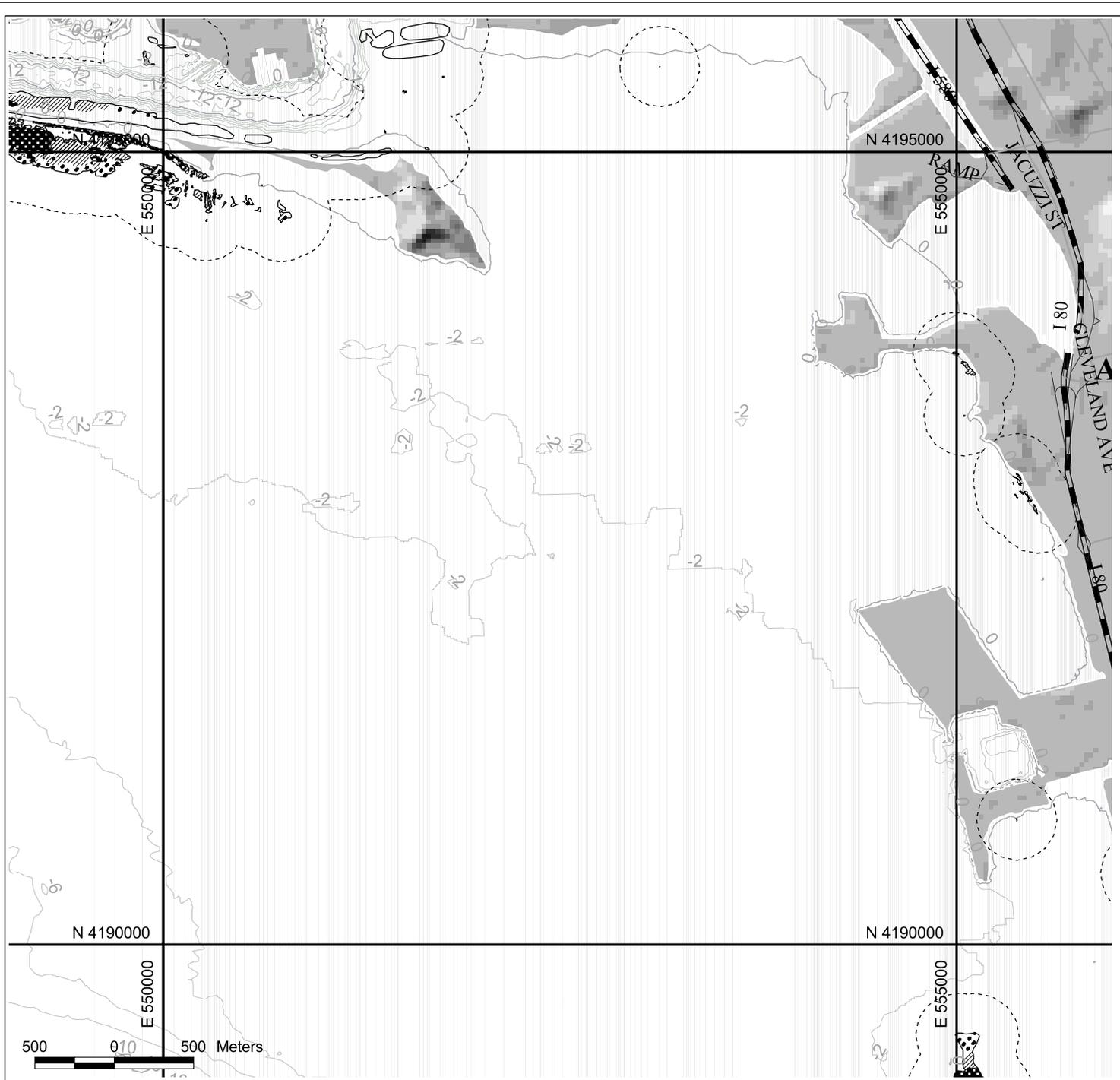
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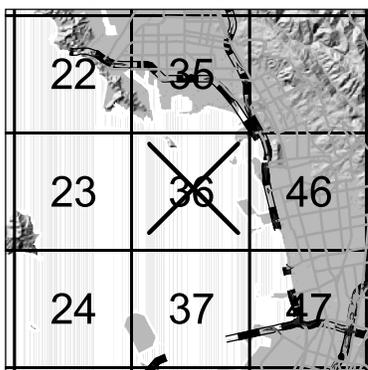
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- Maximum Documented Eelgrass Extents
- 250m Buffer of Maximum Documented Eelgrass Extents

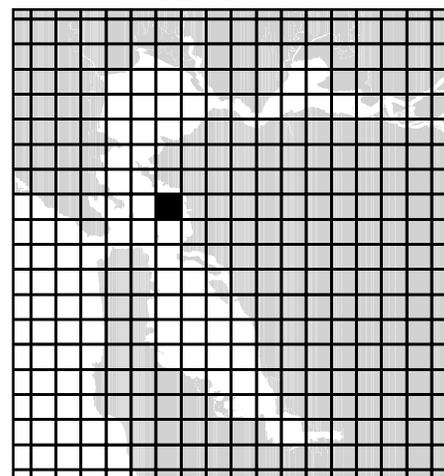




SHEET VICINITY



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SAN FRANCISCO BAY, CALIFORNIA
Eelgrass 2003

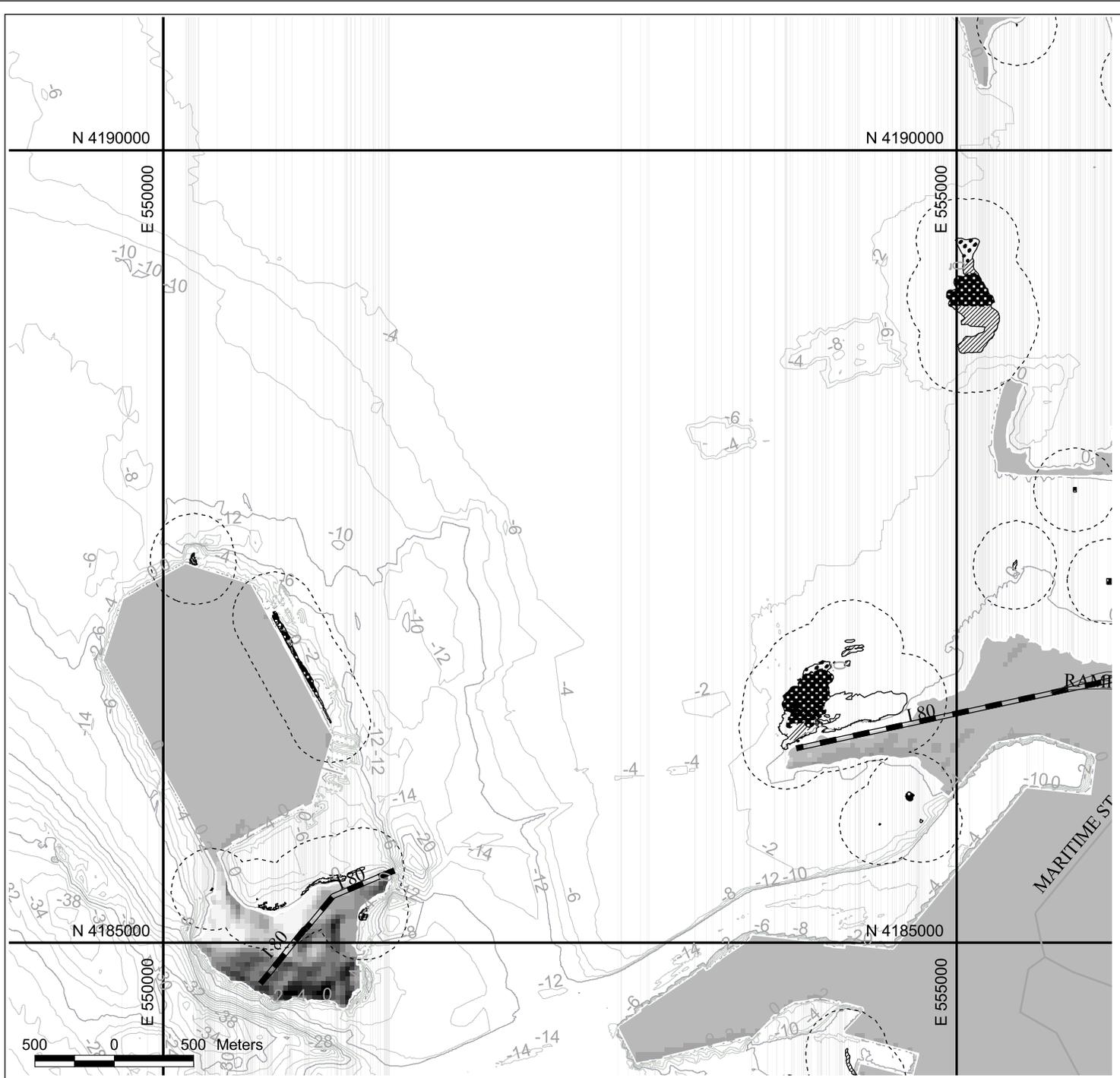
Merkel & Associates, Inc.
San Diego, California Tel: (858) 560-5465

Horizontal Datum: UTM 10N NAD1983 (meters)
Vertical Datum: MLLW (meters)

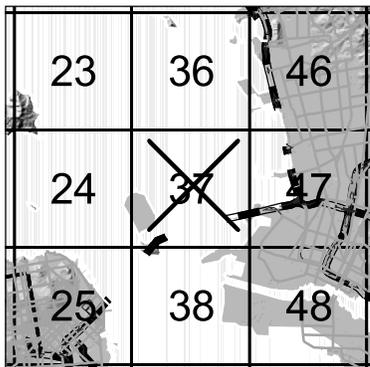
Note: Charts are for planning and management purposes only. Information application is limited by survey scale and some error is expected. Information is not to be used for navigation or specific project applications.

- 0 - 5 % Density
- 5 - 20 % Density
- 20 - 40 % Density
- >40 % Density
- Maximum Documented Eelgrass Extents
- 250m Buffer of Maximum Documented Eelgrass Extents

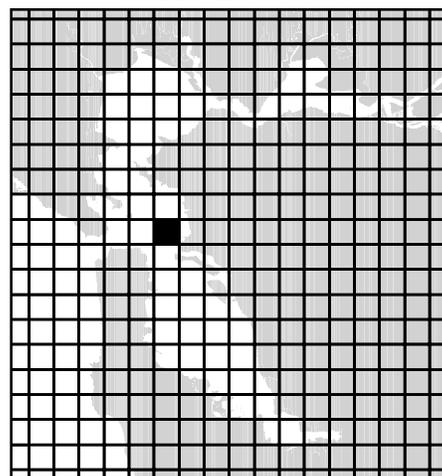




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Eelgrass 2003

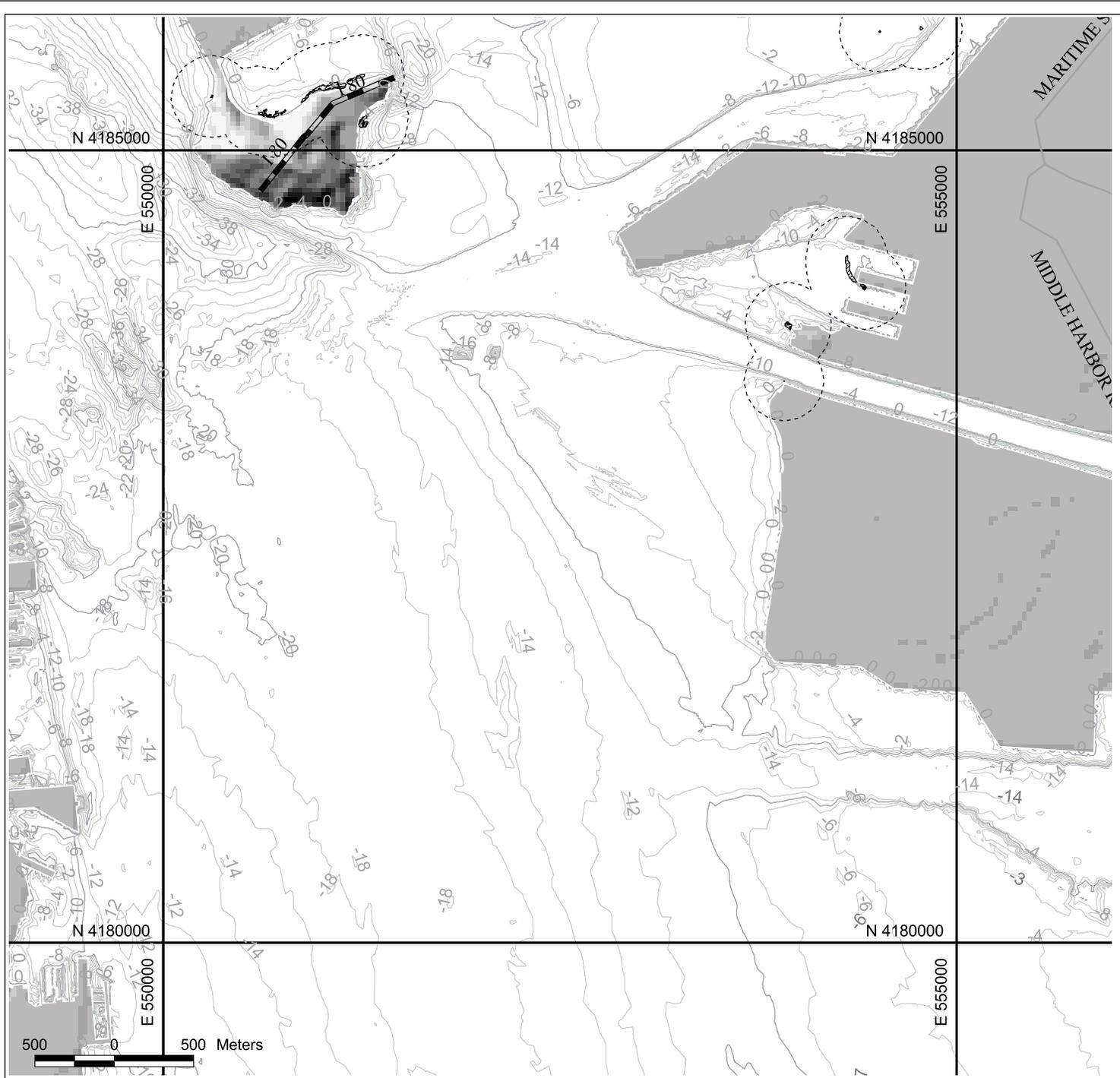
Merkel & Associates, Inc.
San Diego, California Tel: (858) 560-5465

Horizontal Datum: UTM 10N NAD1983 (meters)
Vertical Datum: MLLW (meters)

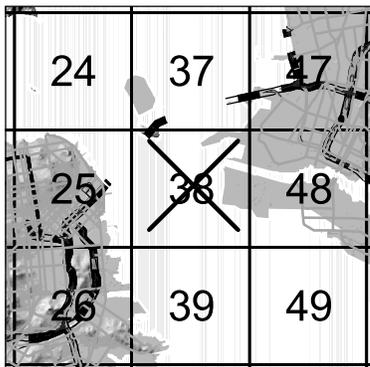
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- 0 - 5 % Density
- 5 - 20 % Density
- 20 - 40 % Density
- >40 % Density
- Maximum Documented Eelgrass Extents
- 250m Buffer of Maximum Documented Eelgrass Extents

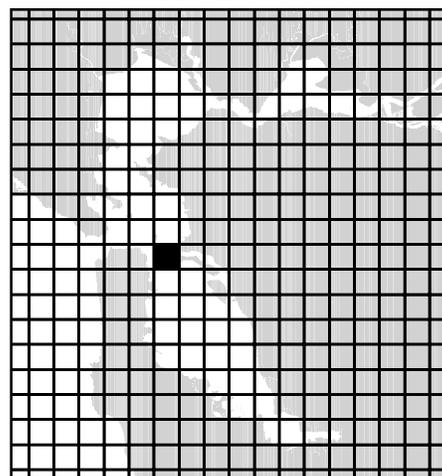




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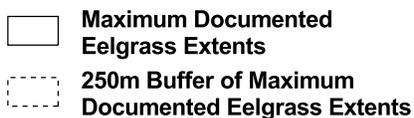


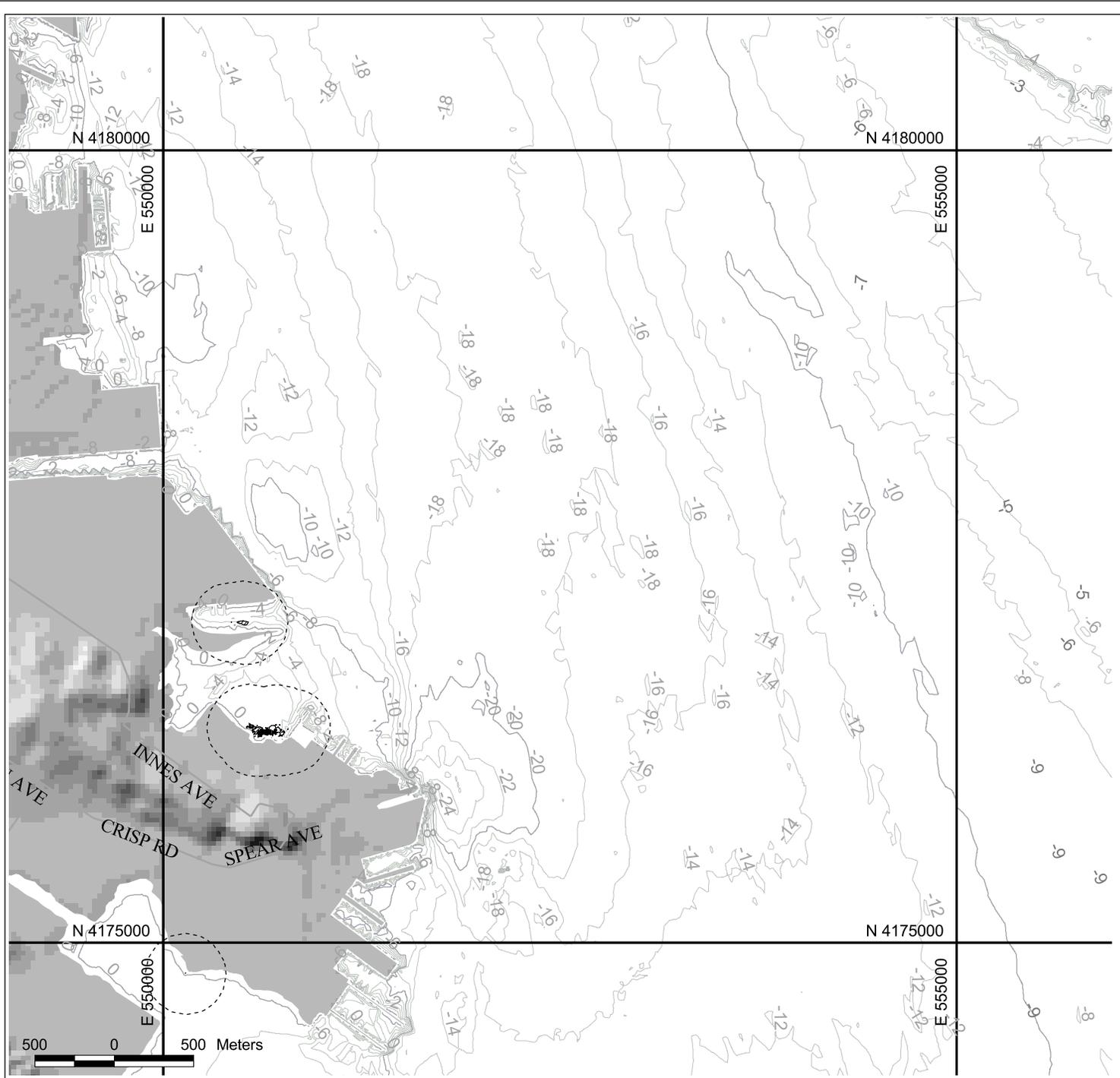
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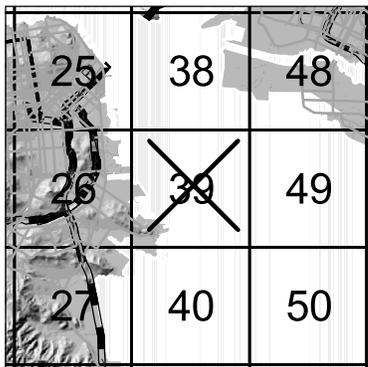
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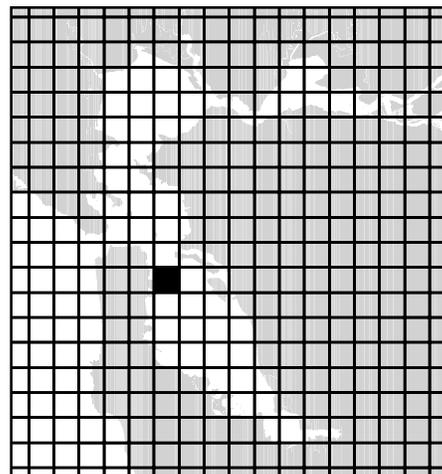




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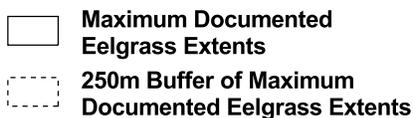


