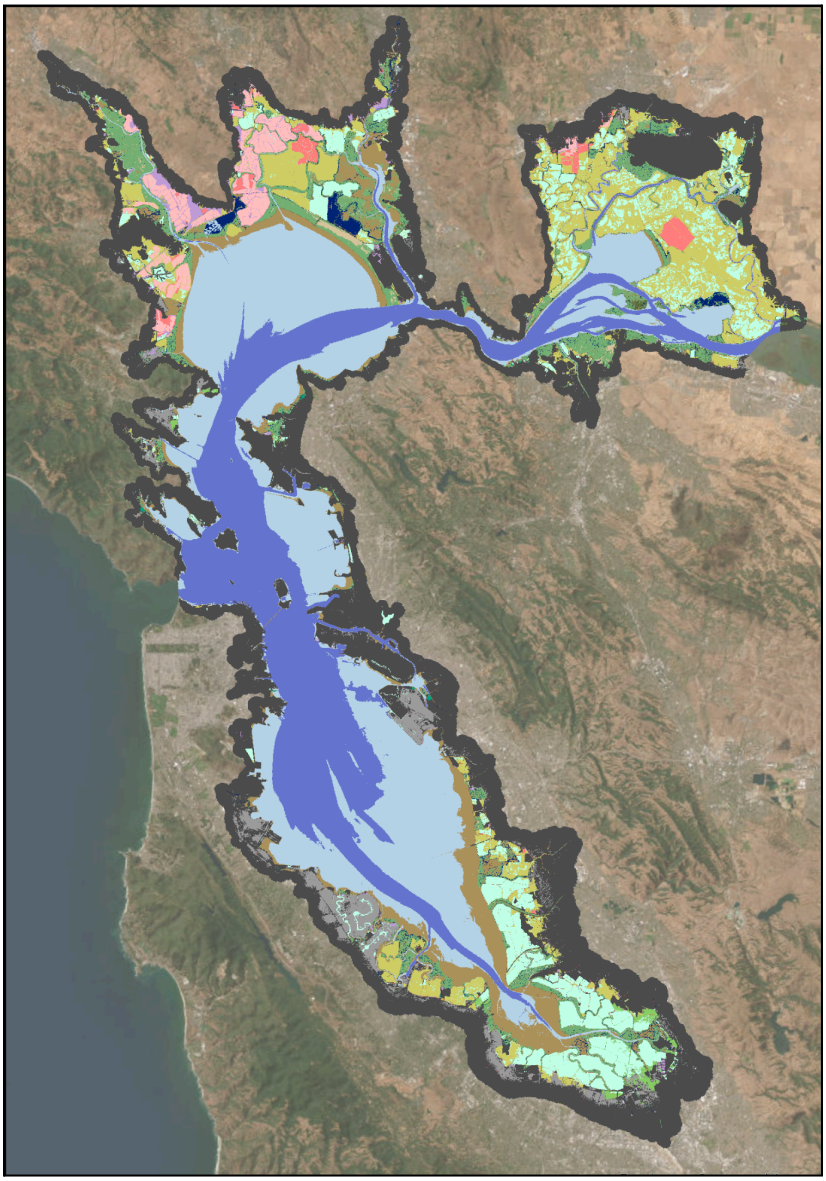
SF ESTUARY
Wetlands
Regional
Monitoring
Program

Baylands Habitat Map 2020
Classification Key



April 2024
Version 1.0

Table of Contents

Baylands Habitat Map 2020 Effort

The Baylands Habitat Map 2020 (BHM2020) mapping effort, aka Baylands Change Basemap (BCB) mapping effort, with the goal of mapping habitat types to meet the needs of the San Francisco Estuary Wetlands Regional Monitoring Program's (WRMP) Indicator 1, makes use of the WRMP Habitat Type Classification System. The BHM2020 effort was funded with the goal of mapping to level 4 "Ecosystem Complex/Habitat Type" within the Classification System, for the purpose of monitoring change over time using primarily remote sensing data. Level 5 "Functional Habitat" classes, although included in the WRMP Habitat Type Classification System, require additional information to accurately map at a regional level. There are limited level 5 classes that were included in the BHM2020 mapping effort to meet the needs of a broad stakeholder group, but should be rolled up to level 4 classes when conducting accuracy assessment and change over time analysis. This is because confidence levels in the accuracy of level 5 distinctions, from using primarily remote sensing data at a regional level, are lower than the accuracy of level 4 classes. For efforts to further speciate classes to level 5 categories, additional information from other data sets and local experts is highly recommended.

During the BHM2020 mapping effort, methods for differentiating one class from another were largely based upon relative tidal elevation, vegetation cover, and feature structure/shape. Tidal influence varies not only across the regions of the bay area, but also between bayland areas within that are constrained by levees and complex hydrological connections. To account for this variability and uncertainty, some flexibility in regard to modeled relative tidal elevation was required and adjustments based on spectral signature was necessary to accurately capture the habitats and extent of influence in areas with complex and varying tidal connections.