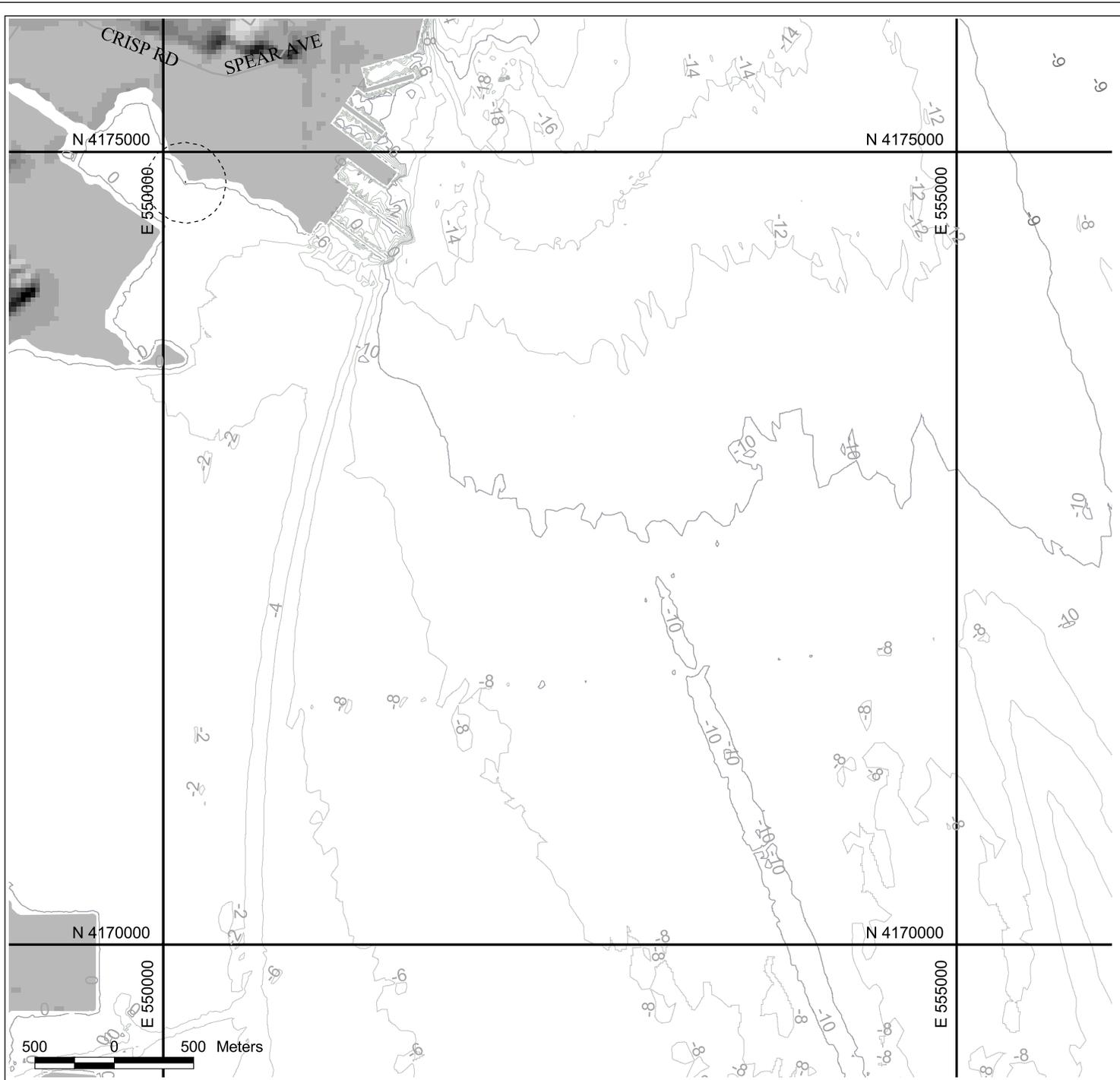
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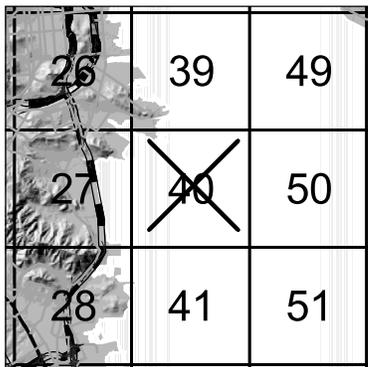
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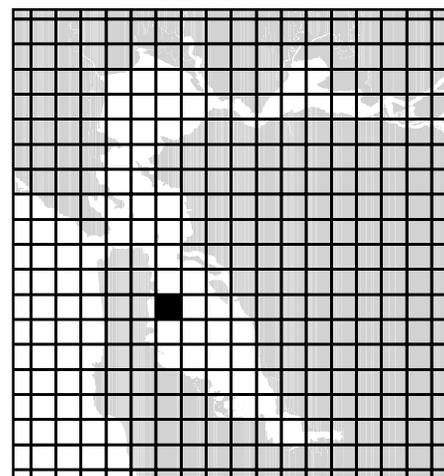




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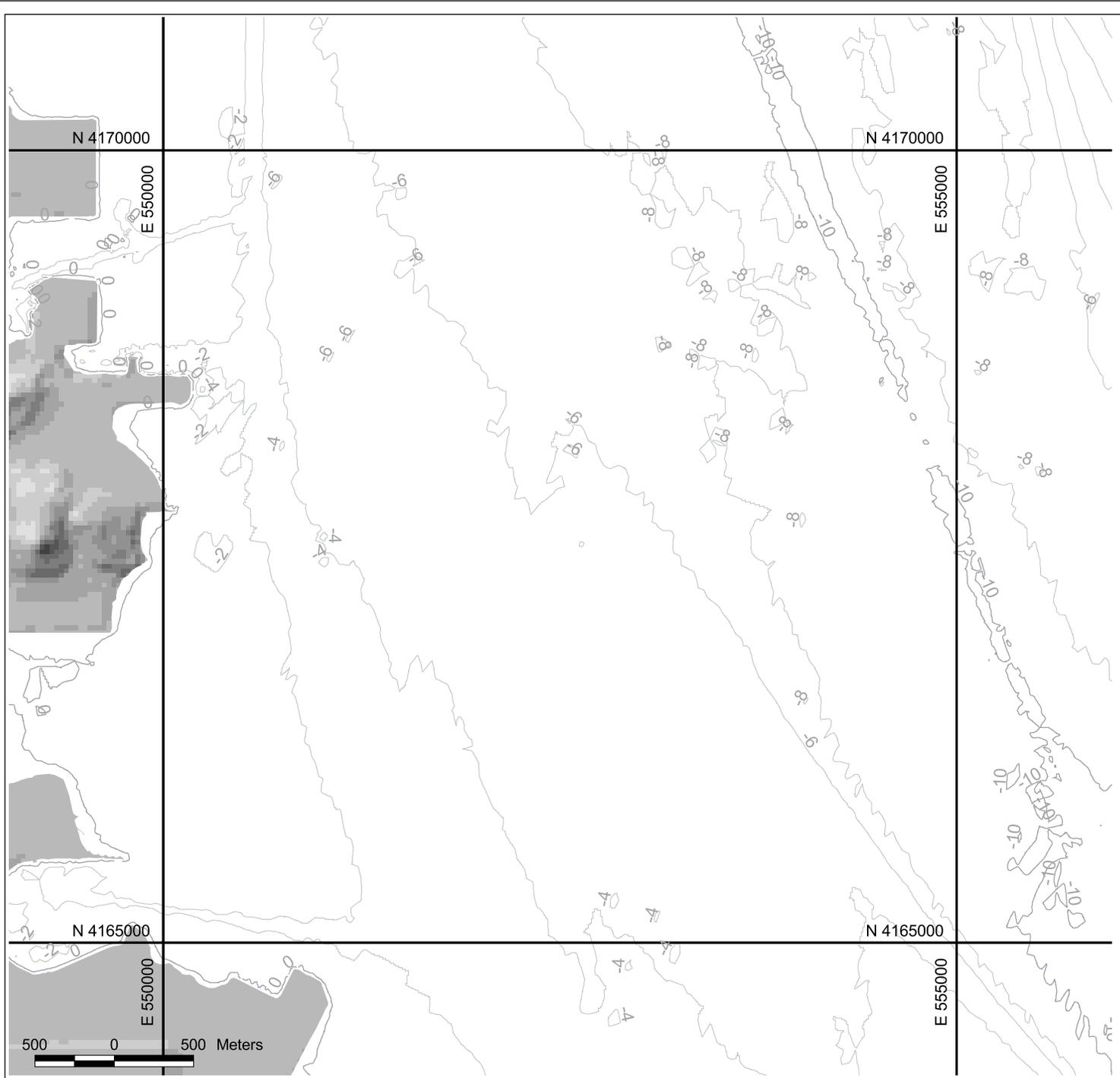
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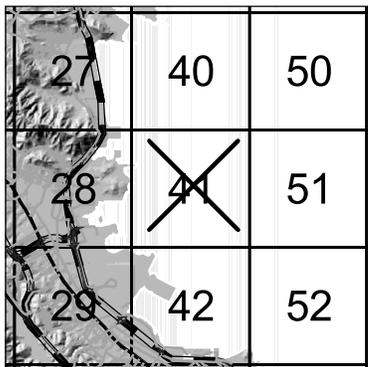
-  0 - 5 % Density
-  5 - 20 % Density
-  20 - 40 % Density
-  >40 % Density

-  Maximum Documented Eelgrass Extents
-  250m Buffer of Maximum Documented Eelgrass Extents

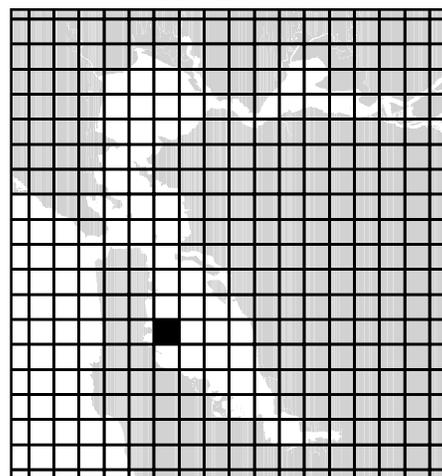




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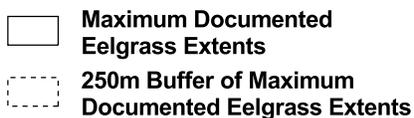


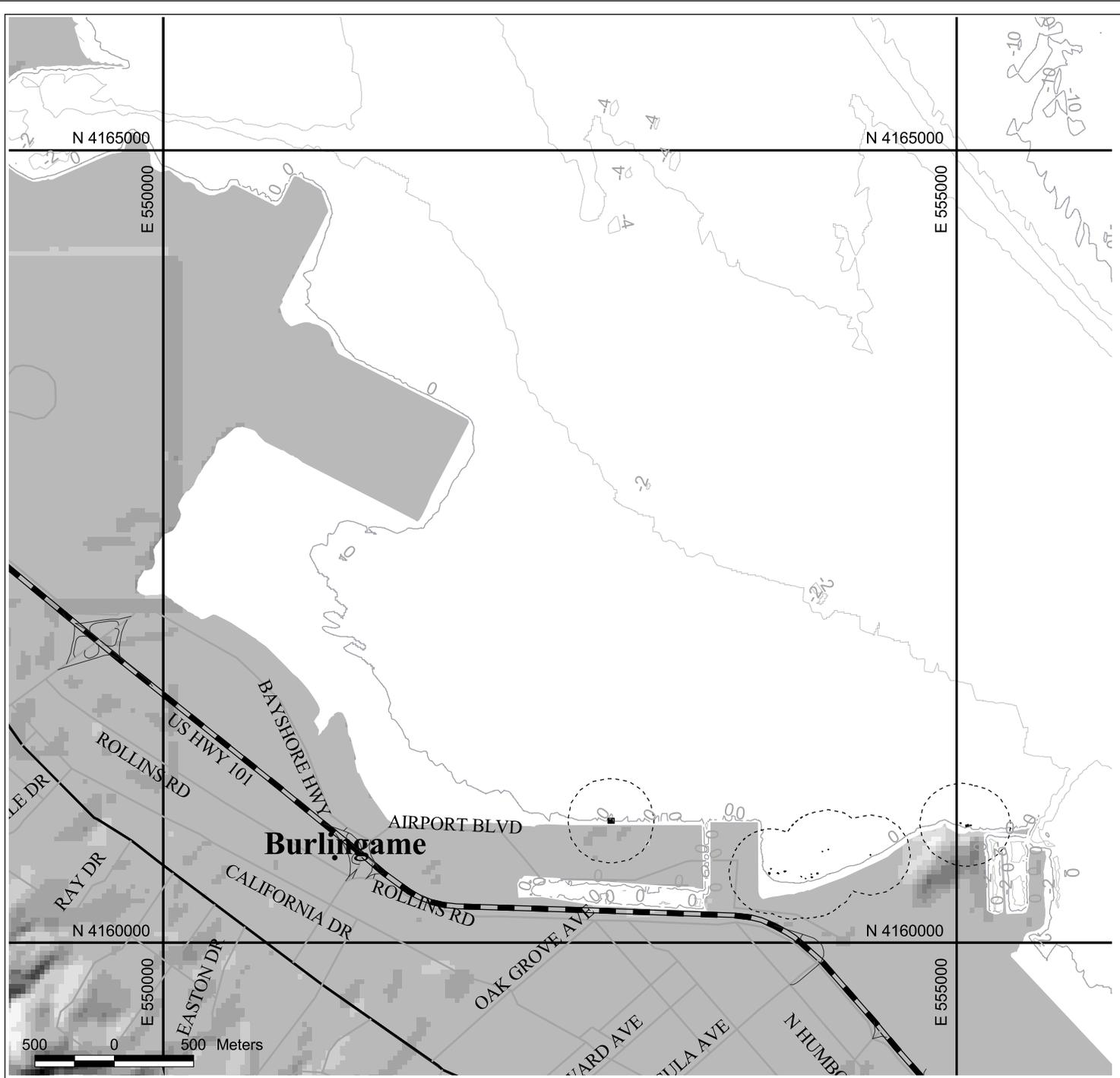
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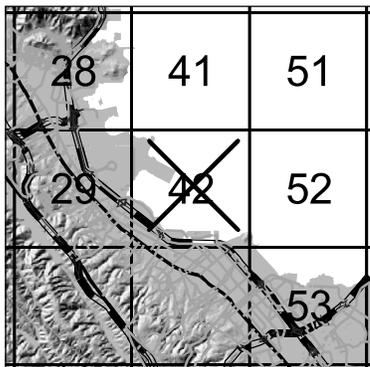
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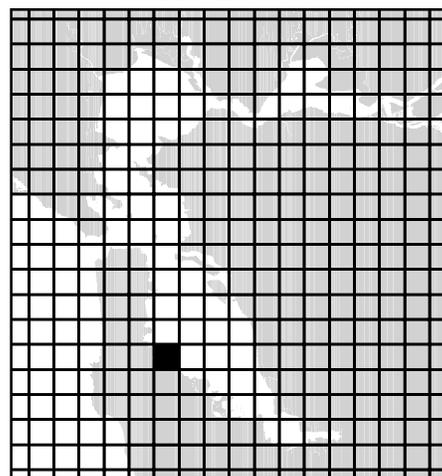




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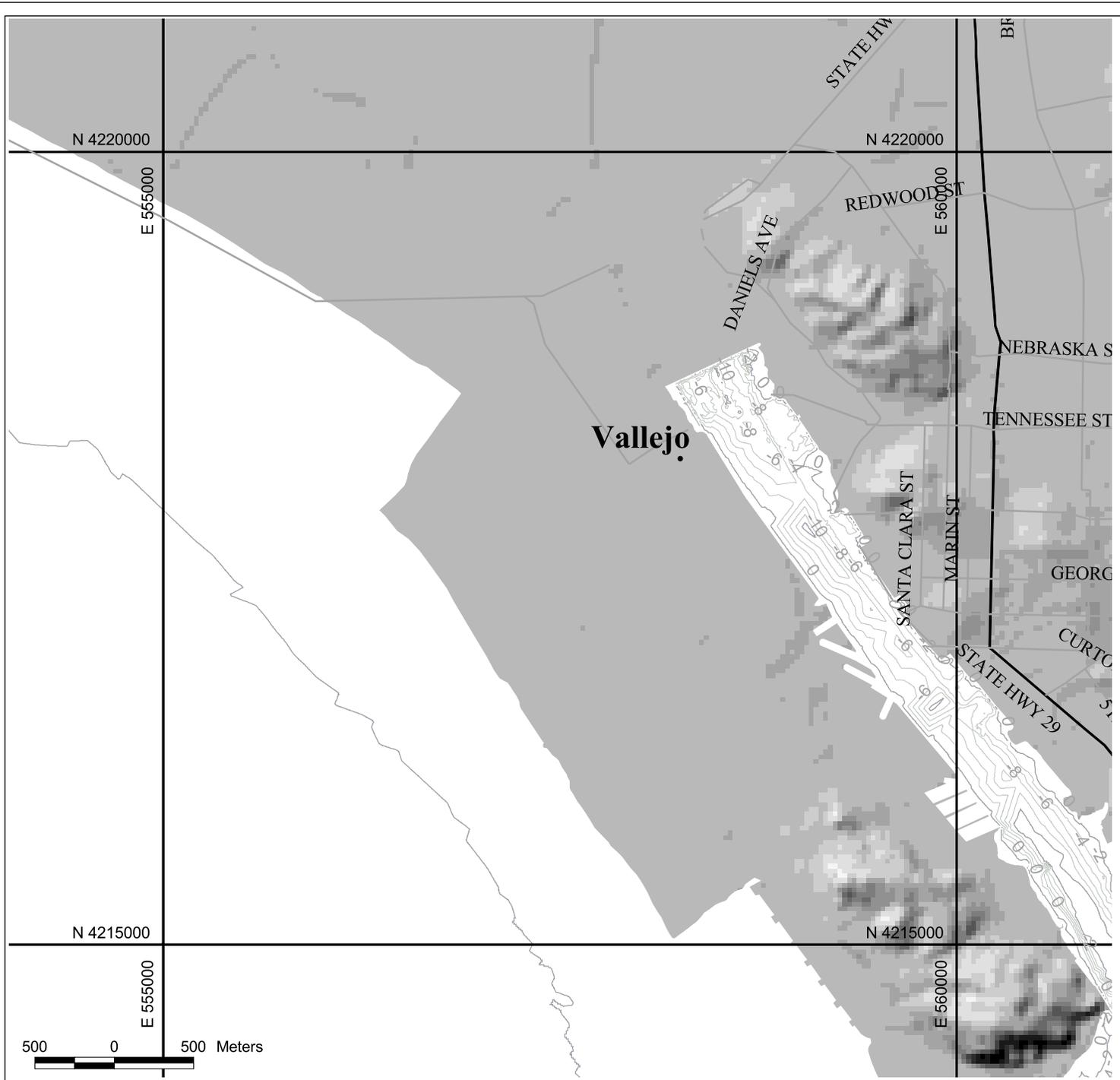
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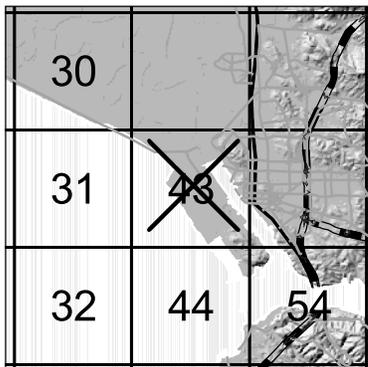
-  0 - 5 % Density
-  5 - 20 % Density
-  20 - 40 % Density
-  >40 % Density

-  Maximum Documented Eelgrass Extents
-  250m Buffer of Maximum Documented Eelgrass Extents

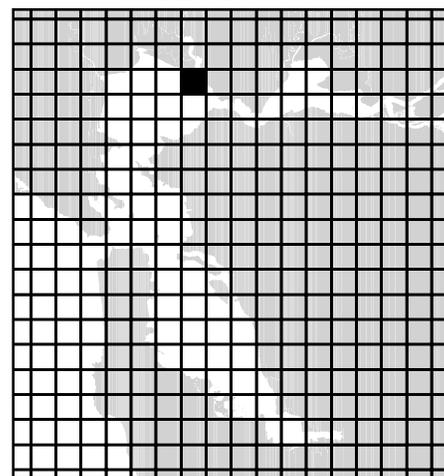




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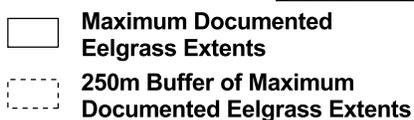


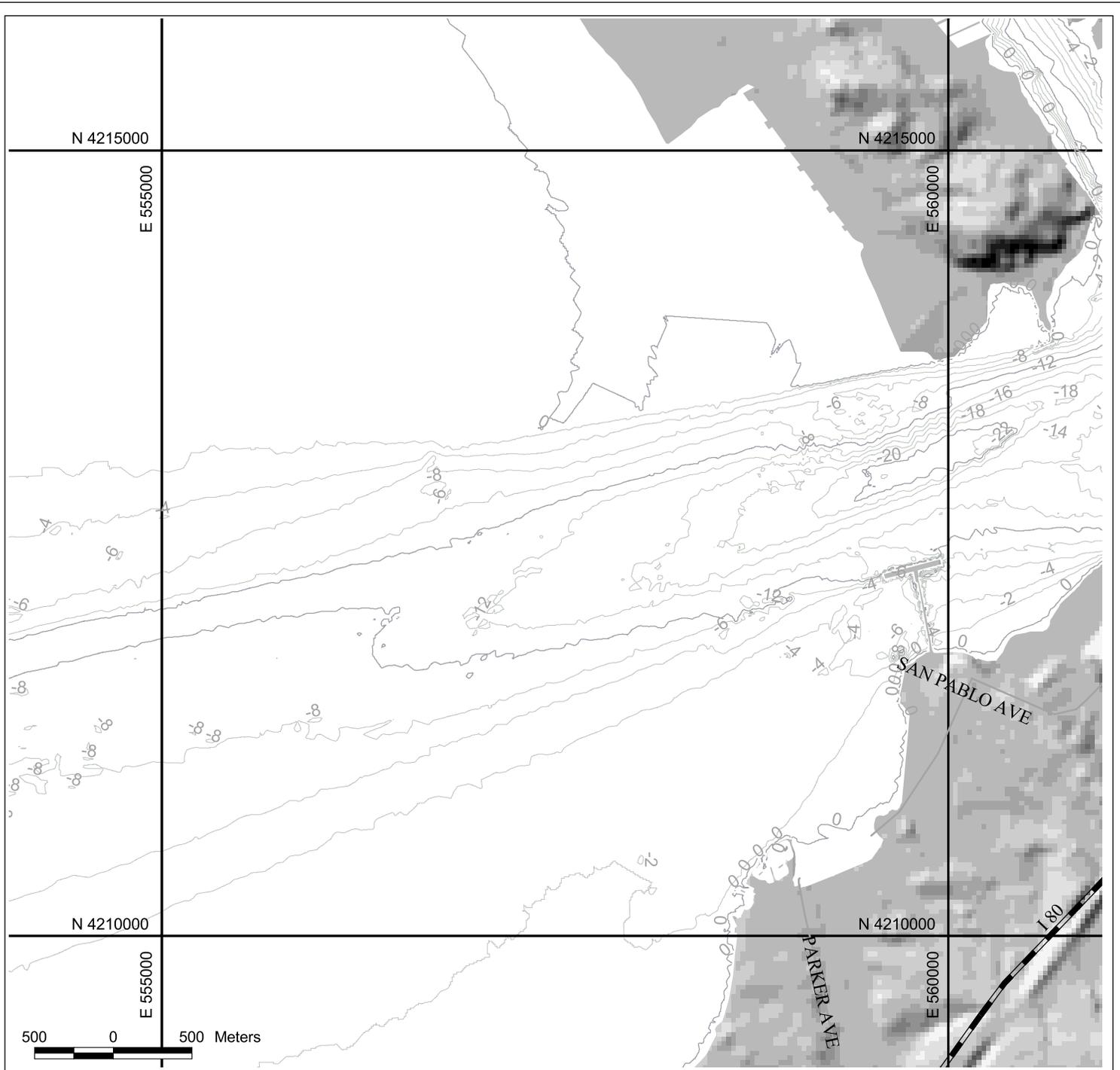
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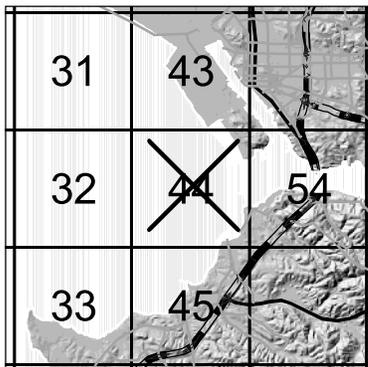
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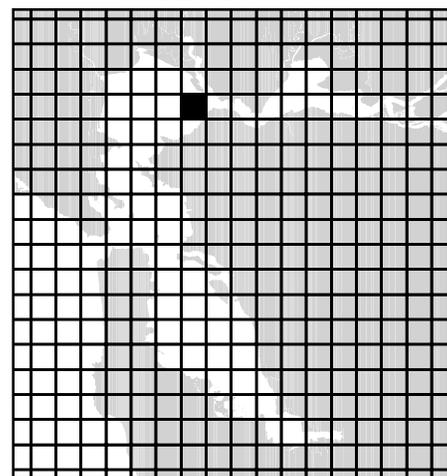




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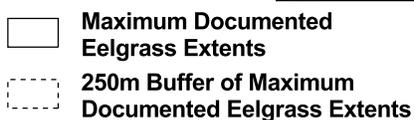


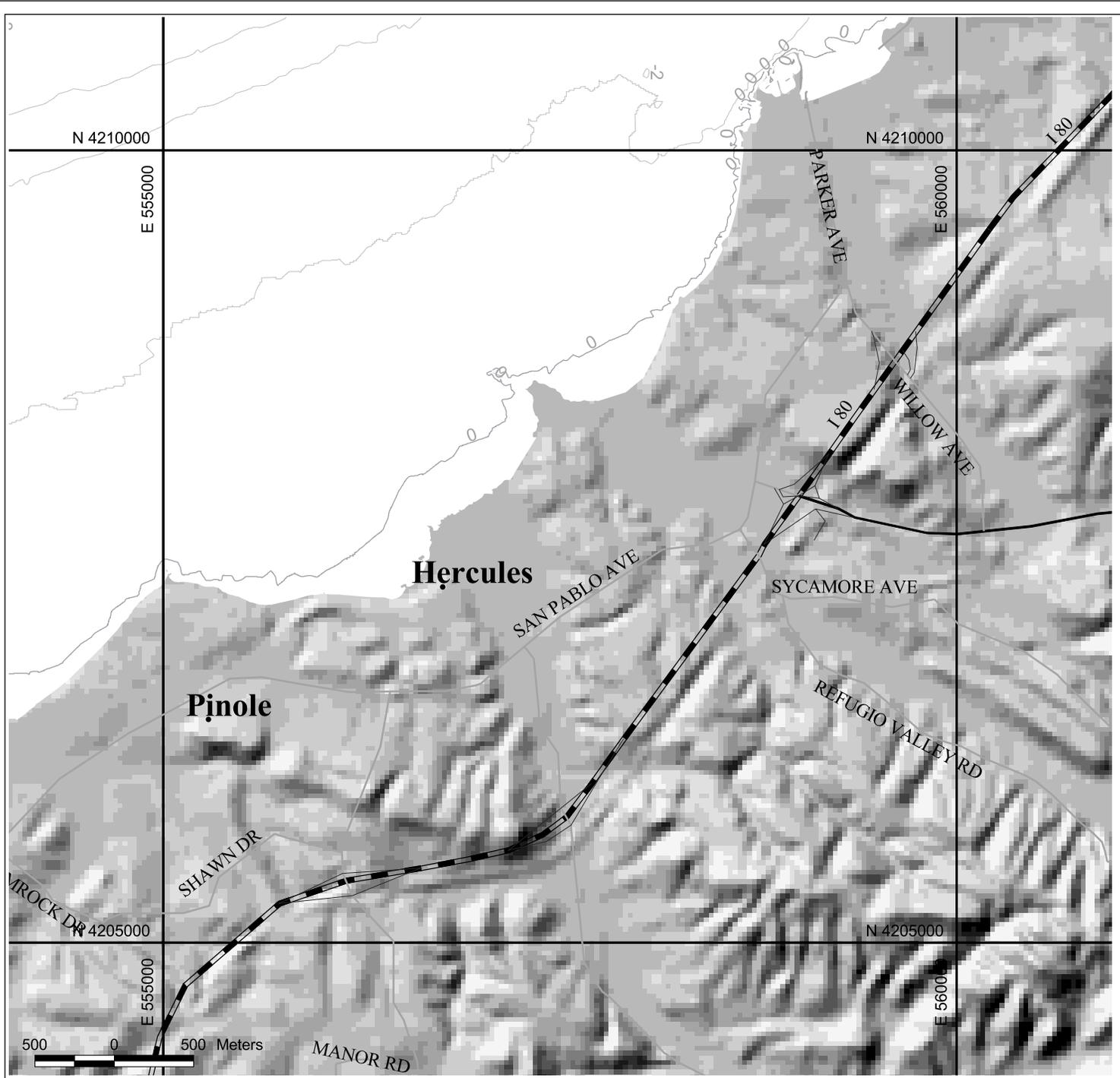
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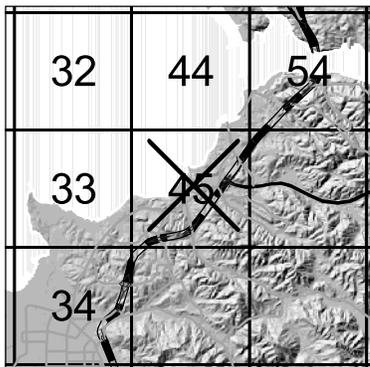
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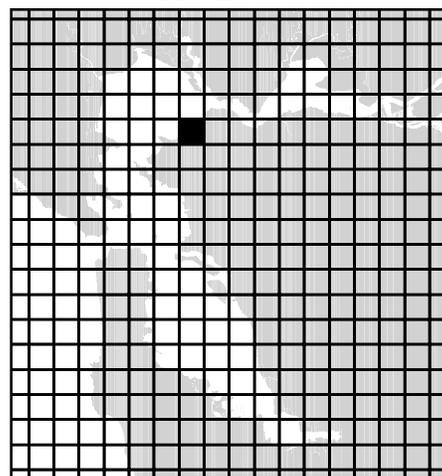




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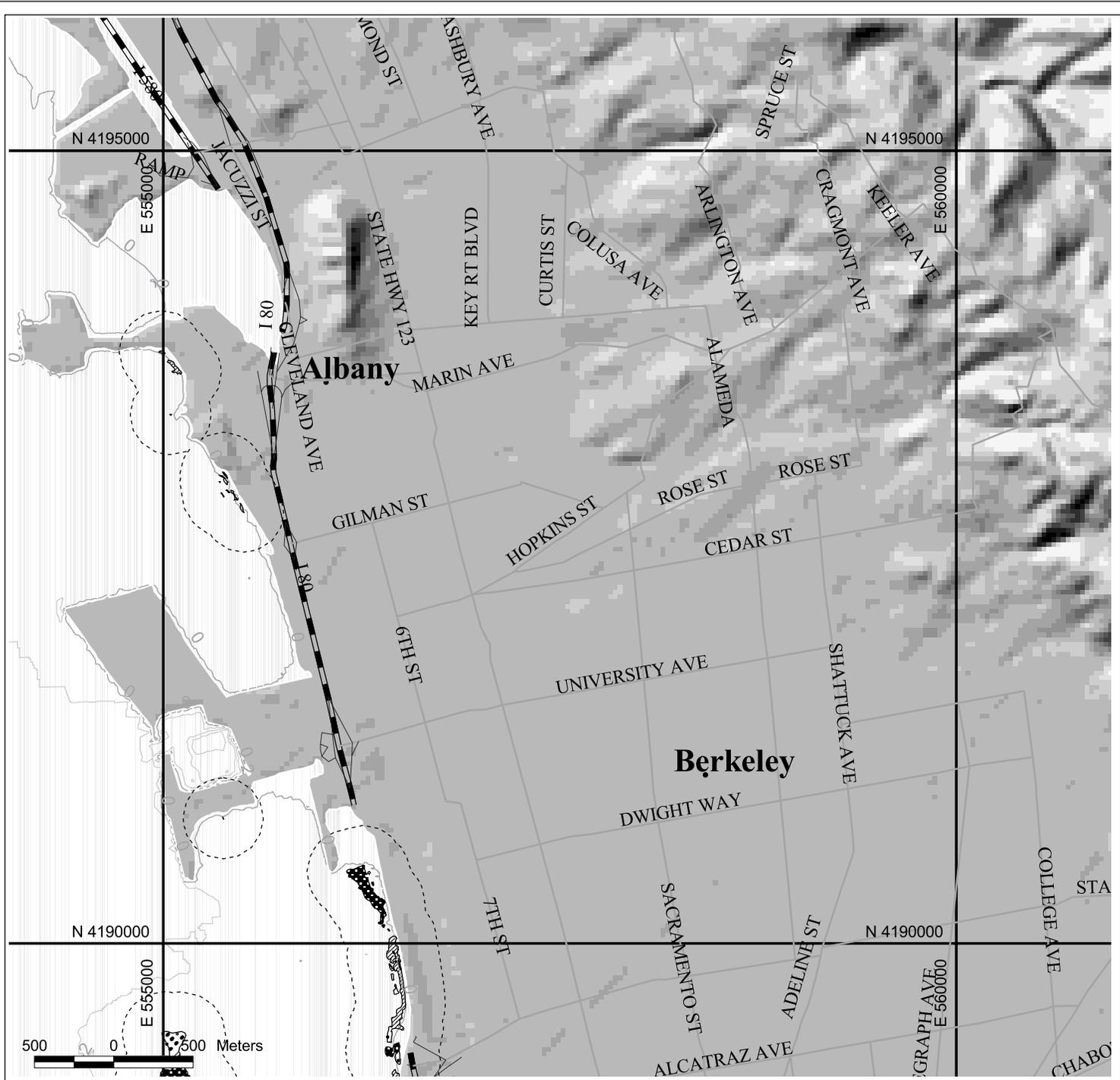
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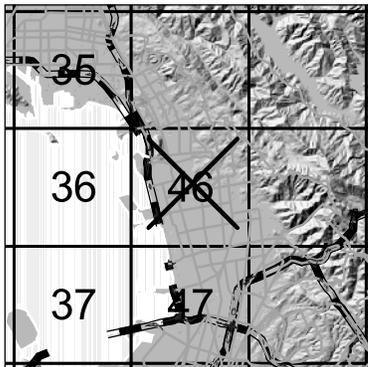
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- | | | | |
|---|--------------------------|---|---|
|  | 0 - 5 % Density |  | Maximum Documented Eelgrass Extents |
|  | 5 - 20 % Density |  | 250m Buffer of Maximum Documented Eelgrass Extents |
|  | 20 - 40 % Density | | |
|  | >40 % Density | | |

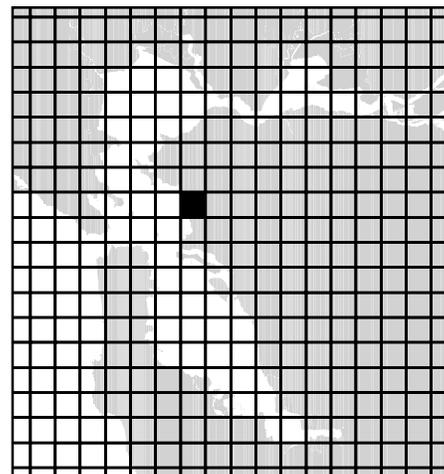




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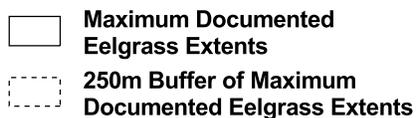


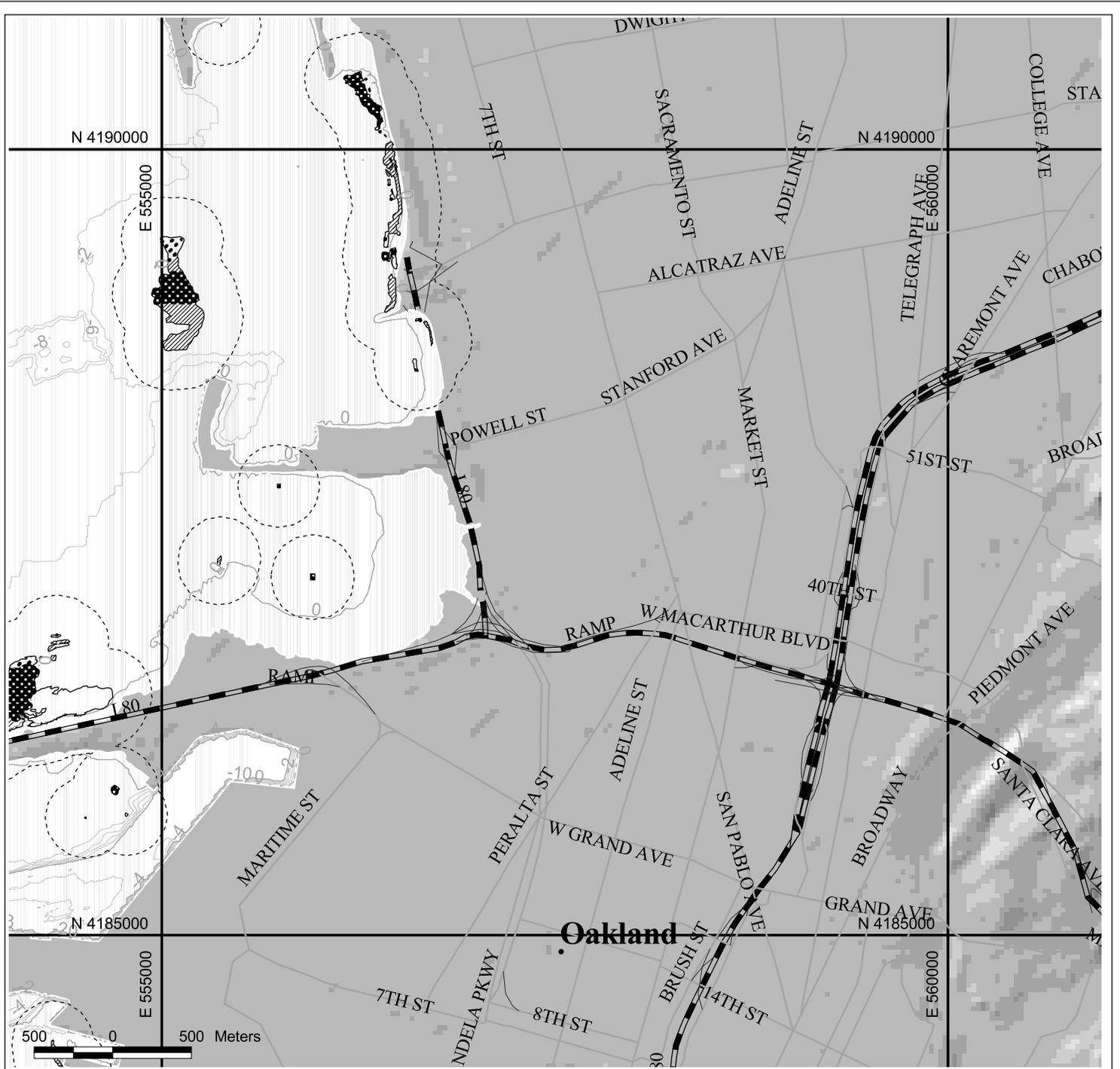
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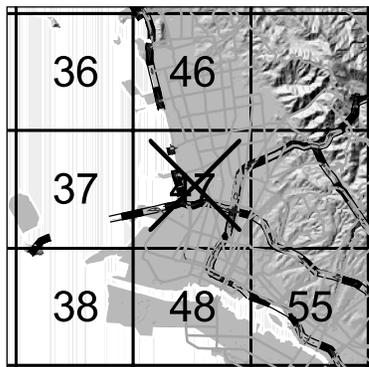
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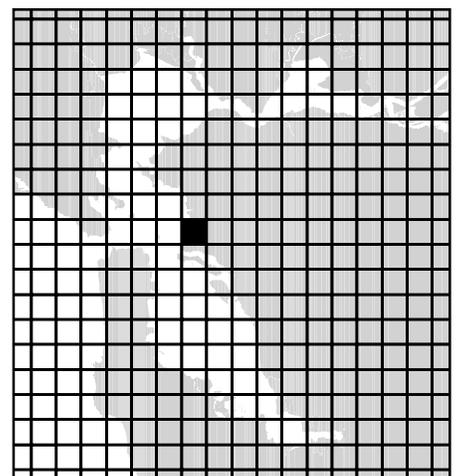




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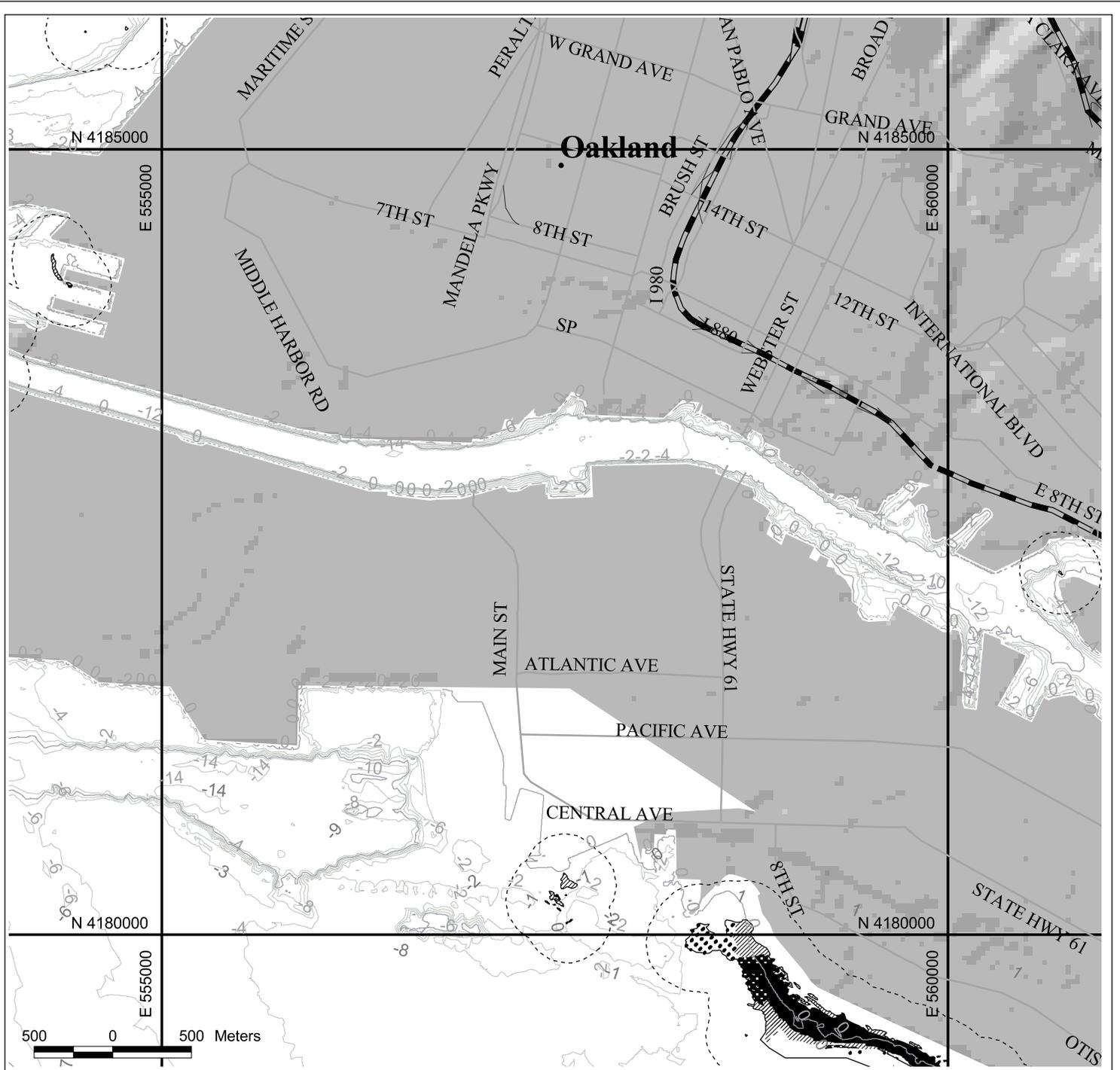
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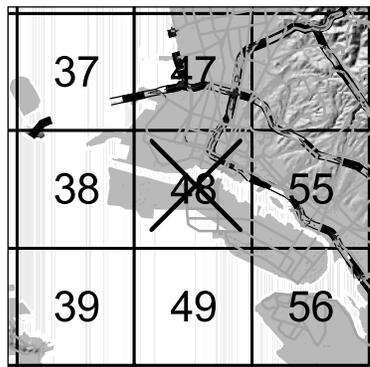
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- | | | | |
|--|-------------------|--|--|
| | 0 - 5 % Density | | Maximum Documented Eelgrass Extents |
| | 5 - 20 % Density | | 250m Buffer of Maximum Documented Eelgrass Extents |
| | 20 - 40 % Density | | |
| | >40 % Density | | |

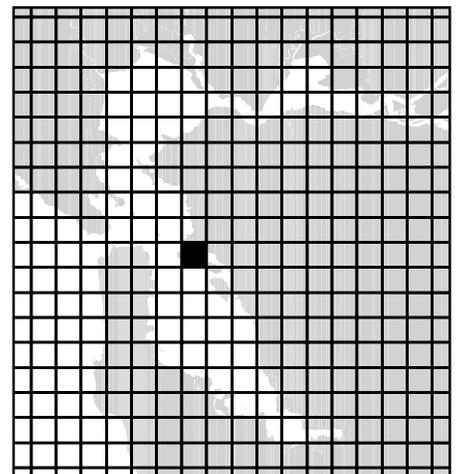




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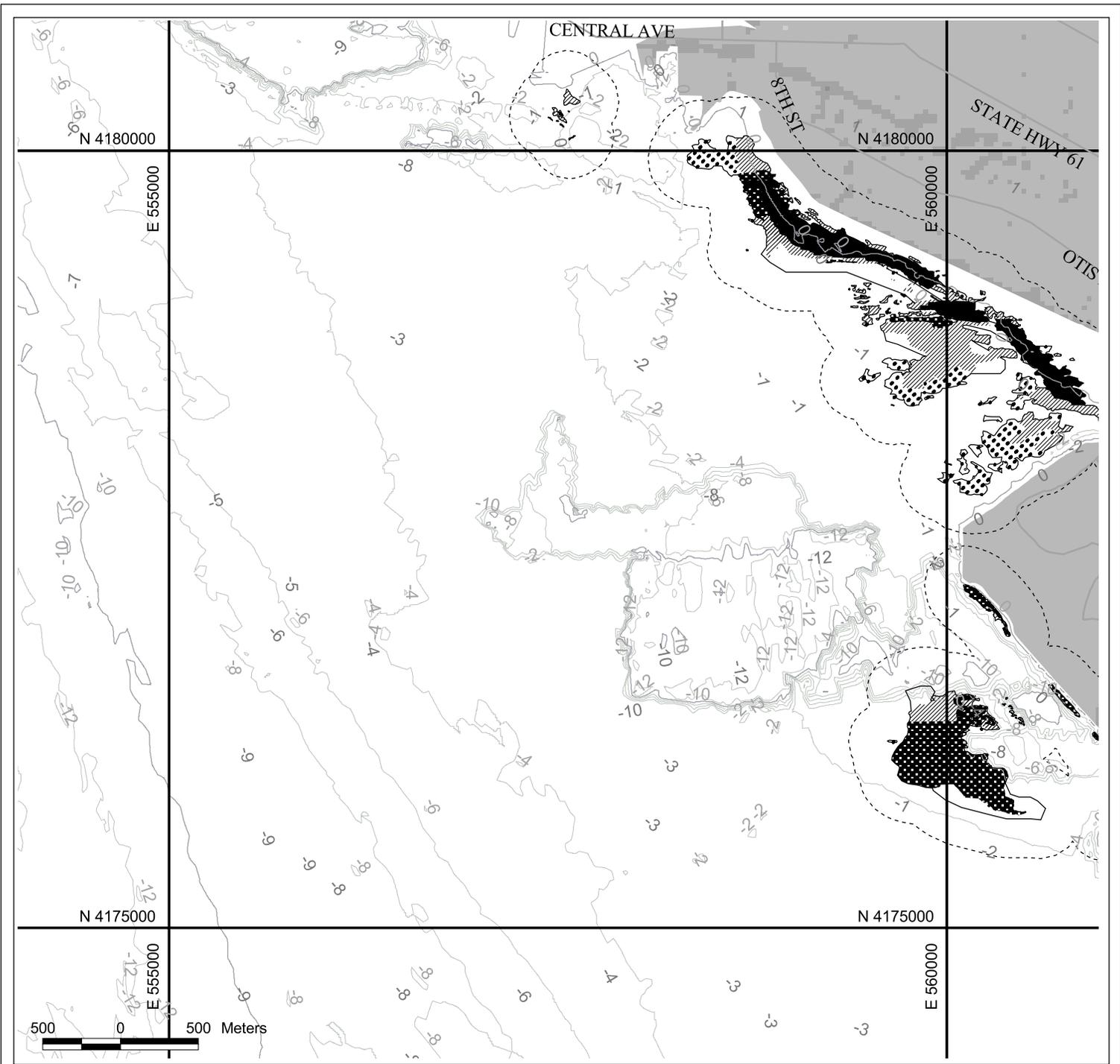
Merkel & Associates, Inc.
San Diego, California Tel: (858) 560-5465