Habitat Key for Baylands Habitat Map 2020

This key is for the Habitat Type types found in the San Francisco Bay Estuary, based on the WRMP Habitat Type Classification System developed by the WRMP Technical Advisory Committee and in consultation with the WRMP Geospatial Workgroup. This classification system was first developed in 2022 by the WRMP. These habitat definitions are largely based on definitions adopted in 1997 by the Hydrogeographic Advisory Team (HAT), a subset of the multi-agency Resource Managers Group (RMG) of the San Francisco Bay Area Wetlands Ecosystem Habitat Goals Project. However, under the guidance of and close coordination with the WRMP Geospatial Workgroup, the San Francisco Estuary Institute (SFEI) aligned the original habitat definitions with regional iterations, the Bay Area (used for the Bay Area Aquatic Resource Inventory (BAARI) and the Delta (used for the Delta Aquatic Resource Inventory (DARI), of the California Aquatic Resources Classification System (CARCS), used for the California Aquatic Resource Inventory (CARI). This allows for comparisons with past bayland habitat mapping efforts to be meaningful. The WRMP Habitat Type classification is intended to support field-based and image interpretation-based identification of bayland habitat types at a level of detail that sufficiently addresses WRMP indicators and management questions.

Due to the high diversity of the bayland habitat types in the area and variable land management group practices, the classification system is broken out into five hierarchical levels with additional modifier fields for salinity, hydrology, and geomorphology. The five levels of habitat classes, from broad to fine scale, are: 1) Geography, 2) Landscape Complex, 3) Hydrogeomorphic Setting, 4) Ecosystem Complex / Habitat Type, and 5) Functional Habitat. Only the portions of the WRMP Habitat Type Classification System that are used for the BHM2020 effort are listed below.
Note that level 5 classes will be marked in Italics to further indicate that they should be rolled up to level 4 classes for the use of accuracy assessments and change over time analyses.

Terms used throughout this Key

Mean High Water (MHW): The average of all the high water heights observed over the National Tidal Datum Epoch.

Mean Higher High Water (MHHW): The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch.

Mean Low Water (MLW): The average of all the low water heights observed over the National Tidal Datum Epoch.

Mean Lower Low Water (MLLW): The average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch.

Mean Tide Level (MTL): The arithmetic mean of MHW and MLW.

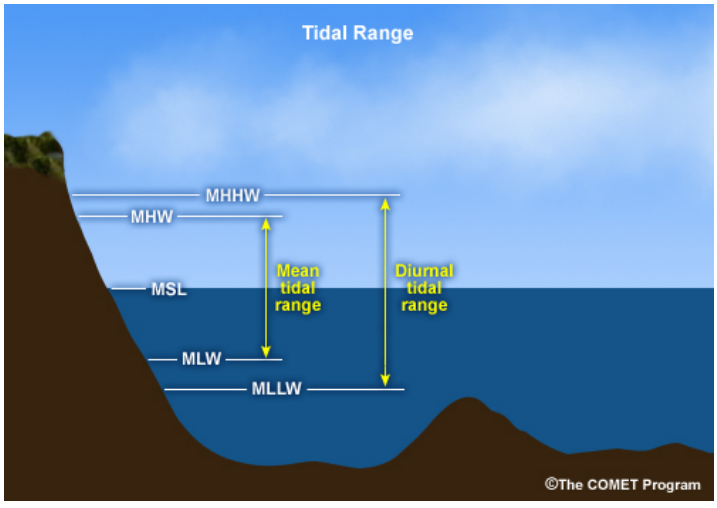


Figure 1: Infographic of tidal ranges, source The COMET Program

Geography - Subregion Extent

The geographic subregion for which WRMP Habitat Types are mapped “includes Suisun Marsh, North Bay, Central Bay, South Bay, Lower South Bay, and the Operational Landscape Geomorphic Unit Types of Headlands + Small Valleys, Alluvial Fans + Alluvial Plains, and Wide Alluvial Valleys (WRMP SOPS for Indicators 1 and 3).

1. Estuarine

Estuarine landscapes exist where rivers, streams, and shorelines meet San Francisco Estuary, and are primarily formed and influenced by estuarine processes such as tides and waves. They are often but not always along the margins of tidal sloughs, bays, and estuaries. They are usually subject to daily or twice daily tidal fluctuations in water height. These fluctuations might be fully natural or muted due to tide gates, culverts, weirs, etc. The water is a mixture of marine or ocean water and freshwater. Water salinity can range from fresh to hyper-saline (i.e., more saline than the ocean). Typical freshwater sources include rivers, streams, groundwater, point discharges (e.g., effluent from sewage treatment facilities), and storm drains. In the San Francisco Estuary, the influence of the tides typically ends farther upstream than the influence of marine salinity; the estuary therefore includes tidal marine, tidal brackish, and tidal freshwater habitats. The region’s estuarine landscapes include features such as beaches that can be outside the reach of daily tides but strongly influenced by estuarine processes such as waves and storm surge. Estuarine habitats in the region include those areas that have been cut off from tidal influence by levees, berms, dikes, unnatural fill, constructions, and any other unnatural features that block the landward excursions of the tide. This is generally captured by selecting lands and waters below the relative tidal elevation of Highest Astronomical Tide (HAT). For BHM2020 a two year annual flood extent, using the 1983-2001 tidal epoch, was used as a proxy for HAT because the 1983-2001 tidal epoch doesn’t include recent sea level rise. In this classification system, estuarine landscapes also include levees and dunes, which are outside the reach of daily tides but exert a significant influence on physical and ecological conditions and processes within those landscapes.

1.1 Subtidal

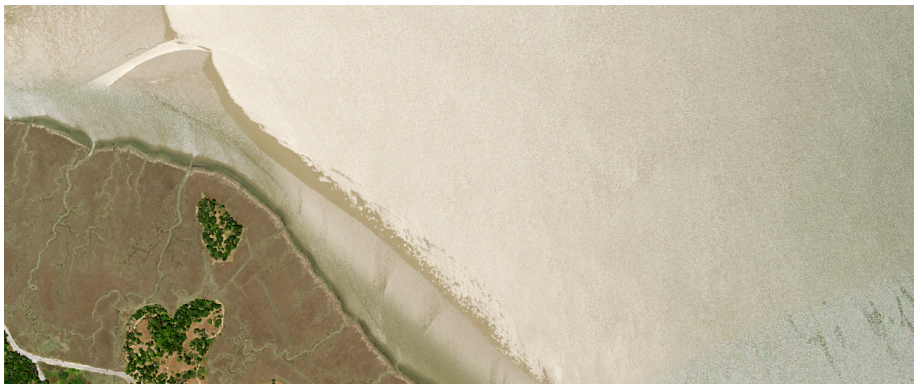
Subtidal estuarine areas are permanently covered by water and support water column and benthic habitats. Subtidal areas have elevations below the local Mean Lower Low Water (MLLW) tidal elevation contour. These areas are typically inundated by estuarine waters

1.1.1 Shallow Subtidal

Shallow subtidal areas are permanently covered by water and support water column and benthic habitats. Shallow subtidal areas exist between local Mean Lower Low Water (MLLW) and the bottom contour 12 ft below MLLW. The benthic substrate is typically silts, muds, and clays, but can also have areas of rocky or artificial substrate. They provide an important benthic habitat that can support a variety of invertebrates such as shellfish, and various species of submerged aquatic vegetation. The water column portion provides habitat for fish and other

aquatic organisms, transports material and organisms between other habitats, and can vary in salinity, temperature and turbidity depending on location within the Bay.

Figure 2: Shallow Subtidal area in Tiburon area. Sarah Pearce, SFEI.



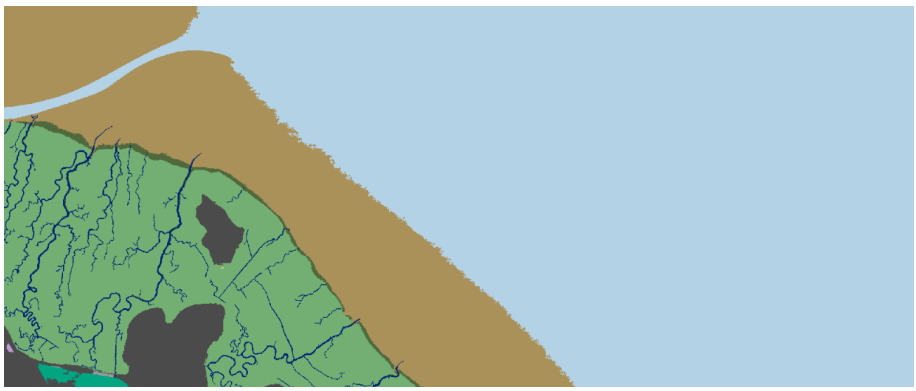


Figure 3 and 4: Shallow Subtidal, True Color 2020 NAIP, and Bayland Habitat Map 2020.

1.1.2 Deep Subtidal

Deep subtidal areas are permanently covered by water and support water column and benthic habitats. Deep subtidal areas extend between the deepest areas of the subtidal up to the contour that is 12 ft below local Mean Lower Low Water (MLLW). The benthic substrate is typically silts, muds, and clays, but can also have areas of rocky or artificial substrate. These habitats can be affected by temperature, salinity and turbidity of the water column, and typically

have lower sunlight penetration than shallow subtidal environments due to the greater water column depth and thus are less likely to support submerged aquatic vegetation.

1.2 Intertidal - Full Tidal Connection

Intertidal estuarine areas have elevations between the local MLLW and Highest Astronomical Tide (HAT). Fully tidally connected areas have unimpeded physical connectivity with source tides.

During the BHM2020 mapping effort, the designation of an area having full tidal connection was assessed by hydro-enforced digital elevation models (DEM), shoreline mapping (San Francisco Bay Shore Inventory - SFEI dataset), and visual interpretation of Google Earth Pro and Google Street View imagery. Additionally, a two year annual flood extent, using the 1983-2001 tidal epoch, was used as a proxy for HAT because the 1983-2001 tidal epoch doesn't include recent sea level rise.