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Vertical Datum: MLLW (meters)

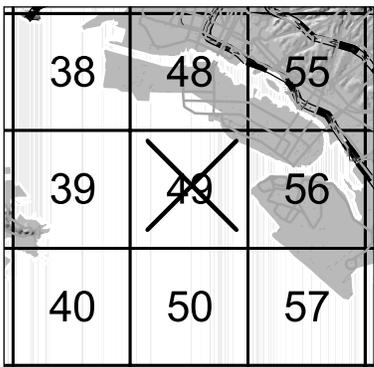
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- | | | | |
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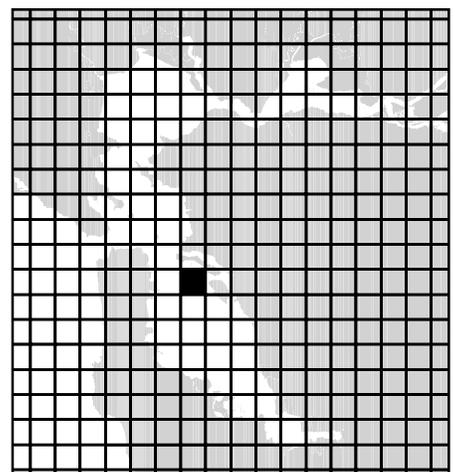




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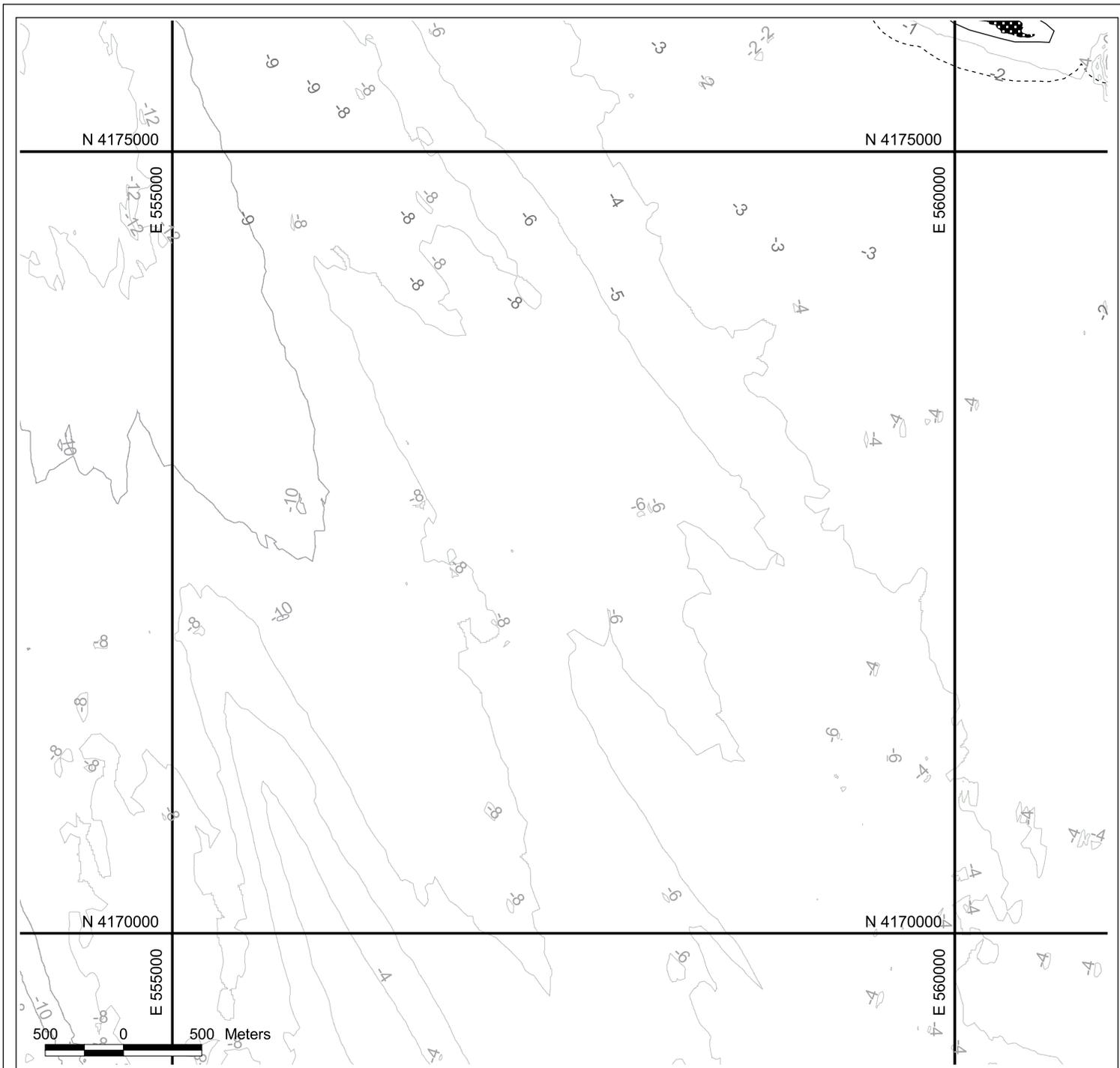
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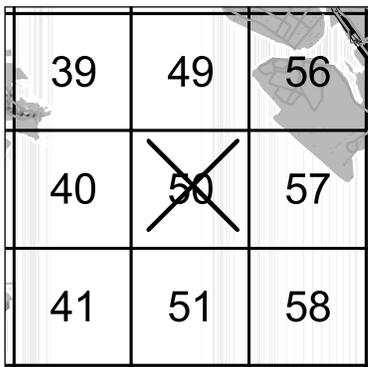
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- 0 - 5 % Density
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- >40 % Density
- Maximum Documented Eelgrass Extents
- 250m Buffer of Maximum Documented Eelgrass Extents

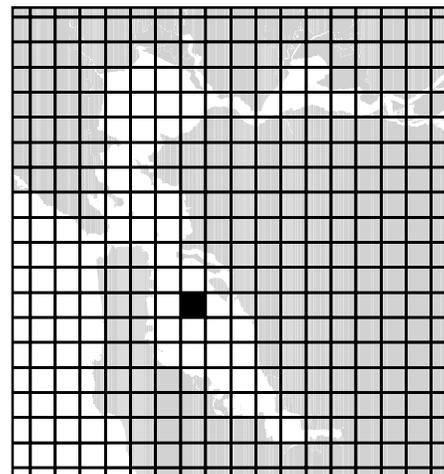




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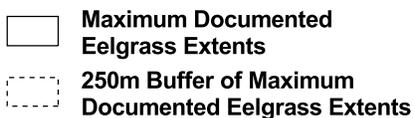


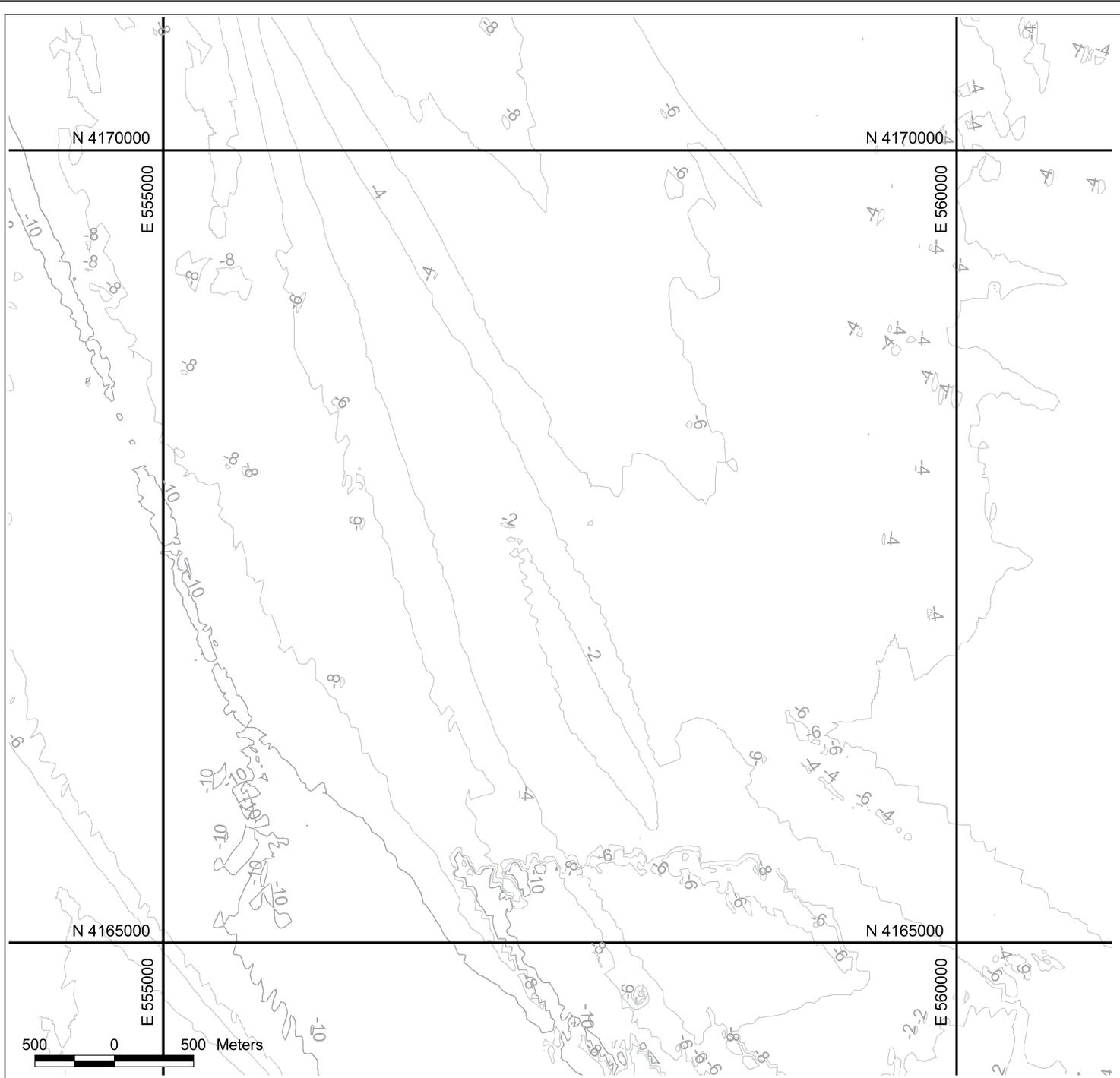
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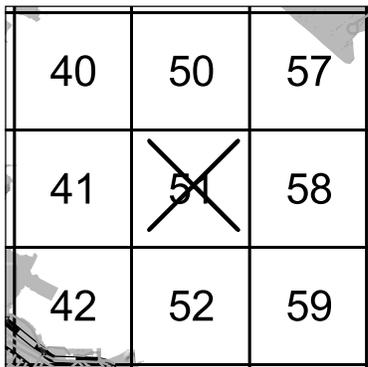
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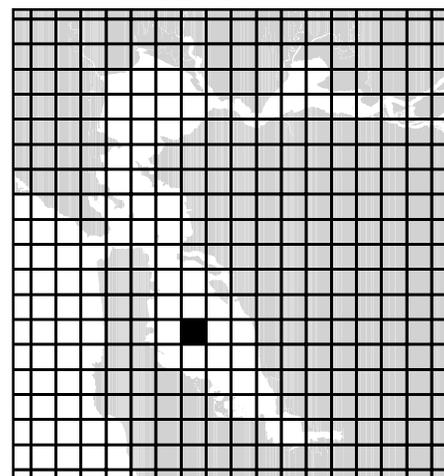




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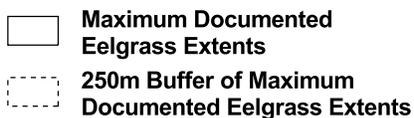


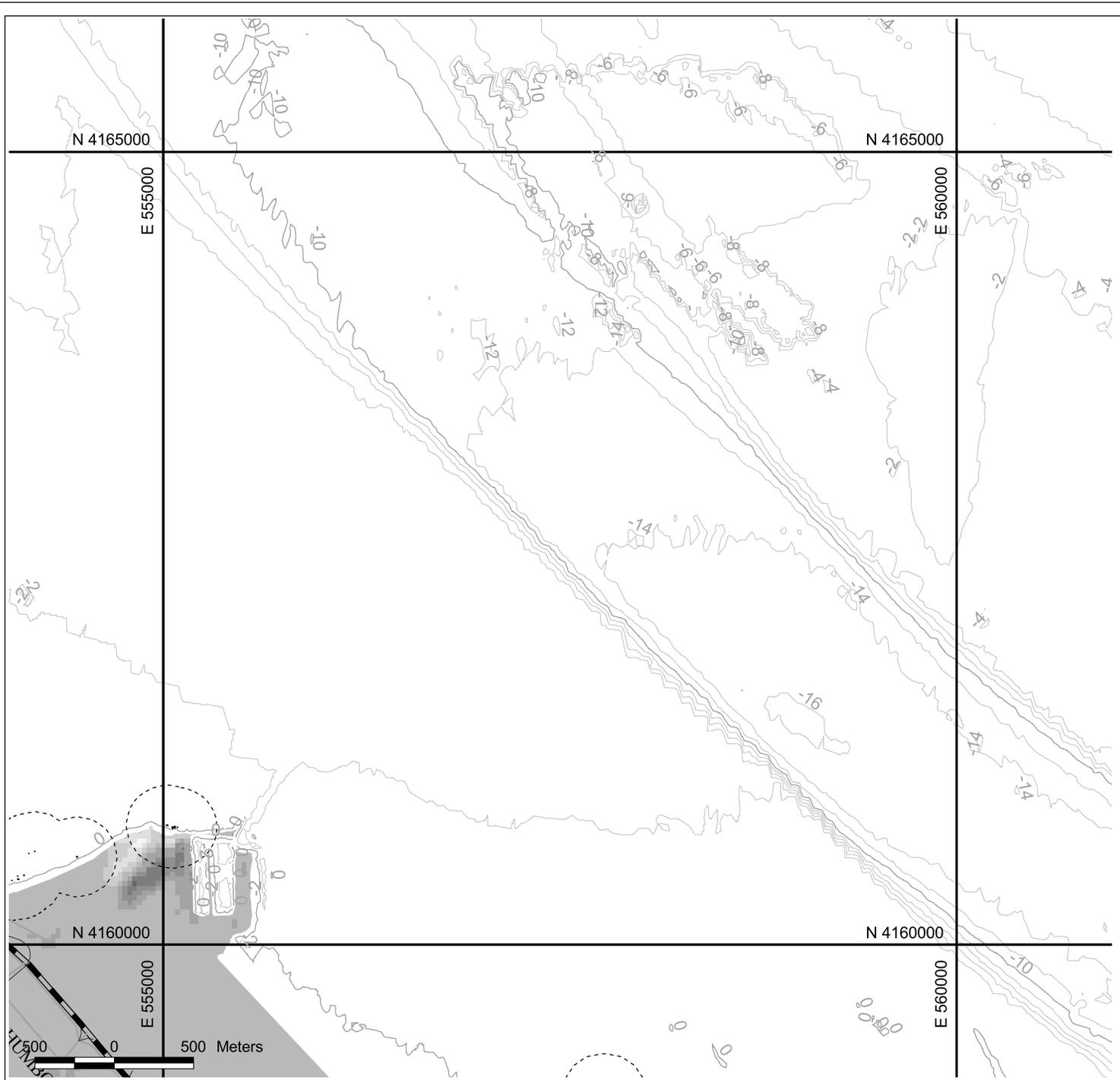
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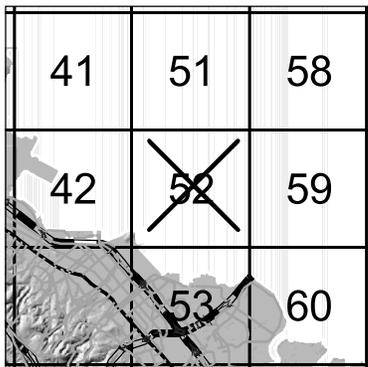
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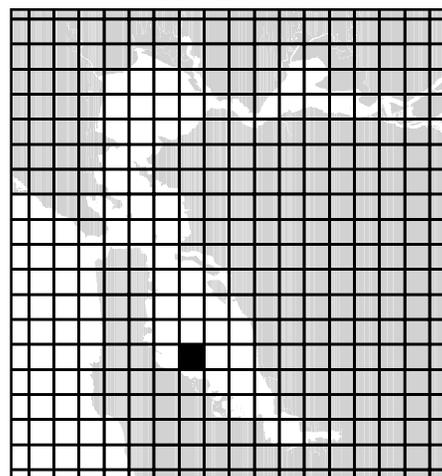




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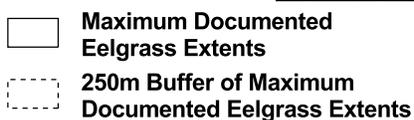
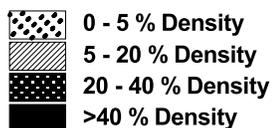


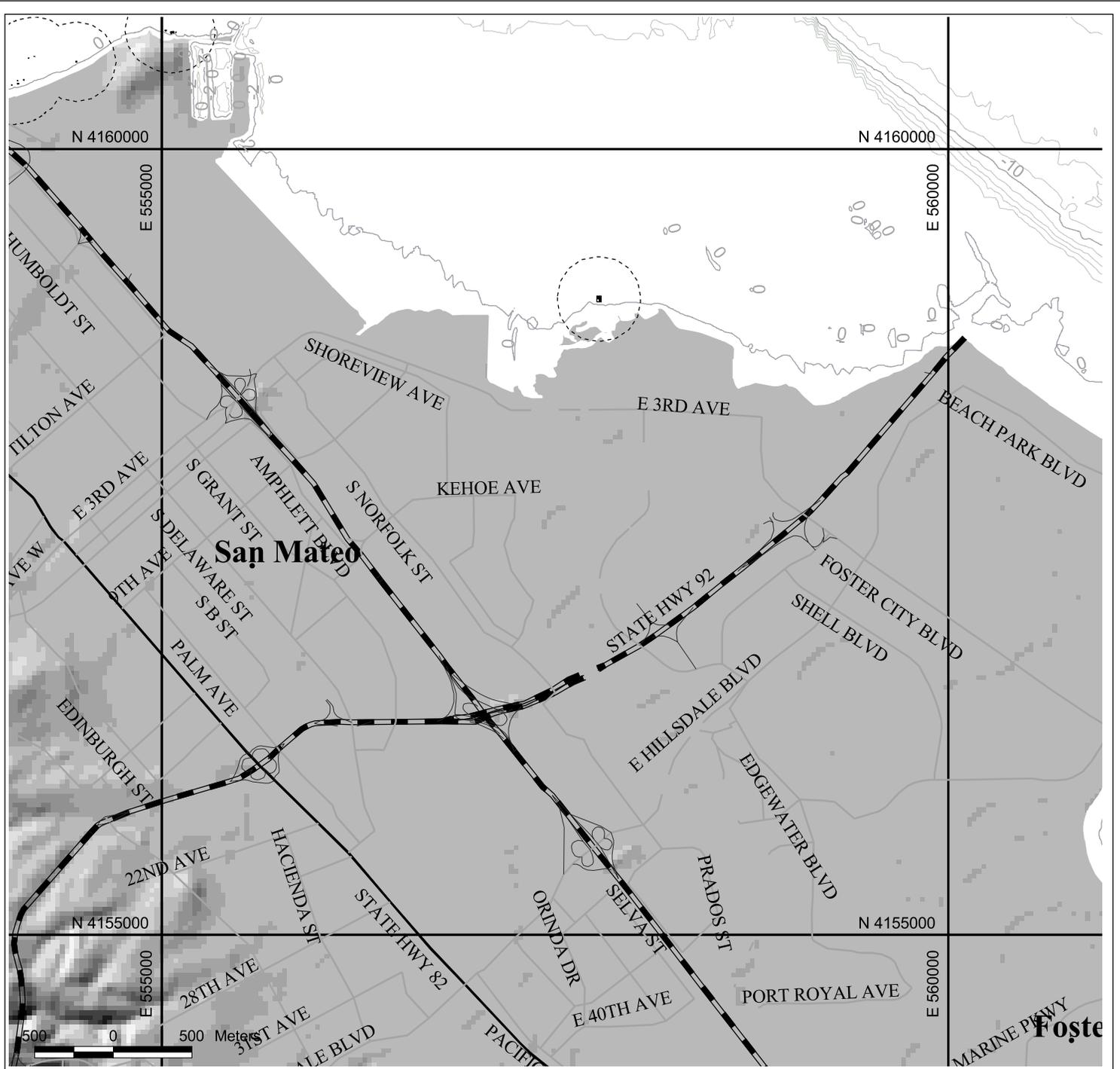
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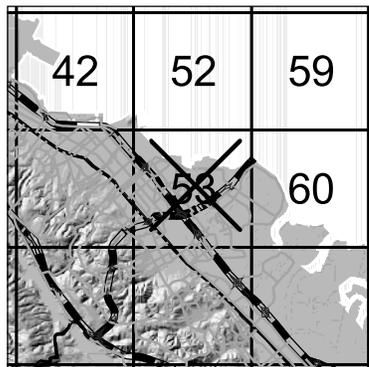
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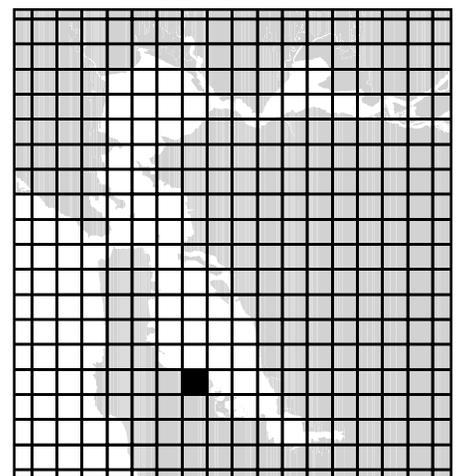




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SAN FRANCISCO BAY, CALIFORNIA
Eelgrass 2003

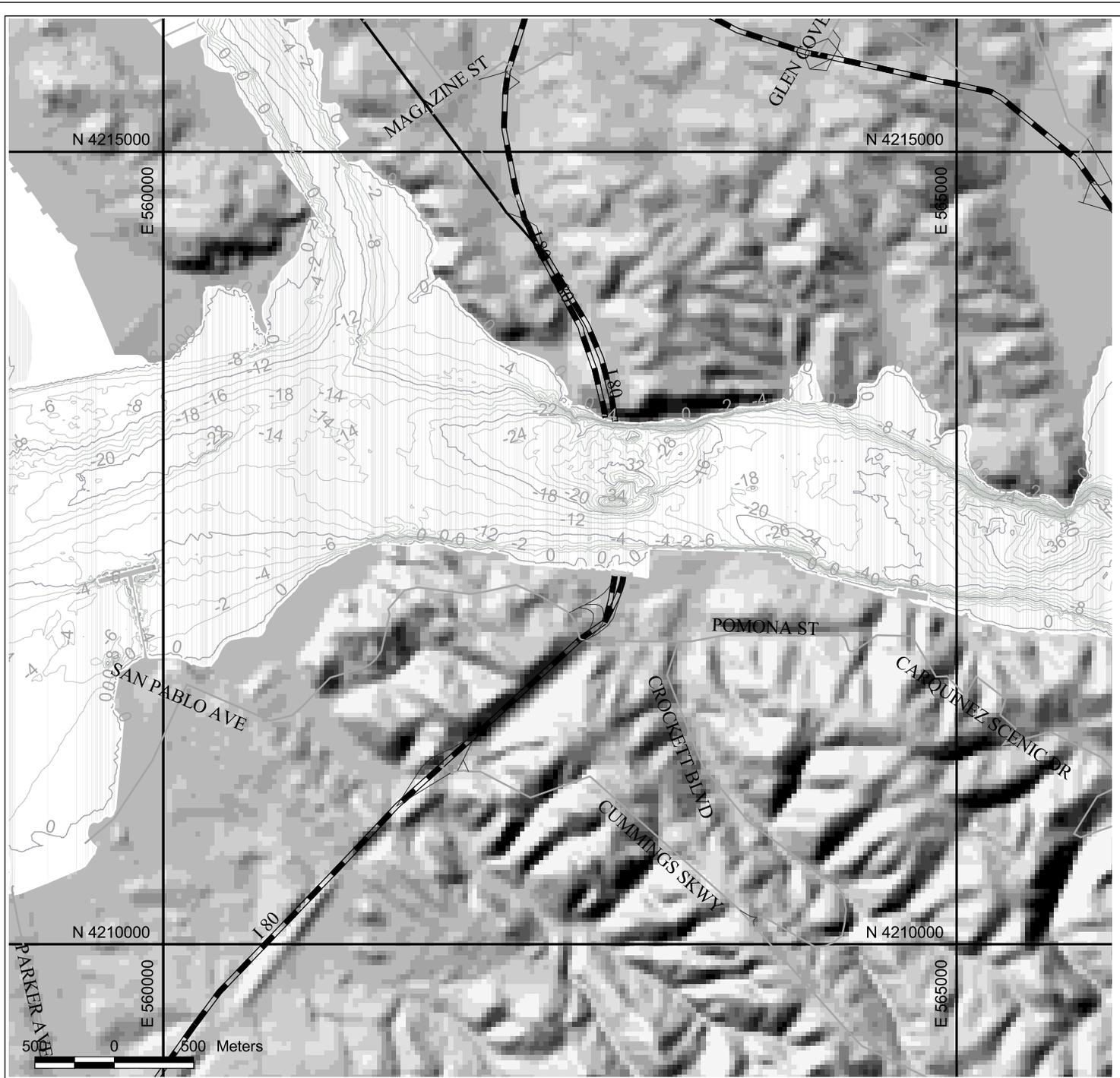
Merkel & Associates, Inc.
San Diego, California Tel: (858) 560-5465

Horizontal Datum: UTM 10N NAD1983 (meters)
Vertical Datum: MLLW (meters)

Note: Charts are for planning and management purposes only. Information application is limited by survey scale and some error is expected. Information is not to be used for navigation or specific project applications.