1.2.1 Tidal Flat

Intertidal flats mostly exist between the local Mean Tide Level tidal datum (MTL) and the local Mean Lower Low Water tidal datum (MLLW), based upon the current tidal epoch, and support less than 30% cover of vascular vegetation, including eelgrass. 30% vegetated cover is used due to the high spatial resolution of the four band imagery (60cm) and is consistent with the cutoff used by U.S. Fish & Wildlife Service for National Wetland Inventory mapping when determining which vegetation type is dominant and determines class type. The tides alternately expose and flood the substrate. Tidal flats include mudflat, sandflat and shellflats, and typically occur along the shallow edges of the Bay.

This habitat can support an extensive community of diatoms, worms, snails and shellfish, as well as algal flora including green algae, red algae, and sea lettuce, providing food web support to fish and wildlife (Goals Project, 1999). When the tidal flat is submerged, it provides foraging habitat for fishes; when the flat is exposed it provides foraging for shorebirds. Tidal flats also provide biogeochemical processing of sediment and water (Goals Project, 1999).

Figure 5: Tidal Flat off of Harney Way, San Francisco. Sarah Pearce, SFEI.

Figure 6 and 7: Mudflat just south of the Dumbarton Bridge, True Color 2020 NAIP, and Bayland Habitat Map 2020. Note that often not all mudflats are visible in plane based imagery.

1.2.2 Tidal Pond/Panne

Tidal ponds tend to be well-defined, persistent, and shallow depressional features that occur on fully mature marsh plains (PWA and Faber, 2004). Pannes and ponds support standing water between tidal inundations and are infrequently flooded by tides. They may be perennial or seasonal, but are typically shallowly flooded during the winter and spring, and intermittently flooded during the summer and fall (SCC and USFWS, 2003). Most pannes have a persistent average depth over time of less than 12 inches. They usually support less than 30% cover of vascular vegetation, although some brackish pannes support dense colonies of submergent vegetation, especially Ruppia maritima. Pannes often form on tidal marsh plains equidistant from tidal channels, and along the upland margins of tidal marshes. 30% vegetated cover is used due to the high spatial resolution of the four band imagery (60cm) and is consistent with the cutoff used by U.S. Fish & Wildlife Service for National Wetland Inventory mapping when determining which vegetation type is dominant and determines class type.

Figure 8: Panne at Hoffman Marsh, Sarah Pearce, SFEI.