- 0 - 5 % Density
- 5 - 20 % Density
- 20 - 40 % Density
- >40 % Density
- Maximum Documented Eelgrass Extents
- 250m Buffer of Maximum Documented Eelgrass Extents





SAN FRANCISCO BAY, CALIFORNIA
Eelgrass 2003

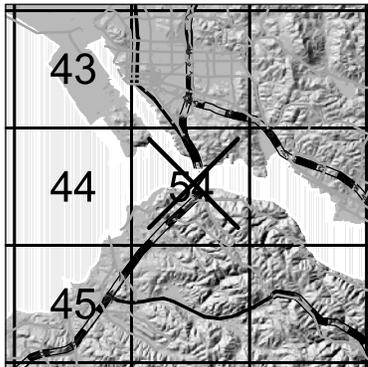
Merkel & Associates, Inc.
 San Diego, California Tel: (858) 560-5465

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 Vertical Datum: MLLW (meters)

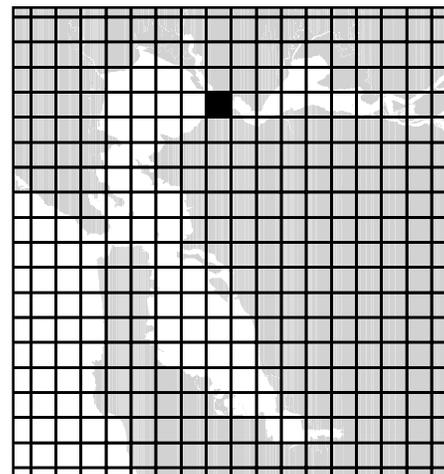
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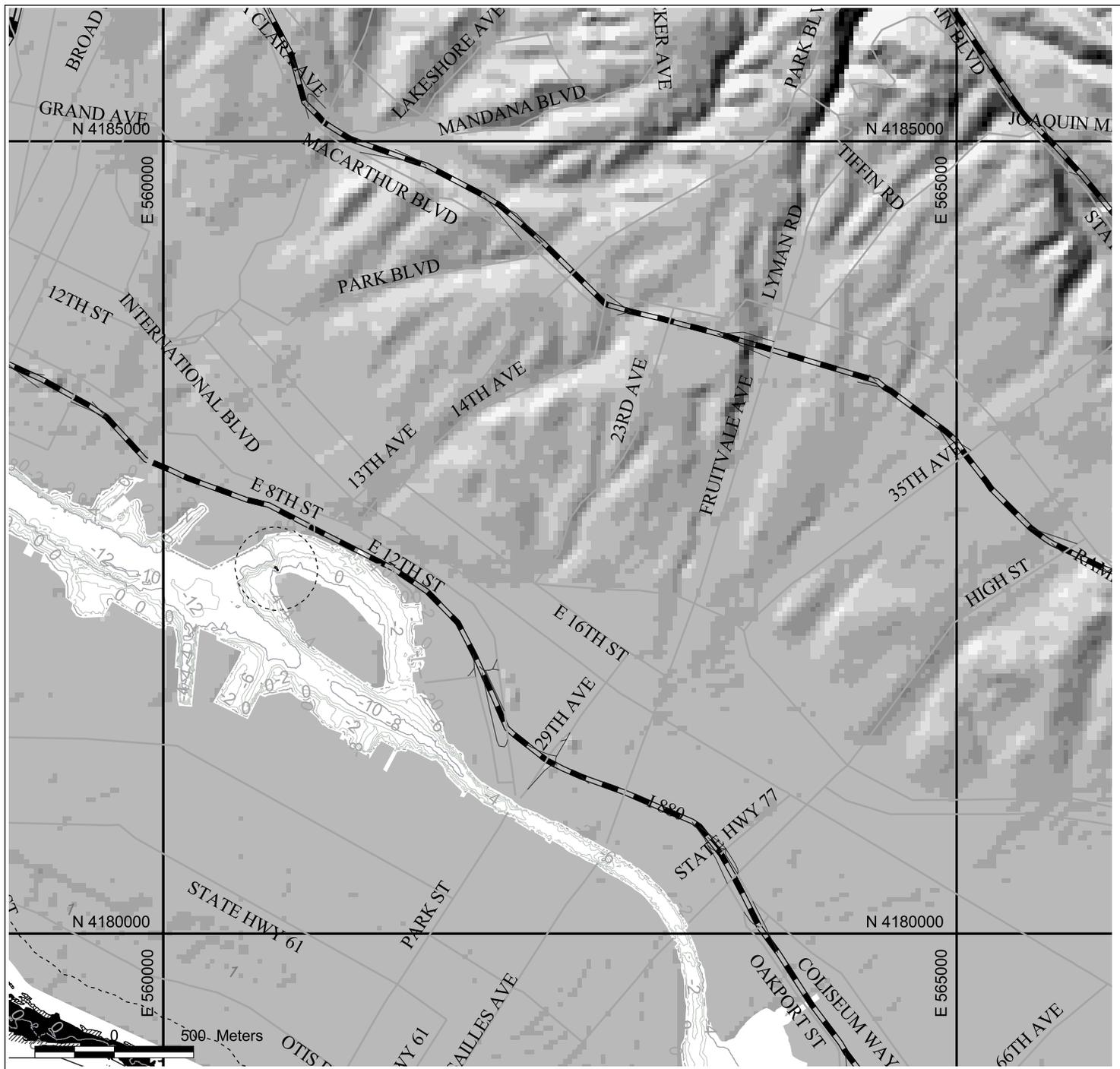


SHEET VICINITY

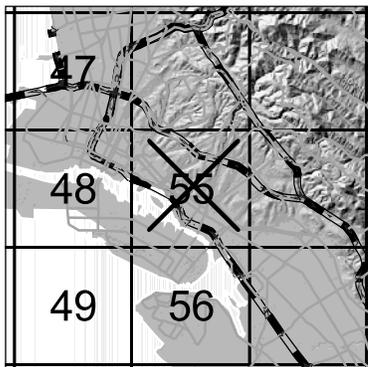


SHEET LOCATOR

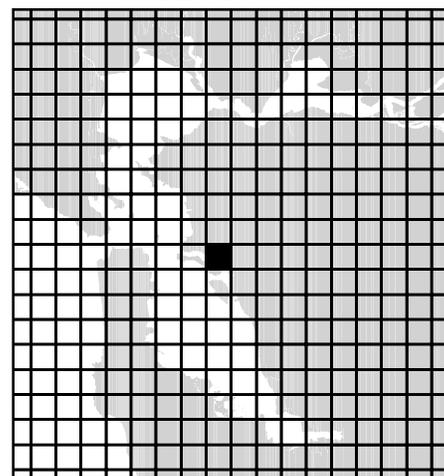




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SHEET LOCATOR



**SAN FRANCISCO BAY, CALIFORNIA
Eelgrass 2003**

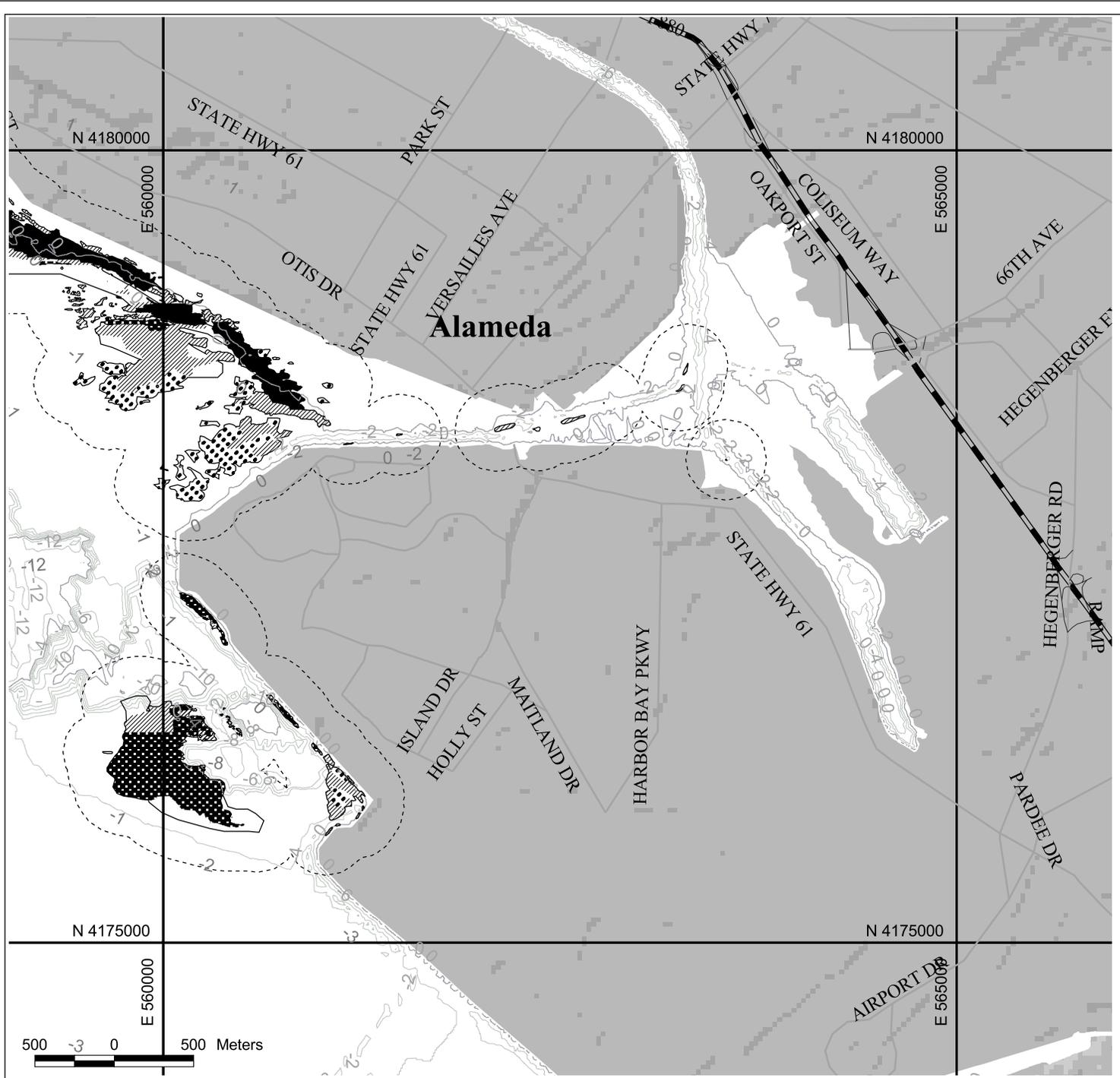
Merkel & Associates, Inc.
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Horizontal Datum: UTM 10N NAD1983 (meters)
Vertical Datum: MLLW (meters)

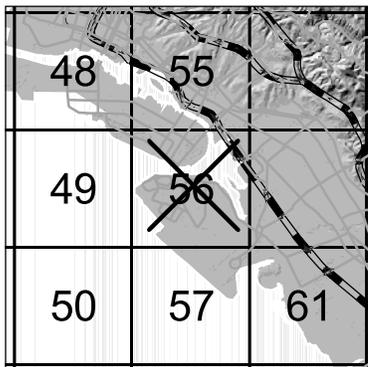
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- | | | | |
|---|--------------------------|---|---|
|  | 0 - 5 % Density |  | Maximum Documented Eelgrass Extents |
|  | 5 - 20 % Density |  | 250m Buffer of Maximum Documented Eelgrass Extents |
|  | 20 - 40 % Density | | |
|  | >40 % Density | | |

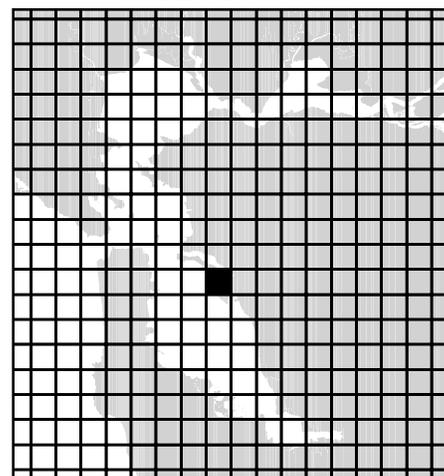




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SHEET LOCATOR



**SAN FRANCISCO BAY, CALIFORNIA
Eelgrass 2003**

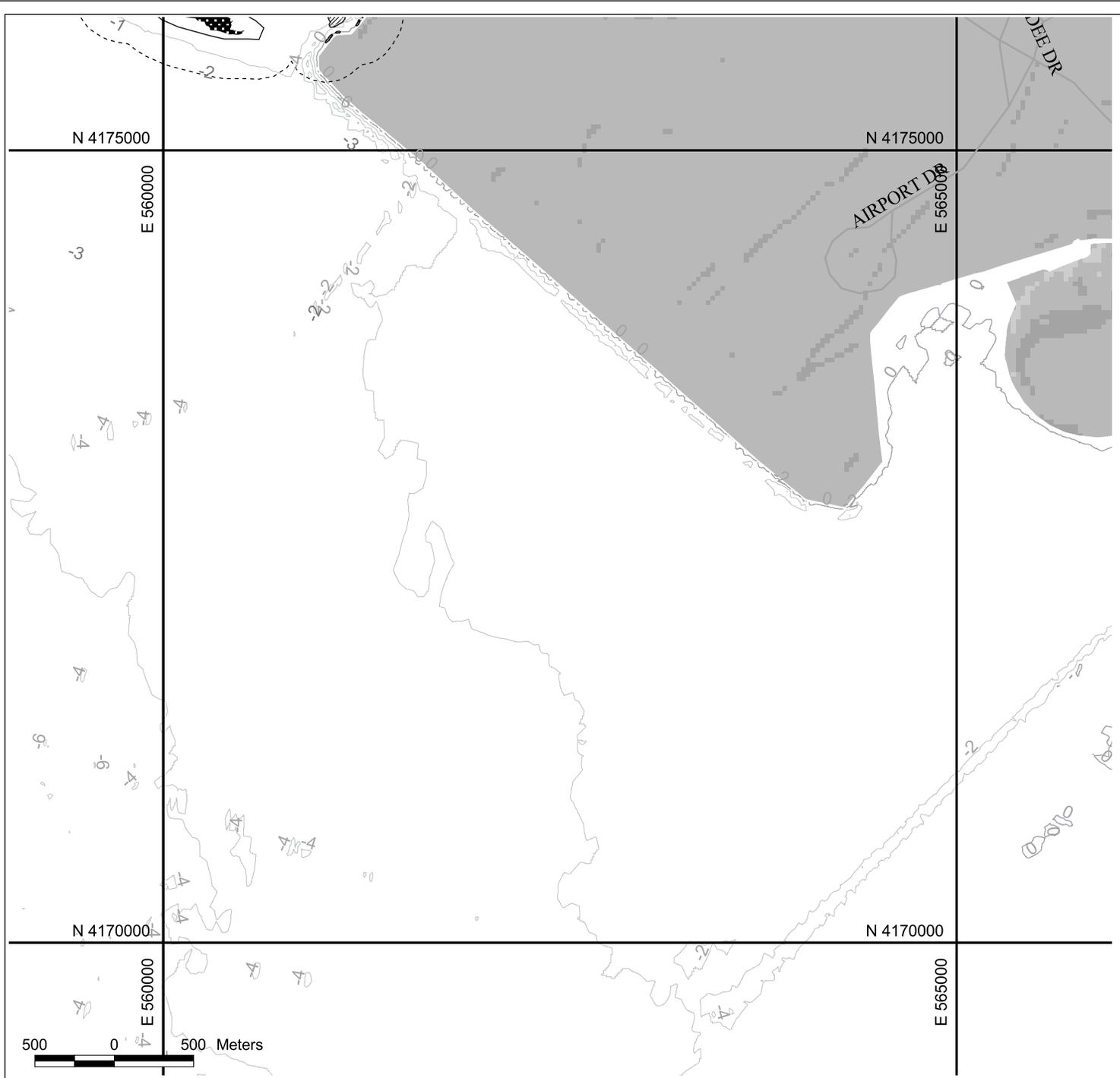
Merkel & Associates, Inc.
San Diego, California Tel: (858) 560-5465

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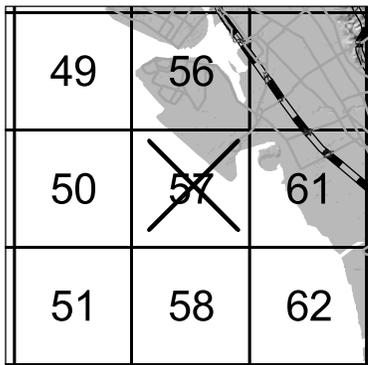
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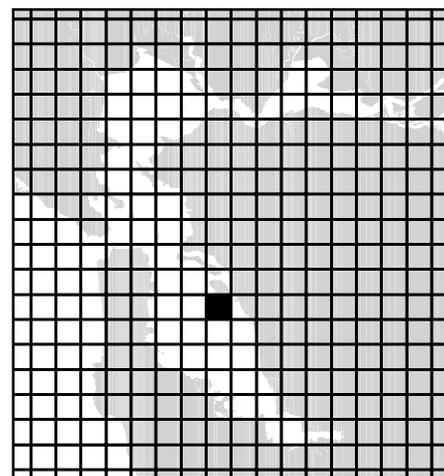




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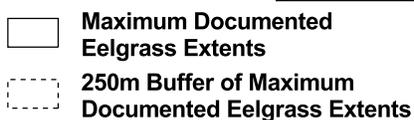


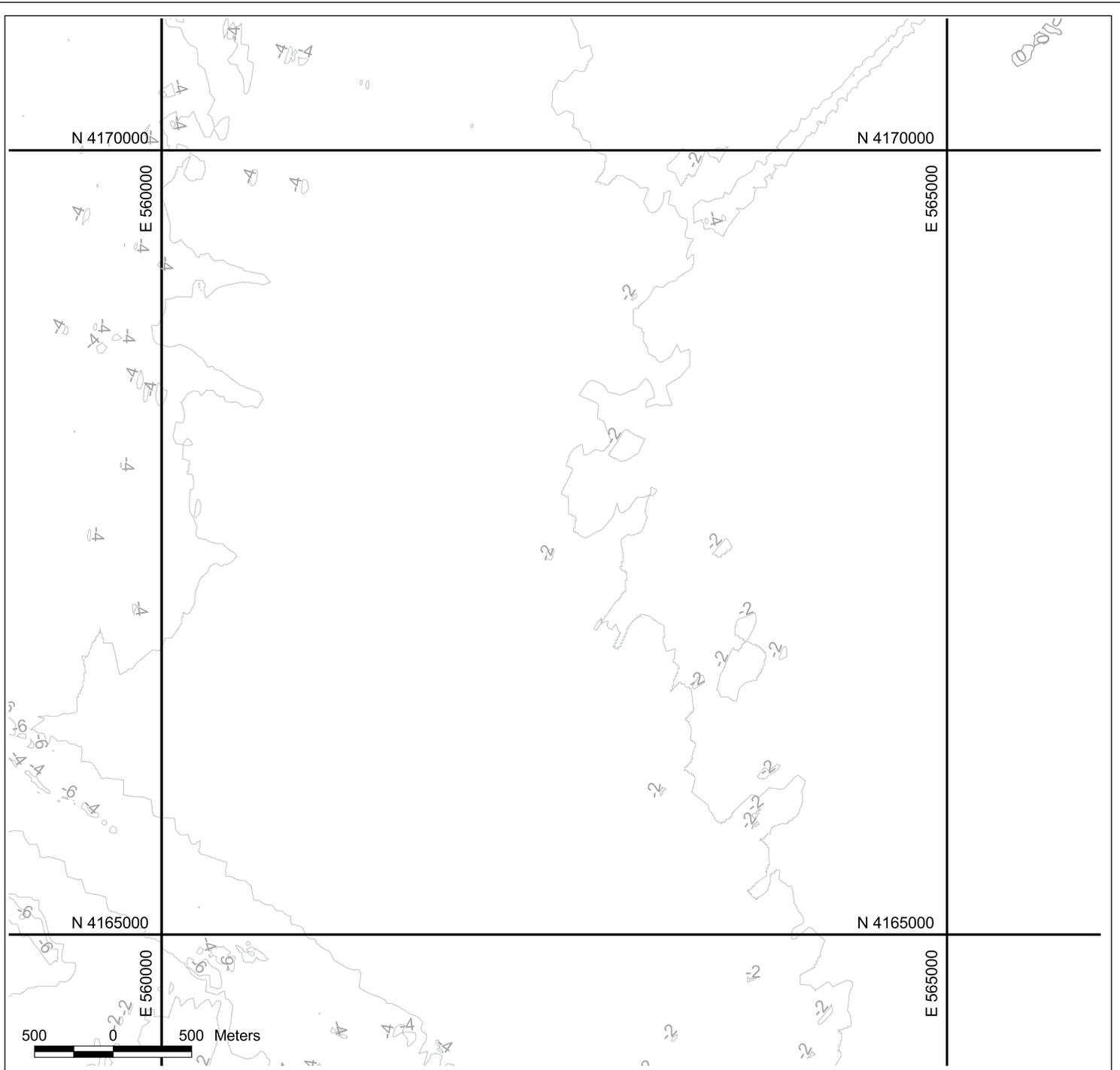
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Eelgrass 2003**