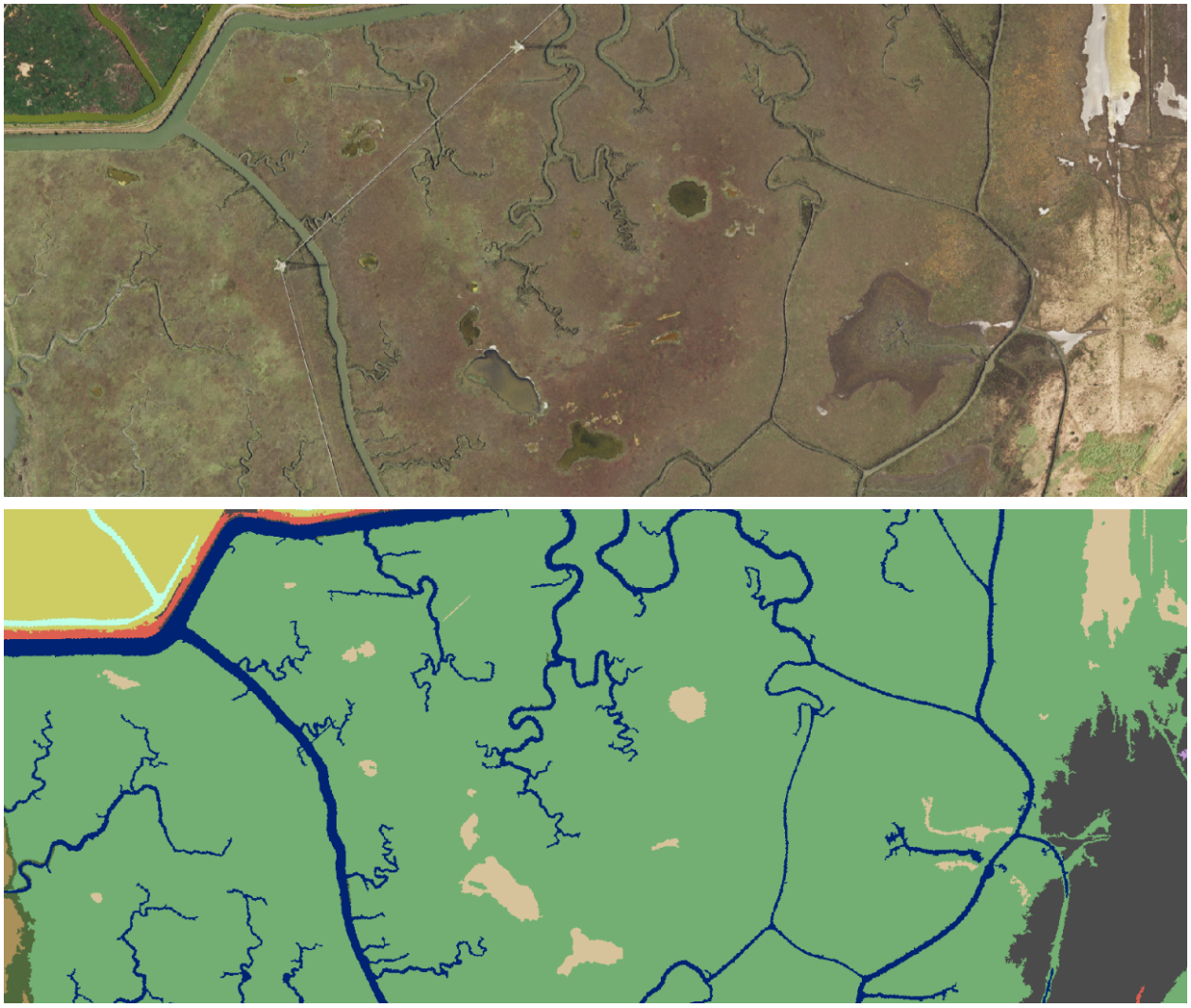


Figure 9 and 10: Tidal Pannes at Wildcat Marsh, True Color 2020 NAIP, and Bayland Habitat Map 2020.

1.2.3 Intertidal Channel

A channel that flows through areas of tidal marsh, muted marsh, other marsh that delivers flows to and from the marsh. Channels are natural or artificial uncovered features through which flow the tide, upland runoff, effluent, or emergent ground water. A channel consists of its bed and its banks. Tidal channels carry bi-directional flow (flood tides and ebb tides) and typically have bed forms and bar forms. Tidal channels transport water, sediment, nutrients, organisms, and plant parts throughout the marsh, connecting the open water to the marsh plain. Water depths increase and decrease with the tidal stage, and channel beds in well-drained marshes are usually above MLLW and exposed or partially exposed during low tide. Tidal channels can support aquatic vegetation, shellfish beds, fish populations, a variety of benthic invertebrates, muskrats and mink and they even provide a pathway for harbor seals to access “haul out” locations.

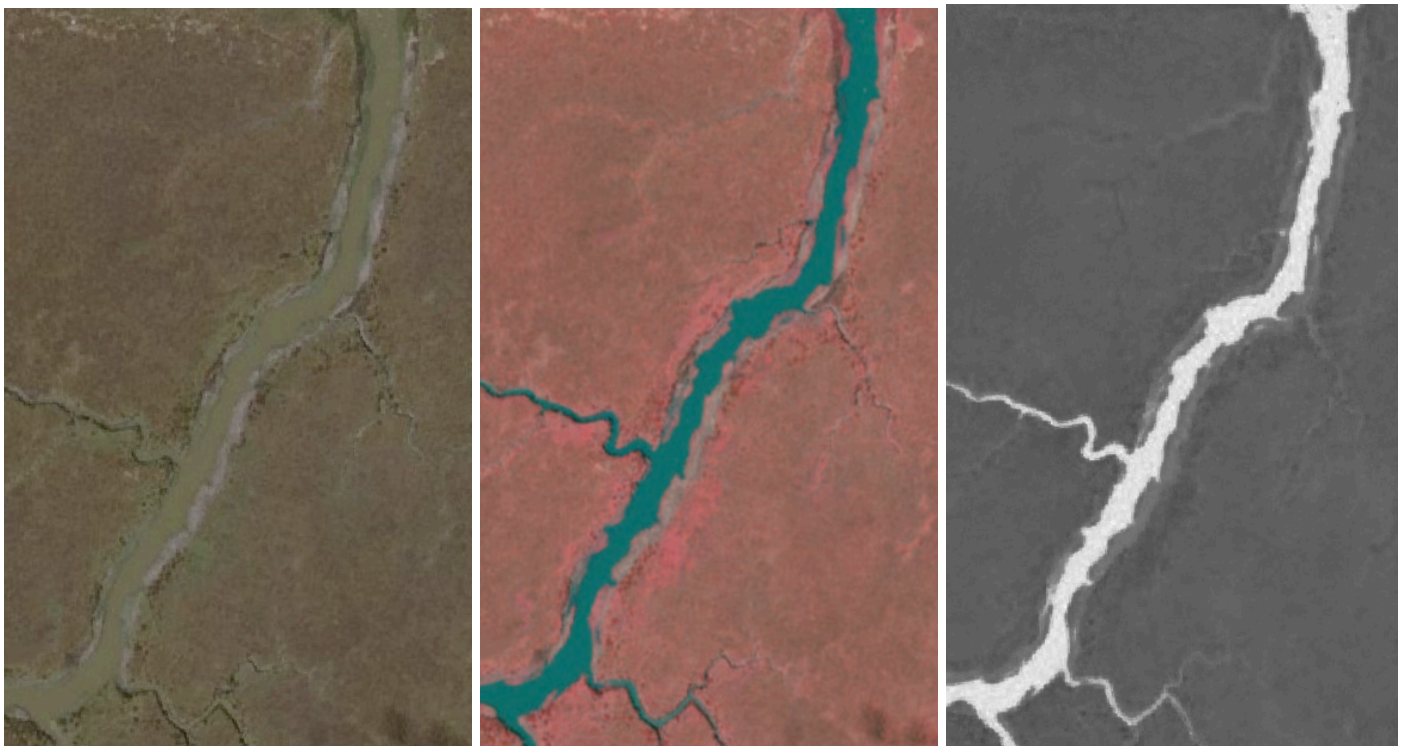


Figure 11: Example of Tidal Channel in True Color NAIP imagery, NIR NAIP imagery, and DEM.