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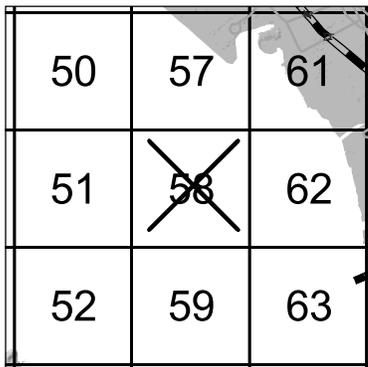
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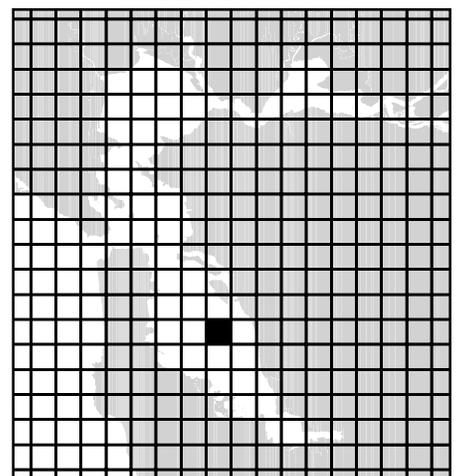




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SHEET LOCATOR



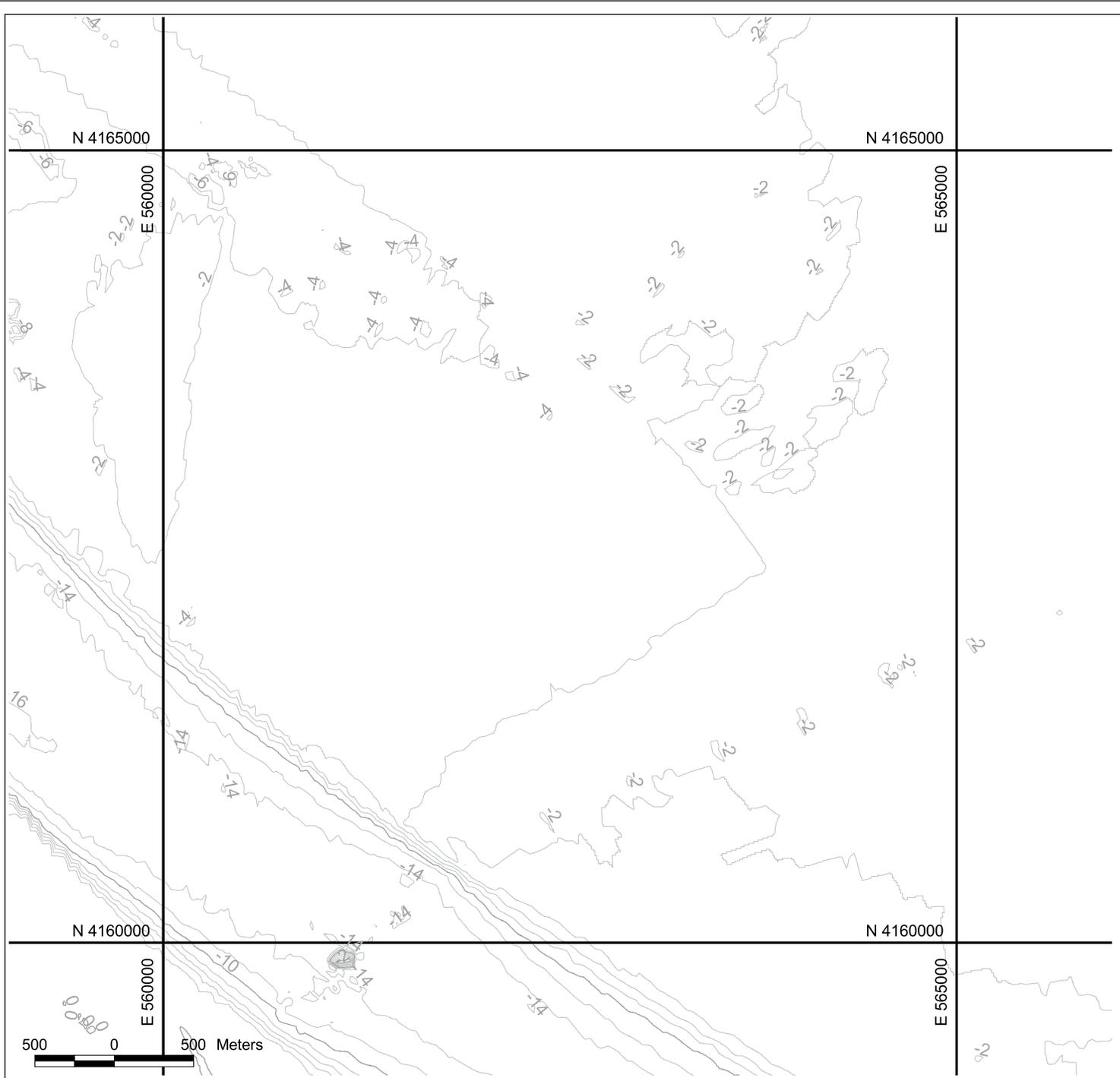
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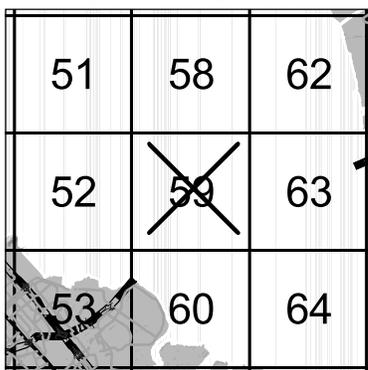
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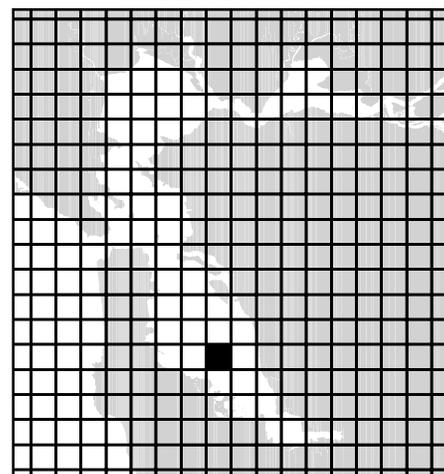




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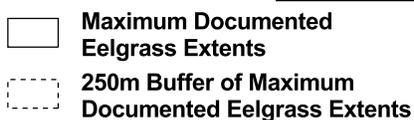


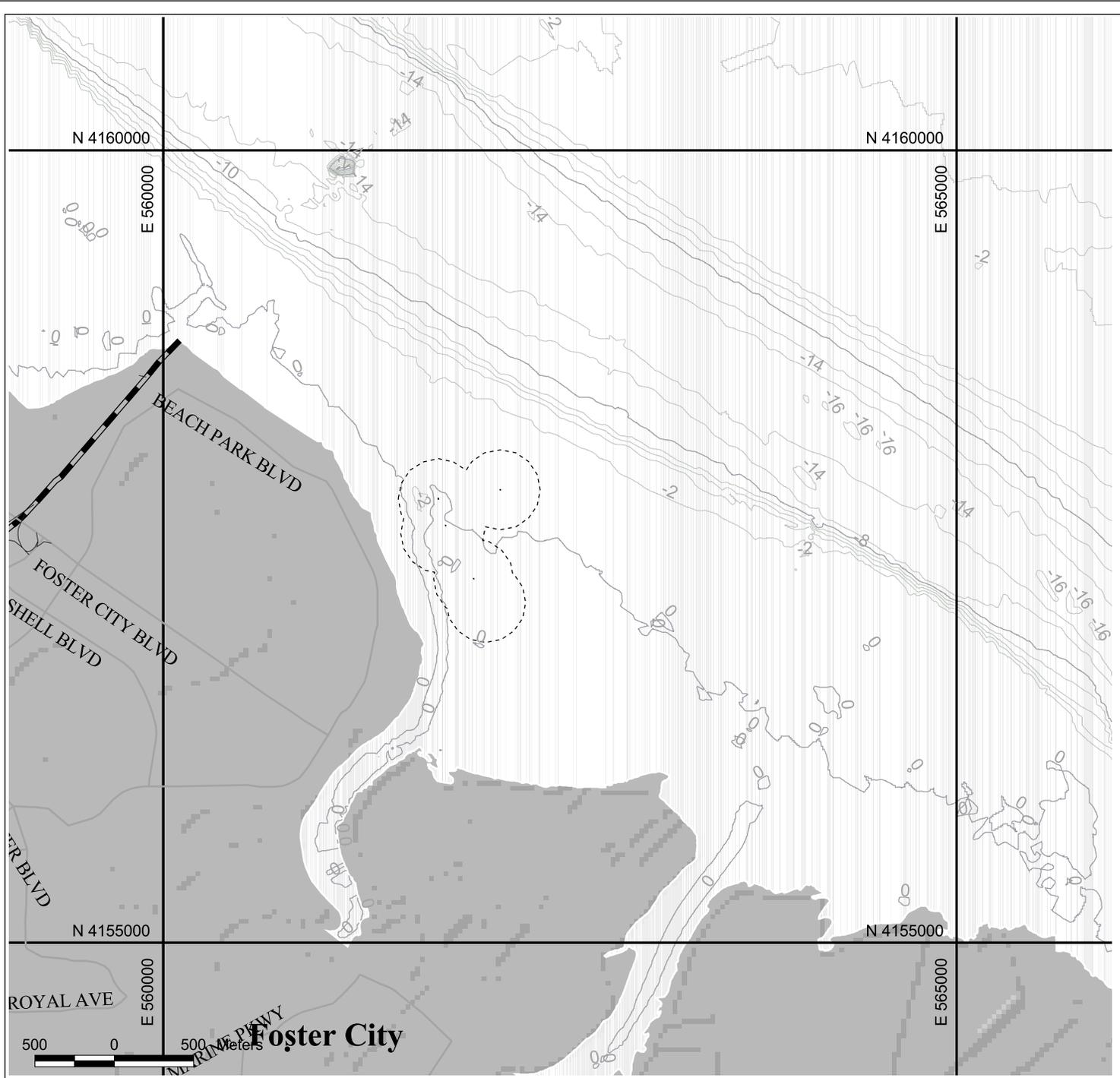
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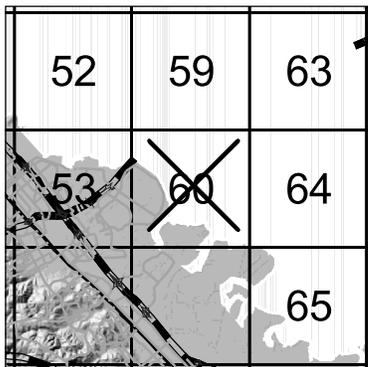
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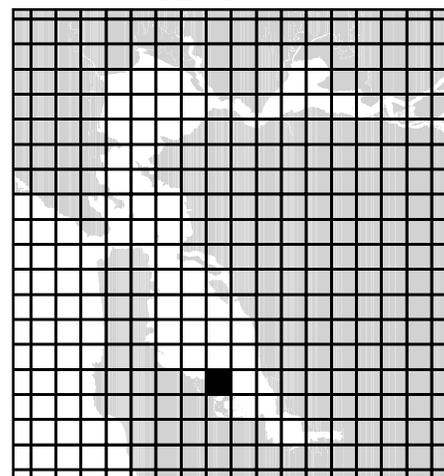




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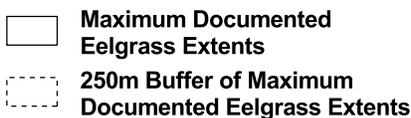


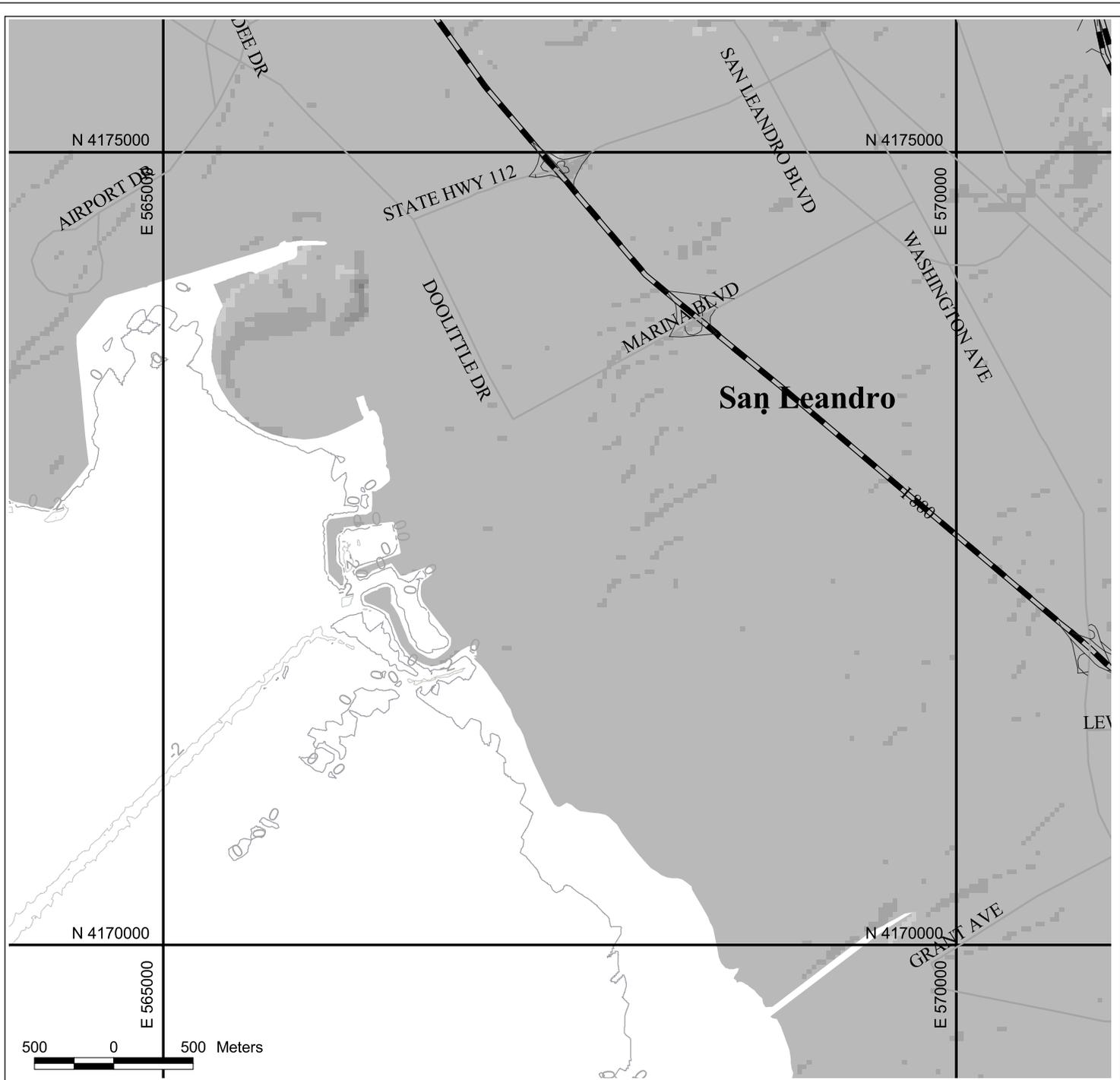
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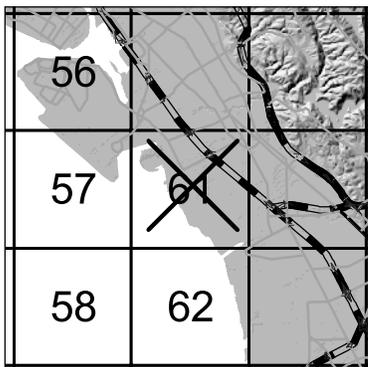
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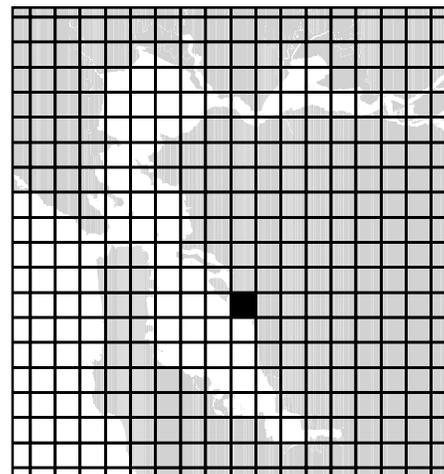




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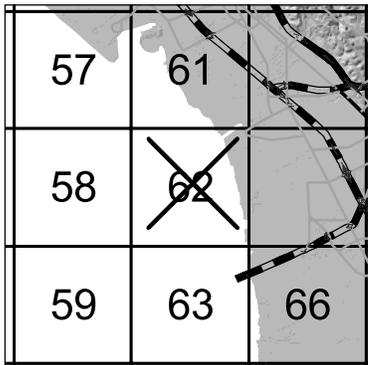
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- | | | | |
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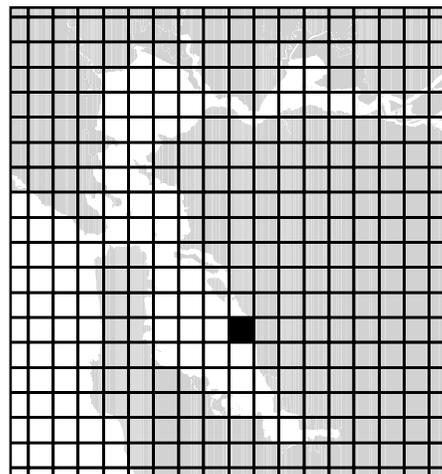




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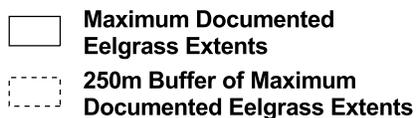


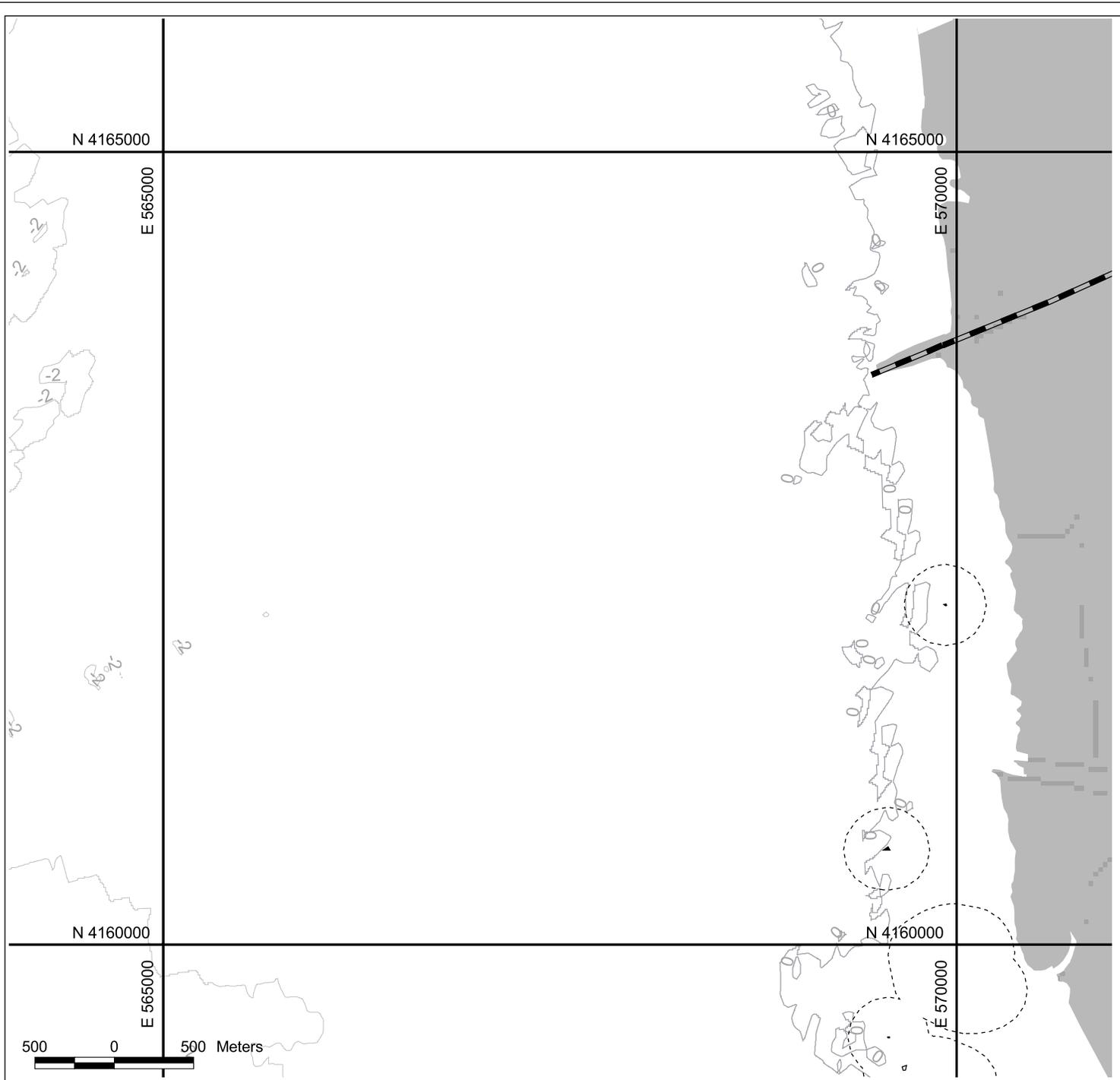
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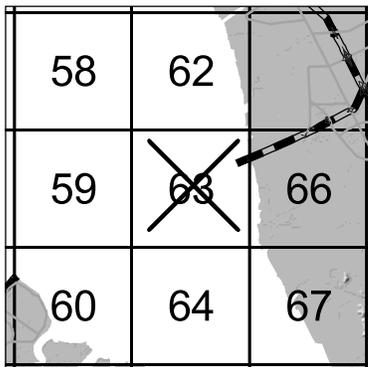
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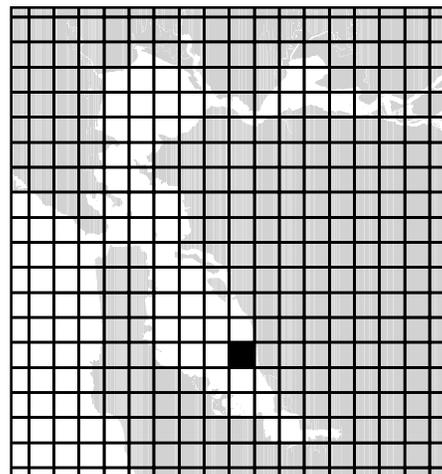




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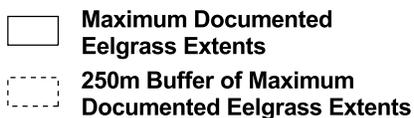


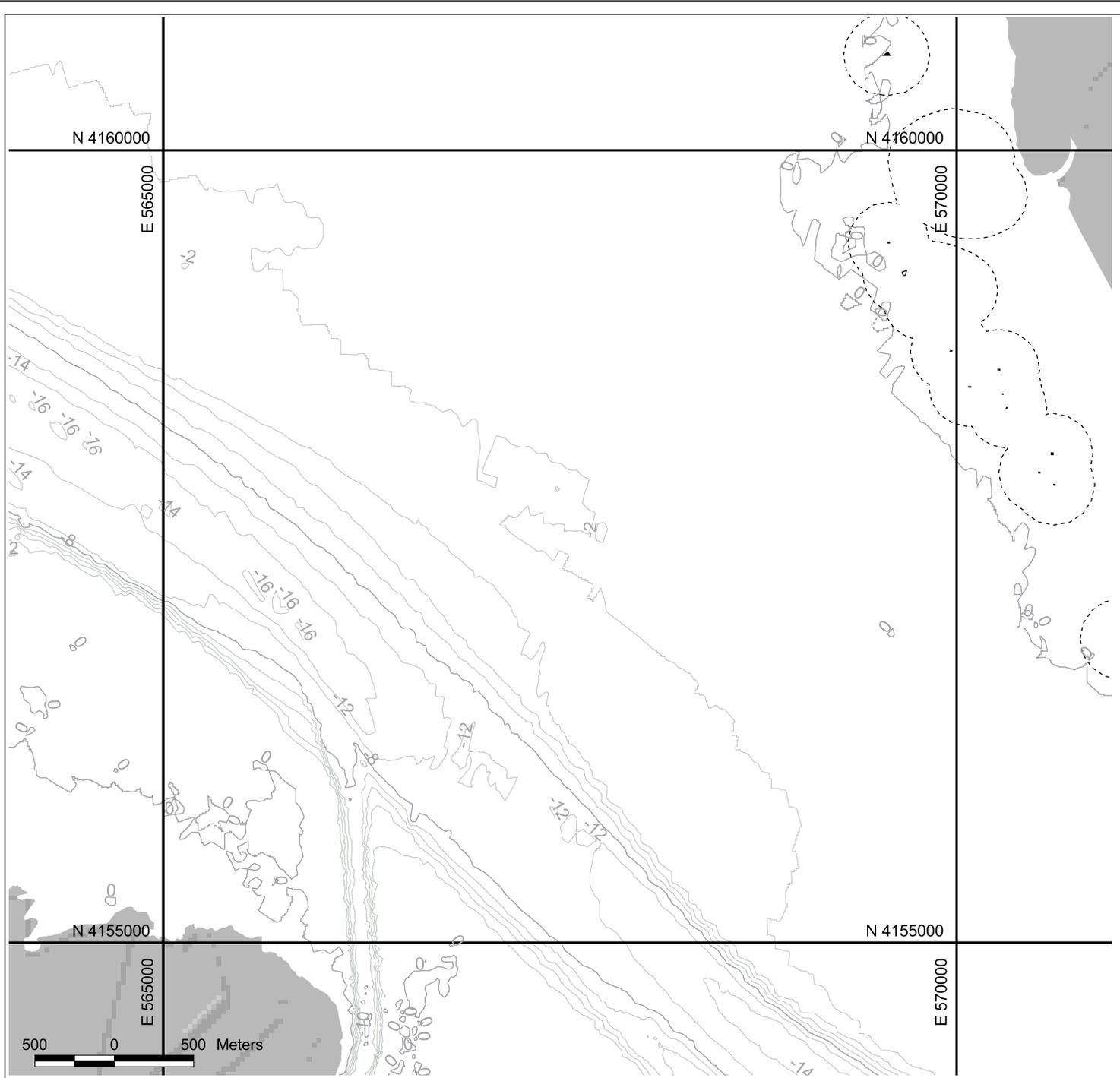
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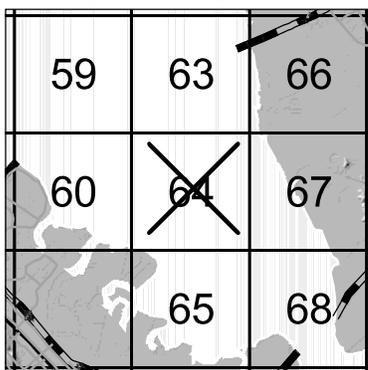
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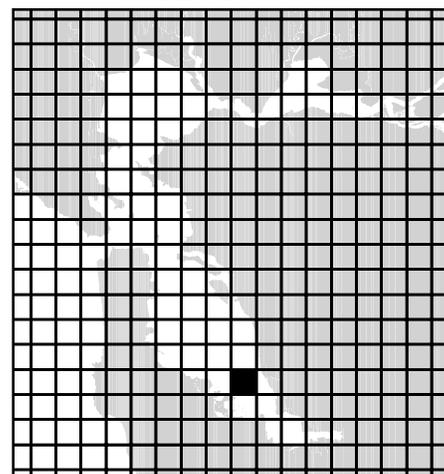




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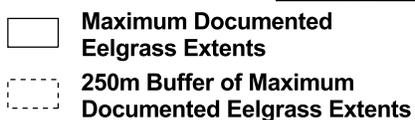


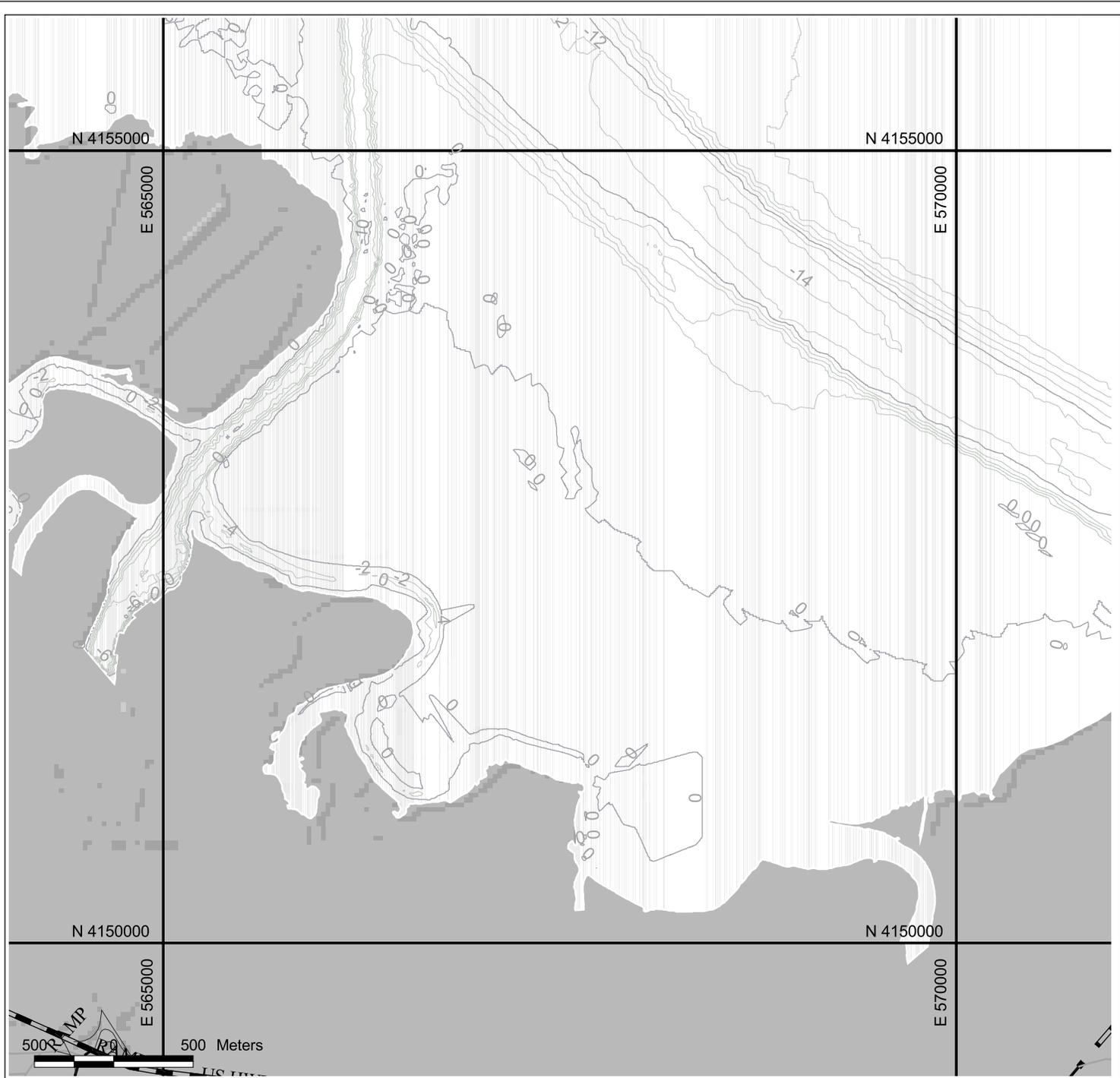
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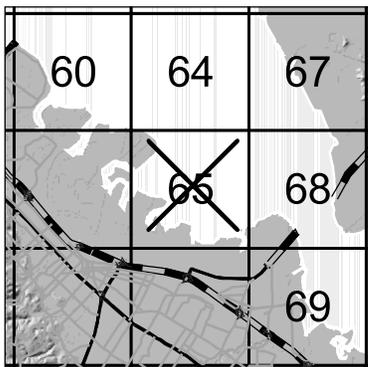
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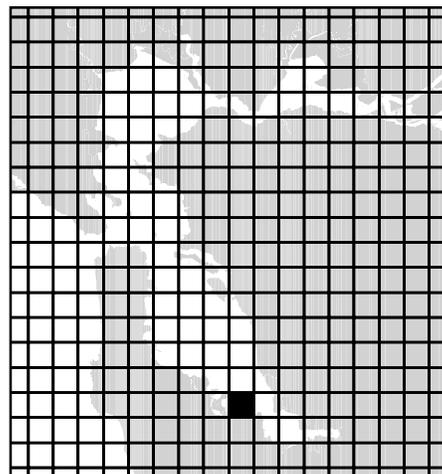




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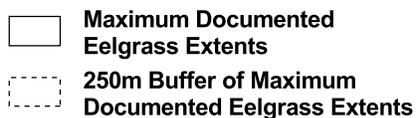


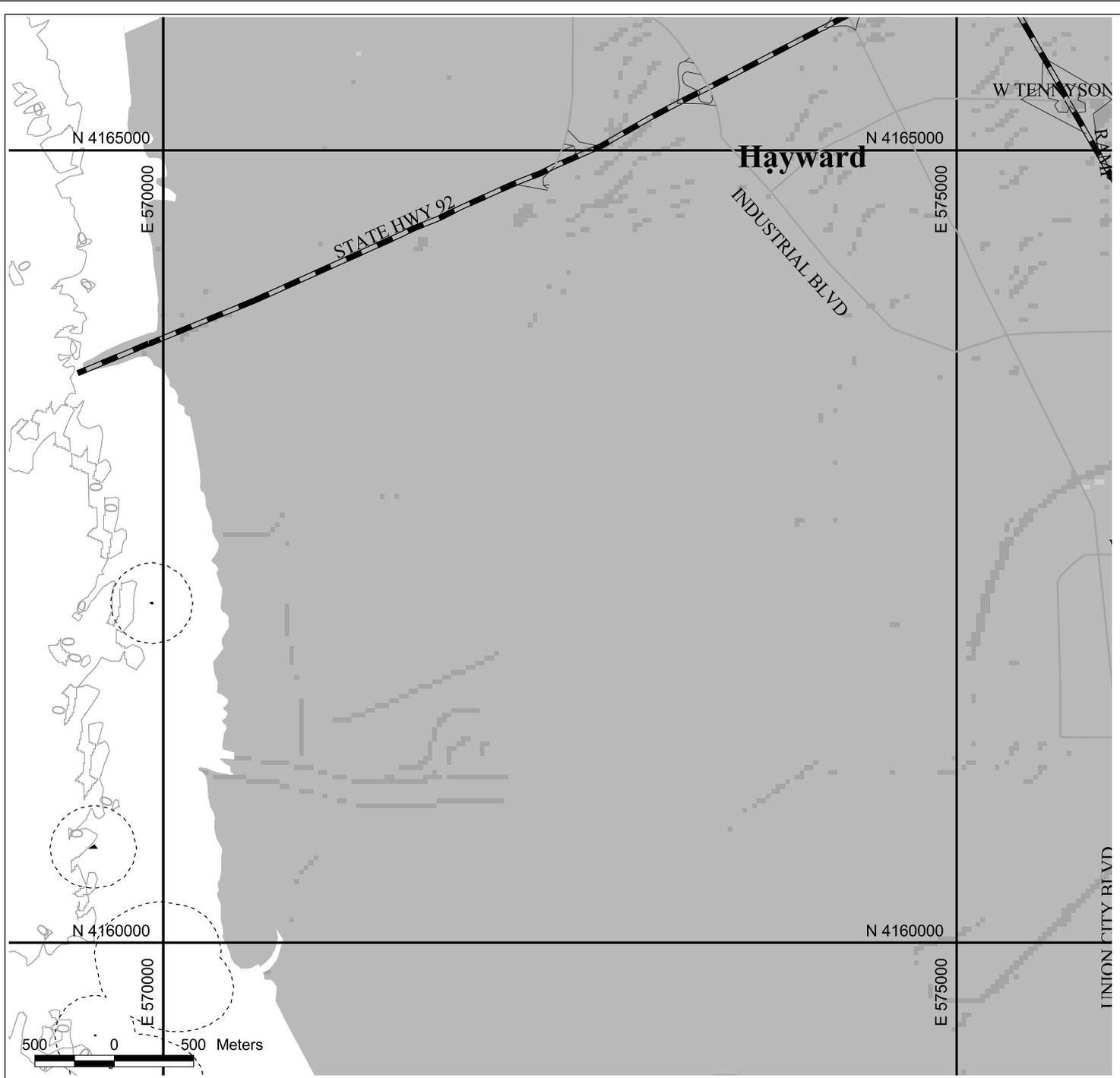
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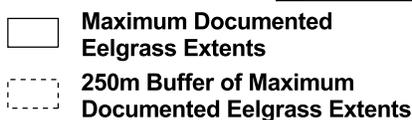


SAN FRANCISCO BAY, CALIFORNIA
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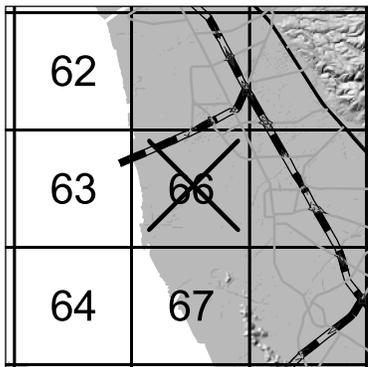
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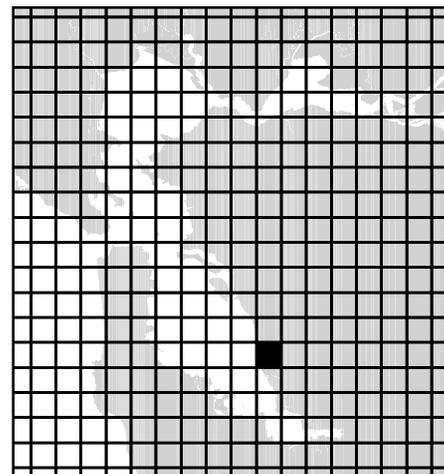
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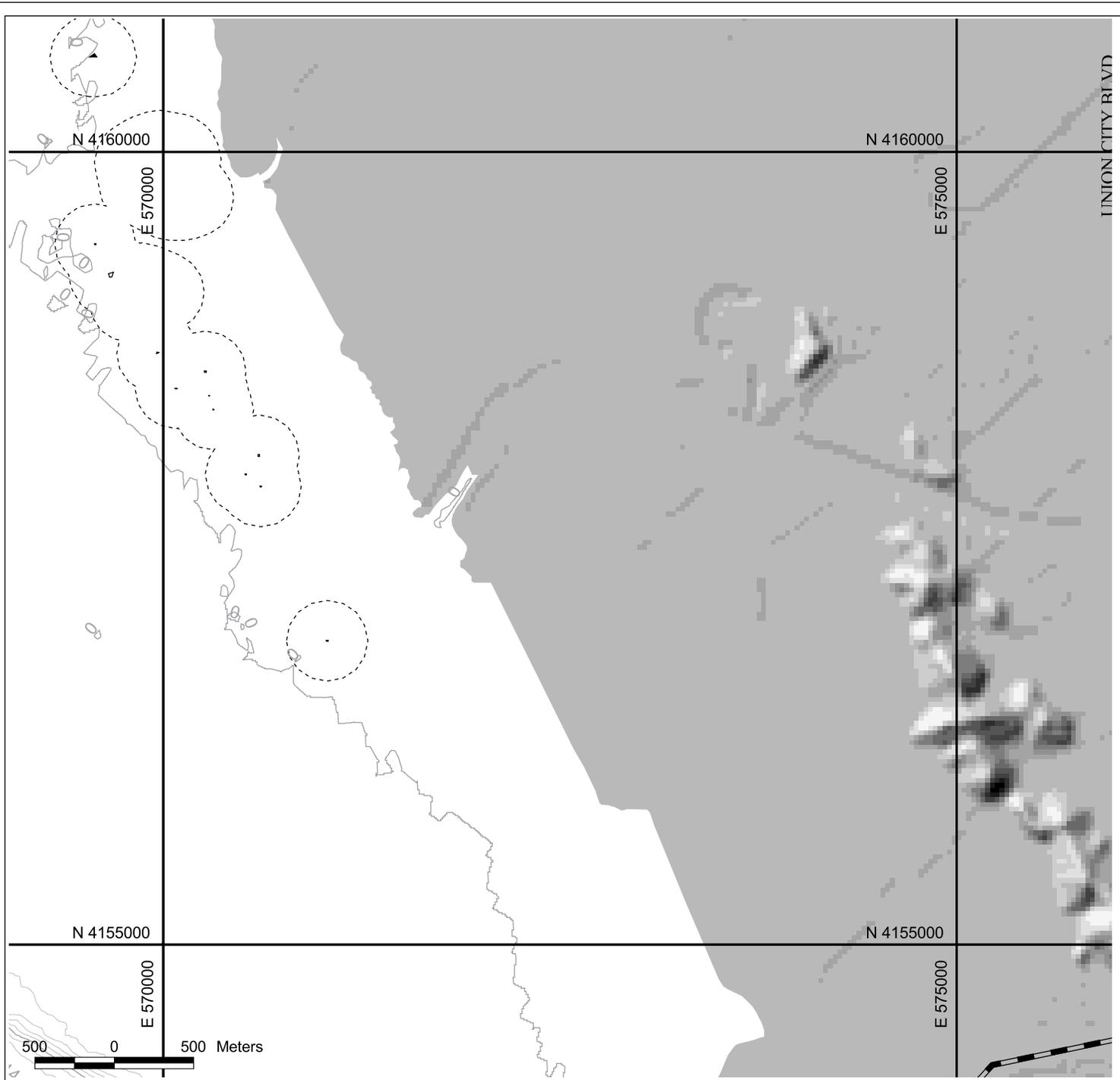


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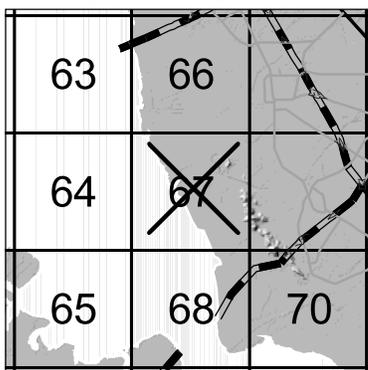
SHEET LOCATOR



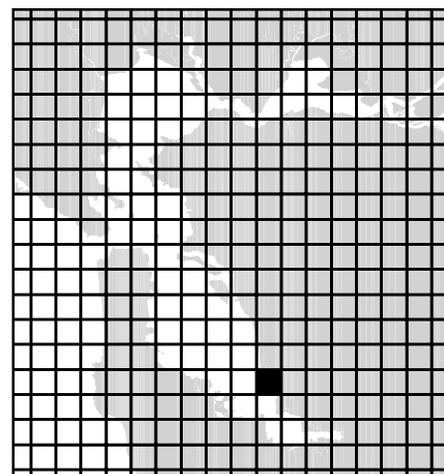


UNION CITY BLVD

SHEET VICINITY



SHEET LOCATOR



SHEET 67 OF 72

**SAN FRANCISCO BAY, CALIFORNIA
Eelgrass 2003**

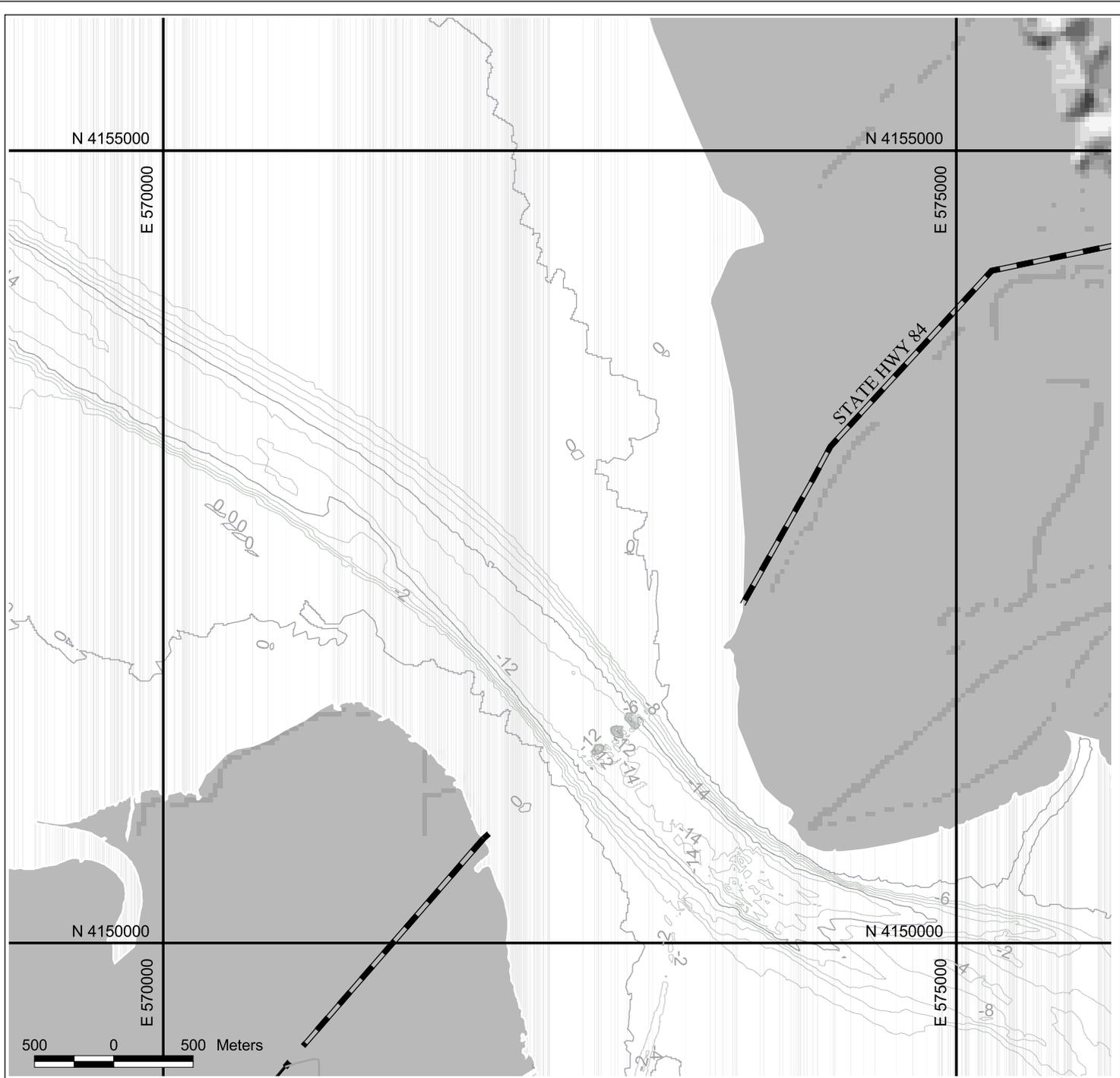
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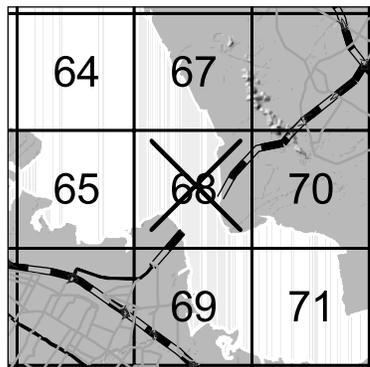
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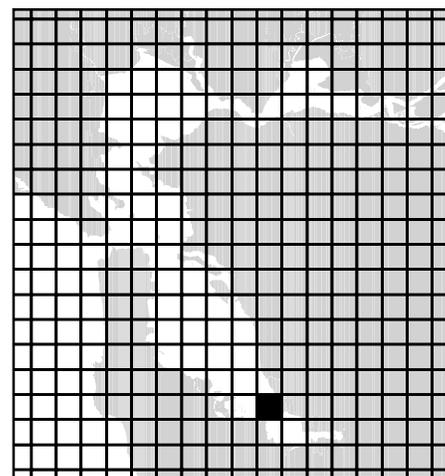