Figure 12: Channel at Hoffman Marsh, Sarah Pearce, SFEI.

Figure 13: Channel at Faber Marsh, Sarah Pearce, SFEI.

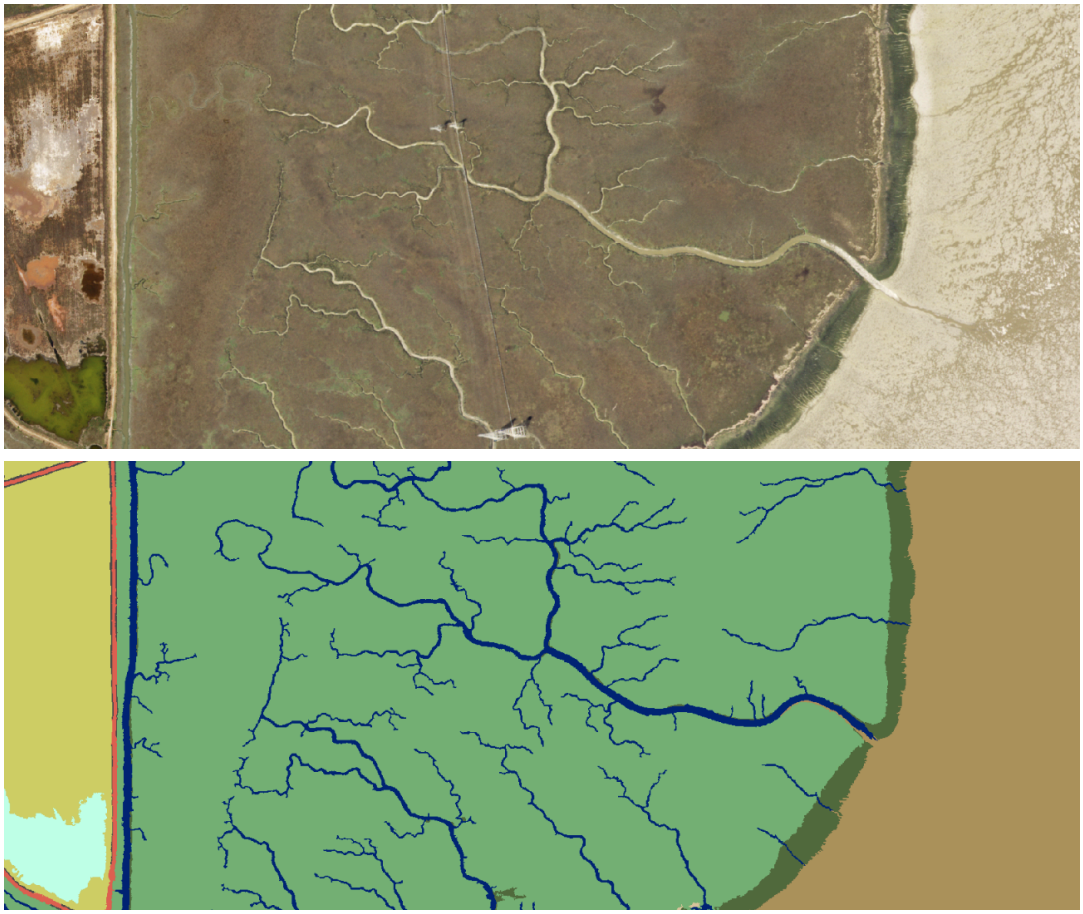


Figure 14 and 15: Tidal Channels and Tidal Marsh (Both High Marsh and Low Marsh) at mature portions of McInnis Marsh, True Color 2020 NAIP, and Bayland Habitat Map 2020.

1.2.4 Tidal Marsh

An area of tidal bayland that supports at least 30% cover of rooted, vascular, wetland vegetation and has a nexus with the tides. 30% vegetated cover is used due to the high spatial resolution of the four band imagery (60cm) and is consistent with the cutoff used by U.S. Fish & Wildlife Service for National Wetland Inventory mapping when determining which vegetation type is dominant and determines class type. Tidal marsh can exist between Mean Low Water tidal datum (MLW) and the Highest Astronomical Tide (HAT). During BHM2020 mapping, a two year annual flood extent, using the 1983-2001 tidal epoch, was used as a proxy for HAT because the 1983-2001 tidal epoch doesn't include recent sea level rise.

Tidal Marsh vegetation communities are typically dominated by species that are emergent, halophytic, and herbaceous. The vegetation community varies with salinity, substrate, wave energy, marsh age, sedimentation, and erosion (Goals Project, 1999). Marshes provide habitat for an extensive suite of fish and wildlife, and can also provide carbon sequestration and protection from shoreline erosion and flooding.

Figure 16: Tidal Marsh at Pillar Point. Sarah Pearce, SFEI.

Figure 17: Tidal Marsh at China Camp State Park. Sarah Pearce, SFEI.

1.2.4.1 High Marsh (lvl 5 class)

High tidal marsh supports at least 30% cover of wetland vegetation and generally exists between the local Mean High Water tidal datum (MHW) and the Highest Astronomical Tide (HAT). During BHM2020 mapping, a two year annual flood extent, using the 1983-2001 tidal epoch, was used as a proxy for HAT because the 1983-2001 tidal epoch doesn't include recent sea level rise. It is distinguished from Low Marsh (see 1.2.4.2 below) by its relatively infrequent tidal inundation and populations of annual forbs. Throughout the estuary, high marsh tends to support perennial pickleweed (*Salicornia pacifica*) with occasional co-dominance of Jaumea (*Jaumea carnosa*), fathen (*Frankenia salina*), saltgrass (*Distichlis spicata*), and other species. This category includes habitats that have been colloquially described as "mid marsh" in other SFE tidal marsh conservation documents.

Figure 18: High Marsh. Corte Madera Ecological Reserve. Sarah Pearce, SFEI.

Figure 19: High Marsh. Laumeister Marsh. Sarah Pearce, SFEI.

1.2.4.2 Low Marsh (lvl 5 class)

Low tidal marsh supports at least 30% cover of wetland vegetation and generally exists between the local Mean High Water tidal datum (MHW) and local Mean Low Water tidal datum (MLW). Under less saline conditions (e.g. Suisun Marsh, locations where large tributaries enter the

estuary), low tidal marsh can in some cases extend to MLLW. It is distinguished from High Marsh (see 1.2.4.1 above) by its relatively frequent tidal inundation and dominance by perennial vegetation. In more saline portions of the estuary, low marsh is typically dominated by perennial native cordgrass (*Spartina foliosa*) or, in occasional ephemeral populations, annual pickleweed (*Salicornia depressa*). In less saline portions of the estuary, low marsh can be dominated by numerous perennial species including alkali bulrush (*Bolboschoenus maritimus*), cattails (*Typha* spp.), and tules (*Schoenoplectus* spp.). Eelgrass (*Zostera marina*) beds are subtidal habitats and are not included in low marsh.

Figure 20: Low Marsh. China Camp State Park. Sarah Pearce, SFEI.

Figure 21: Low Marsh. China Camp State Park. Gwen Miller, SFEI.

Figure 22: Low Marsh. China Camp State Park. NAIP NIR.

1.2.5 Beach

Beaches are tidal baylands above Mean Lower Low Water (MLLW) and below the Highest Astronomical Tide (HAT), that mostly consist of unconsolidated sand, gravel, or shell fragments that are deposited by wind waves and vessel wakes, and that support less than 30% cover of vascular plant growth. This vegetated cover cut off is consistent with the U.S. Fish & Wildlife Service's National Wetland Inventory "Unconsolidated Shore" definition. Beaches provide high tide or flood refugia for wildlife, provide unvegetated high tide shorebird roosts, and create well-drained high marsh habitat for tidal marsh plants (USFWS 2013).

During BHM2020 mapping, a two year annual flood extent, using the 1983-2001 tidal epoch, was used as a proxy for HAT because the 1983-2001 tidal epoch doesn't include recent sea level rise. Furthermore spectral similarity growth both upward and downward is utilized instead of using hard cut offs at modeled relative tidal elevation to account for variation in tidal influence across the study area.

Figure 23: Point Pinole shoreline. Sarah Pearce, SFEI.

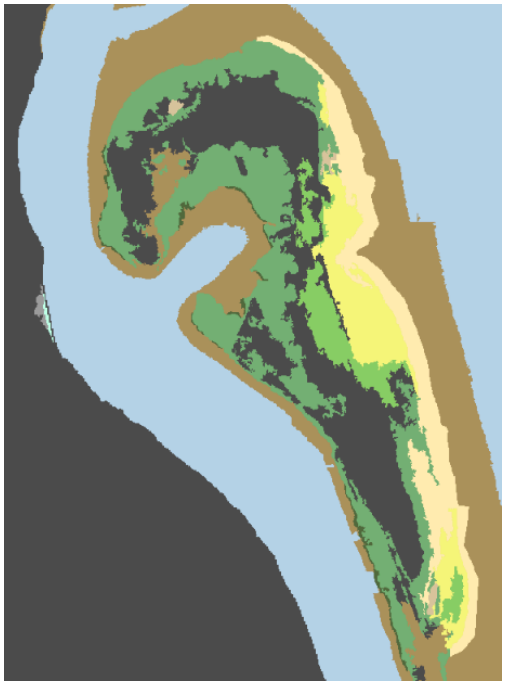


Figure 24 and 25: Beach and Dune habitat on the East facing side of Aramburu Island, True Color 2020 NAIP, and Bayland Habitat Map 2020.