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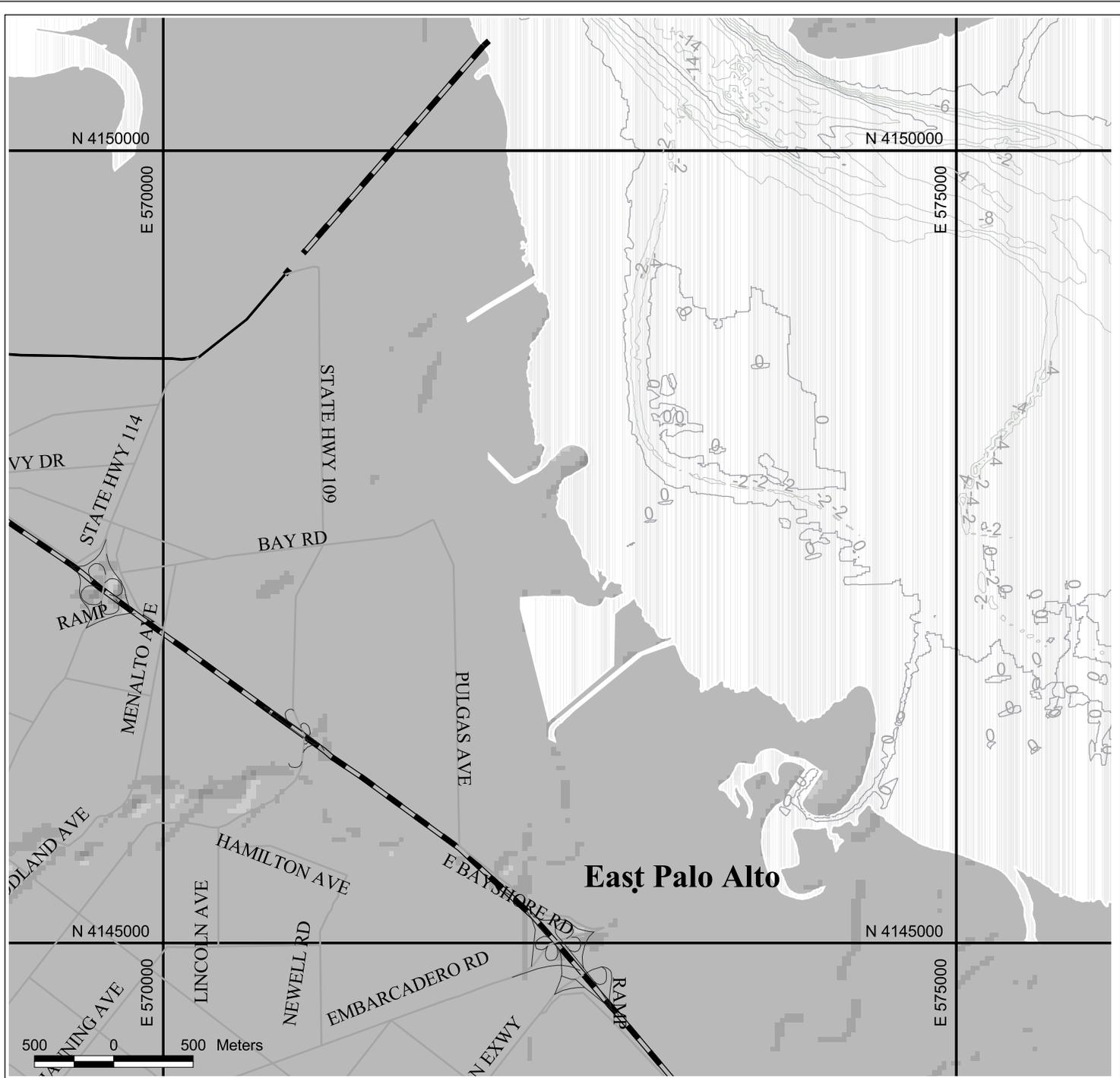
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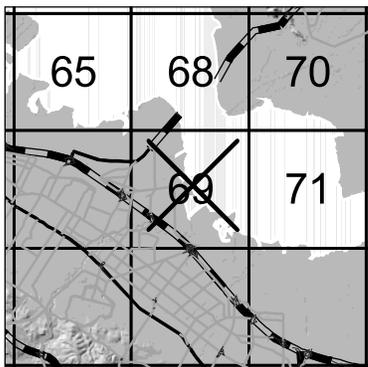
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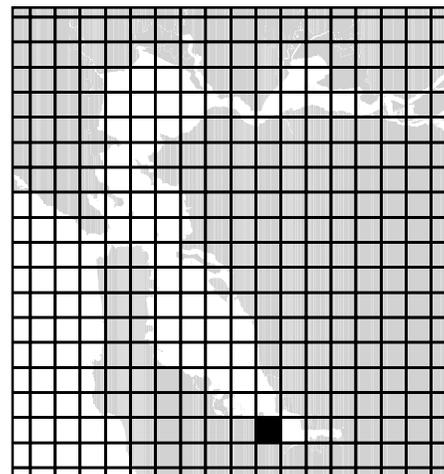


East Palo Alto

SHEET VICINITY



SHEET LOCATOR



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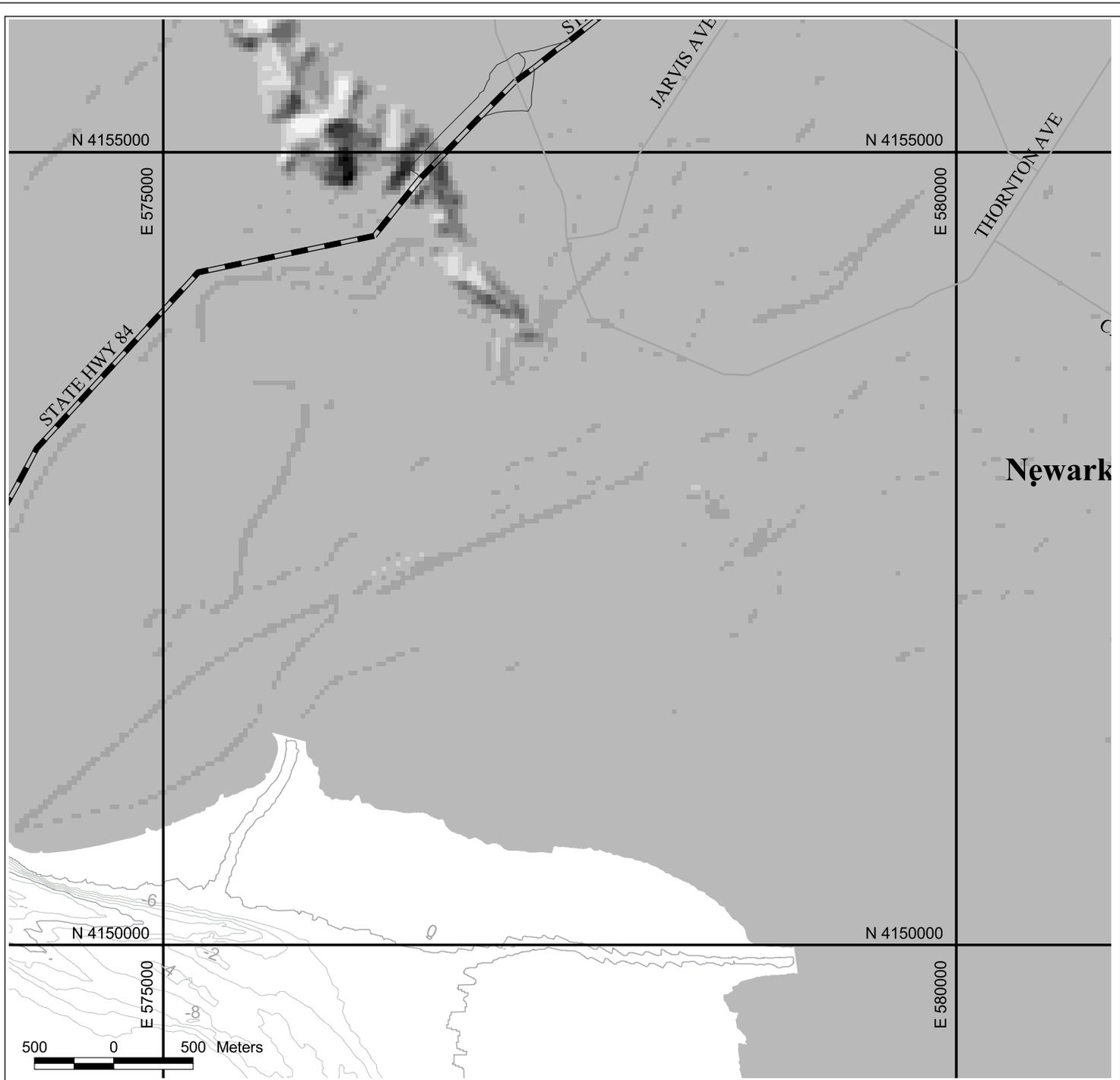
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San Diego, California Tel: (858) 560-5465

Horizontal Datum: UTM 10N NAD1983 (meters)
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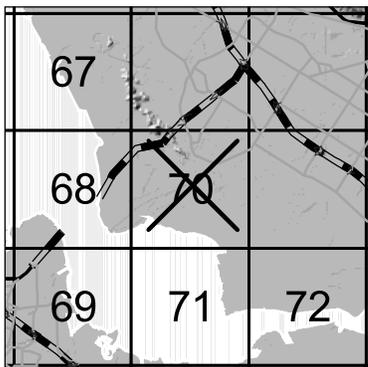
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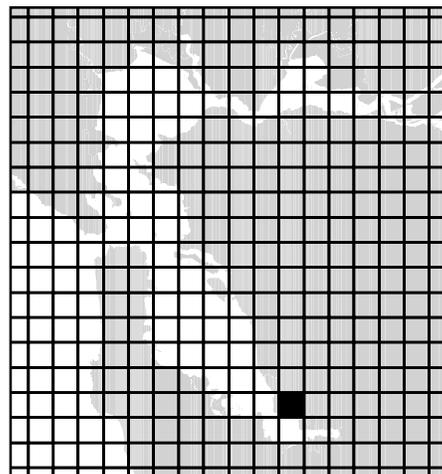




SHEET VICINITY



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Eelgrass 2003**

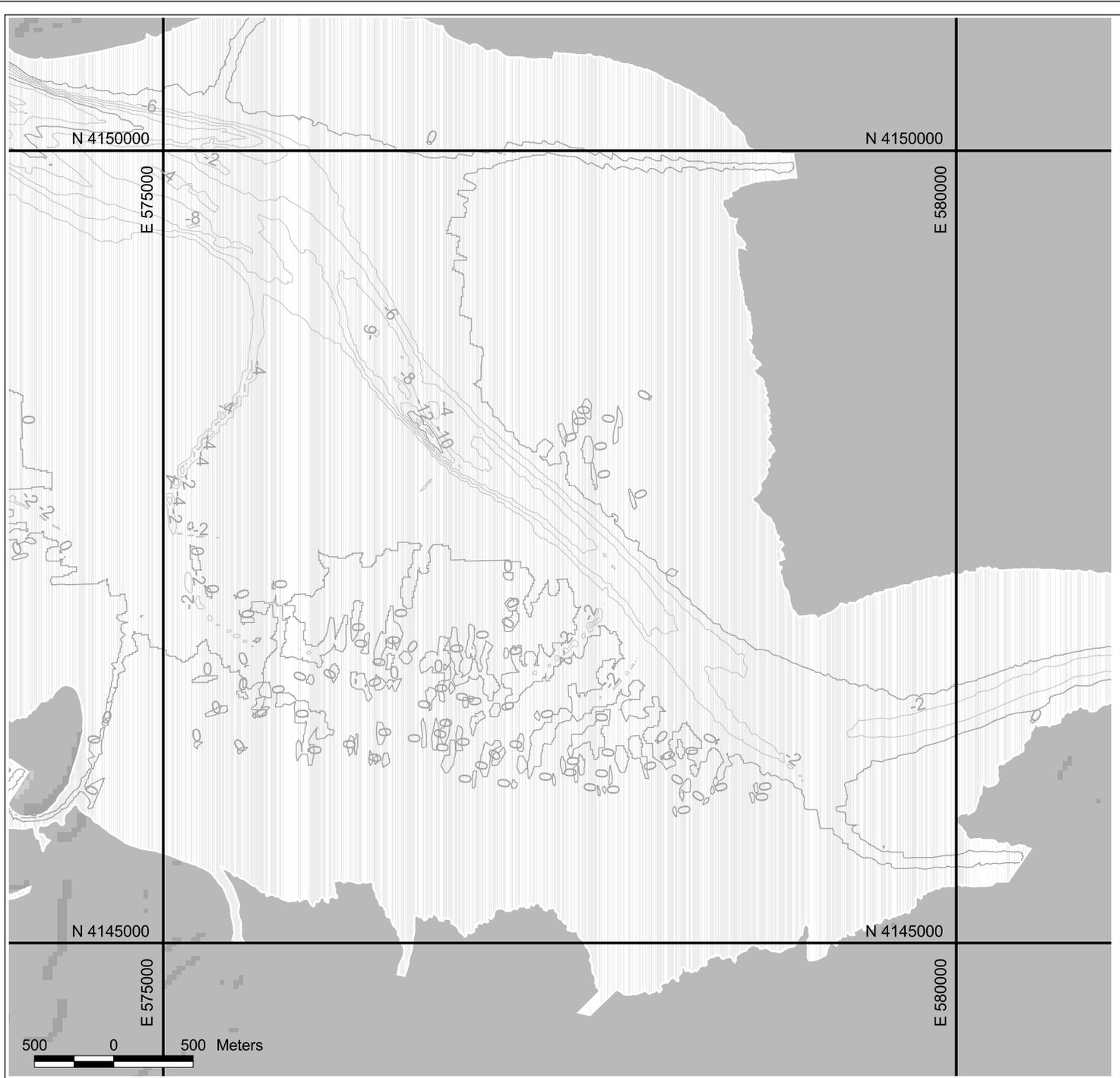
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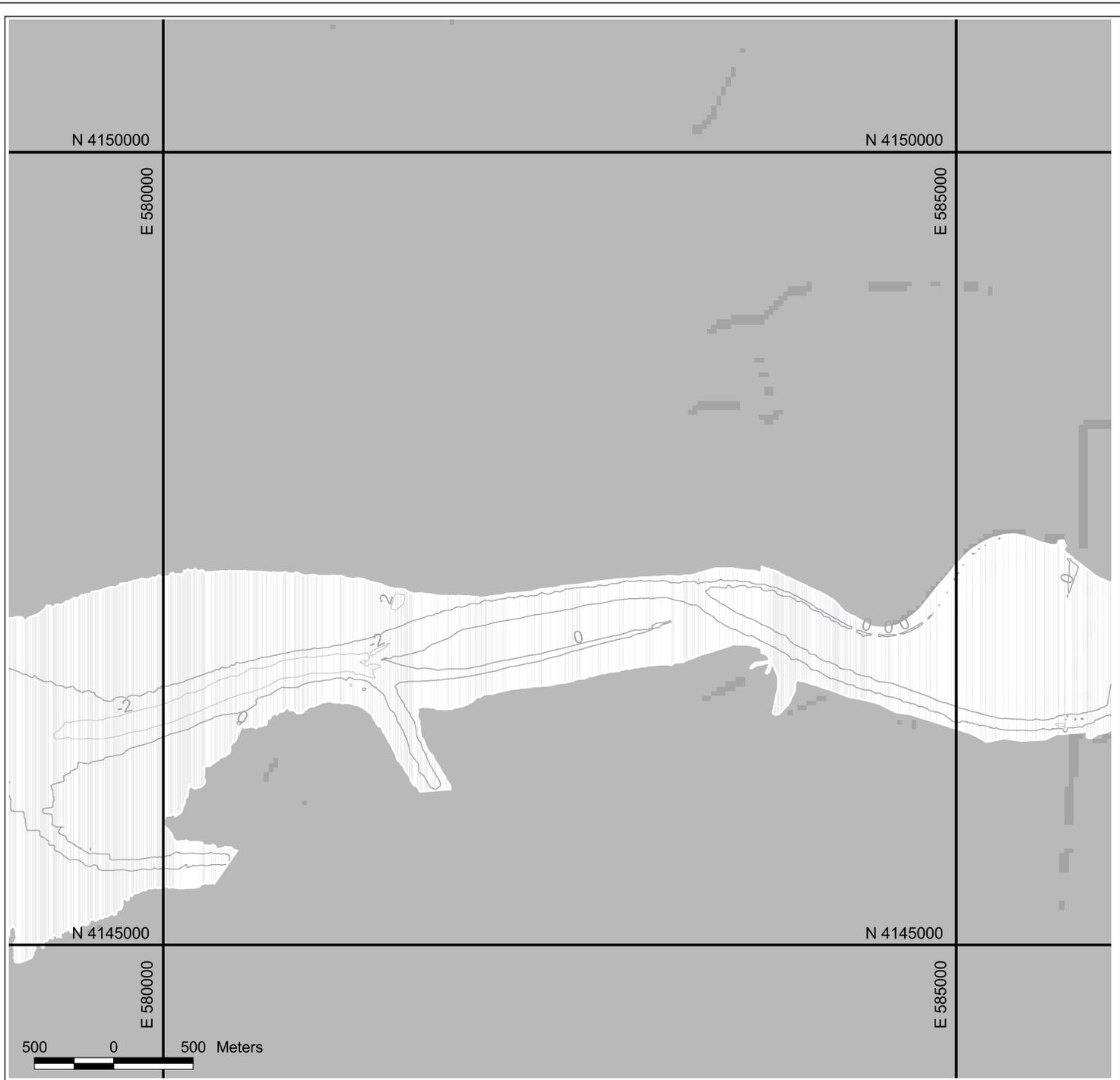
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| >40% Density symbol"/> | >40 % Density | | |

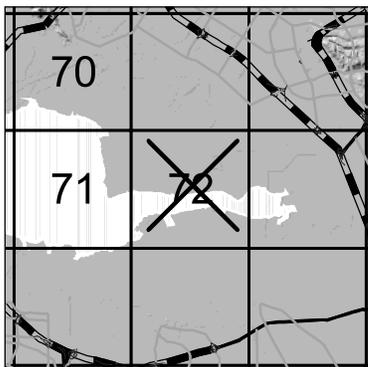




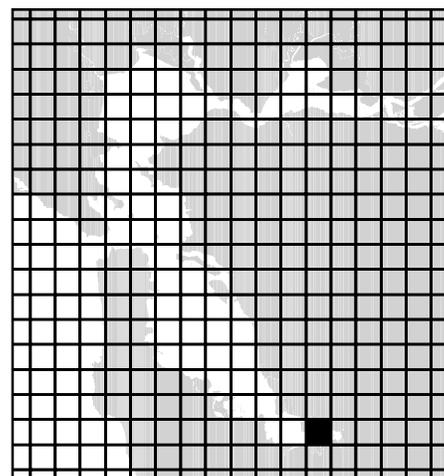
SAN FRANCISCO BAY, CALIFORNIA Eelgrass 2003		SHEET VICINITY		SHEET LOCATOR													
Merkel & Associates, Inc. San Diego, California Tel: (858) 560-5465																	
Horizontal Datum: UTM 10N NAD1983 (meters) Vertical Datum: MLLW (meters)				SHEET 71 OF 72													
<p><i>Note: Charts are for planning and management purposes only. Information application is limited by survey scale and some error is expected. Information is not to be used for navigation or specific project applications.</i></p>		<table border="0" style="width: 100%;"> <tr> <td style="width: 50%; vertical-align: top;"> <table border="0"> <tr> <td></td> <td>0 - 5 % Density</td> </tr> <tr> <td></td> <td>5 - 20 % Density</td> </tr> <tr> <td></td> <td>20 - 40 % Density</td> </tr> <tr> <td></td> <td>>40 % Density</td> </tr> </table> </td> <td style="width: 50%; vertical-align: top;"> <table border="0"> <tr> <td></td> <td>Maximum Documented Eelgrass Extents</td> </tr> <tr> <td></td> <td>250m Buffer of Maximum Documented Eelgrass Extents</td> </tr> </table> </td> </tr> </table>		<table border="0"> <tr> <td></td> <td>0 - 5 % Density</td> </tr> <tr> <td></td> <td>5 - 20 % Density</td> </tr> <tr> <td></td> <td>20 - 40 % Density</td> </tr> <tr> <td></td> <td>>40 % Density</td> </tr> </table>		0 - 5 % Density		5 - 20 % Density		20 - 40 % Density		>40 % Density	<table border="0"> <tr> <td></td> <td>Maximum Documented Eelgrass Extents</td> </tr> <tr> <td></td> <td>250m Buffer of Maximum Documented Eelgrass Extents</td> </tr> </table>		Maximum Documented Eelgrass Extents		250m Buffer of Maximum Documented Eelgrass Extents
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SHEET LOCATOR



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