1.3 Intertidal - Limited to No Tidal Connection

Intertidal estuarine areas have elevations between the local MLLW and Highest Astronomical Tide (HAT). Areas that have limited to no tidal connection have their physical connectivity with source tides impeded by structures such as levees, tide gates, and other obstructions. This category includes estuarine areas with muted and/or managed tides, as well as areas that have been completely cut off from tidal influences such as baylands used for agricultural purposes and developed/urban bayland areas.

During the BHM2020 mapping effort, the designation of an area having limited or no tidal connection was assessed by hydro-enforced digital elevation models (DEM), shoreline mapping (San Francisco Bay Shore Inventory - SFEI dataset), and visual interpretation of Google Earth Pro and Google Street View imagery. Also during BHM2020 mapping, a two year annual flood extent, using the 1983-2001 tidal epoch, was used as a proxy for HAT because the 1983-2001 tidal epoch doesn't include recent sea level rise.

1.3.1 Other Marsh

Other marsh includes non-tidal, muted tidal, and managed tidal marsh supporting at least 30% cover of tidal marsh vegetation and that are regularly wetted. 30% vegetated cover is used due to the high spatial resolution of the four band imagery (60cm) and is consistent with the cutoff used by U.S. Fish & Wildlife Service for National Wetland Inventory mapping when determining which vegetation type is dominant and determines class type.

Marsh functions and habitat provided largely depend upon management of the marsh. For instance, some muted tidal marshes (such as abandoned salt ponds, farmed bayland or grazed bayland) can provide good quality habitat without actively being managed as wildlife habitat. Managed marsh areas are actively managed to provide wildlife habitat, but can be managed for specific species or suites of species (e.g. ducks) or for other purposes (e.g., floodwater storage basins), causing a wide variety of resultant habitats and functions. Additionally, the hydroperiod, including the frequency, duration, and spatial extent of inundation, will vary with the type of marsh and management.

1.3.1.1 Muted Tidal Marsh (lvl 5 class)

A muted tidal marsh is an area of tidal bayland supporting at least 30% cover of tidal marsh vegetation, and a monthly or more frequent nexus with a muted tide, meaning that the depth or spatial extent of tidal inundation of the muted tidal marsh is lessened by artificial water control structures, such as constructed levees, seas walls, berms, tide gates, culverts, weirs, etc. The muted tide tends to attain a lesser height than the closest source of unmuted tide. 30% vegetated cover is used due to the high spatial resolution of the four band imagery (60cm) and is consistent with the cutoff used by U.S. Fish & Wildlife Service for National Wetland Inventory mapping when determining which vegetation type is dominant and determines class type.

The concept of a muted tide does not pertain to lands that are purposefully irrigated or inundated by the tide on either seasonal or annual schedules, such as some salt evaporation

ponds, lagoons, or duck clubs, or that are occasionally or infrequently tidal to any extent, such as some lagoons. The concept also does not pertain to interior or inland reaches of tidal marsh that only experience an occasional nexus with the tide due to their existence at the upper limit of the intertidal zone, or near the maximum landward extent of the tidal wave, but not due to the influence of artificial water control structures. For example, Marta's Marsh in Marin County is a muted tidal marsh, whereas the Grizzly Island Unit of the Suisun Marsh is not a muted tidal marsh.

Figure 26: Hoffman Marsh, Sarah Pearce, SFEI.

1.3.1.2 Managed Marsh (lvl 5 class)

Managed marshes are diked baylands or muted tidal marshes that support at least 30% cover of wetland vegetation, and that are actively managed to support native wildlife. Managed Marshes can include duck clubs, public wildlife refuges, and floodwater storage basins.

Areas of "Other Marsh" are only designated as "Managed Marsh" when there is a higher level of confidence regarding the management regime due to feedback from partners/stakeholders. This is because it is challenging to use remotely sensing to determine management in this often modified environment.

1.3.1.3 Undetermined Other Marsh (lvl 5 class)

Undetermined Other Marsh refers to an area of tidal bayland supporting at least 30% cover of tidal marsh vegetation and is regularly wetted. 30% vegetated cover is used due to the high spatial resolution of the four band imagery (60cm) and is consistent with the cutoff used by U.S.

Fish & Wildlife Service for National Wetland Inventory mapping when determining which vegetation type is dominant and determines class type. These areas may in fact be muted or managed marshes, but that distinction hasn't been determined. This may be because the management or full tidal influence is difficult to fully assess through plane based imagery and elevation data alone. To further refine their classification it would likely require obtaining site specific information from land owners and/or managers.

1.3.2 Other Open Water

Other Open Water is used to describe intertidal areas, that are often inundated, have limited to no tidal connection, and support less than 30% vascular vegetation. They often are impoundments of surface or bay waters that may or may not have a connection to tidal action. These areas do not regularly receive upland runoff either as channelized flow or sheet flow. This category includes the level five classes of managed open water, playas, wastewater ponds, salt ponds and undetermined other open water areas.

During the BHM2020 mapping effort, breakline datasets from the most recent LiDAR datasets were used to help delineate "Other Open Water" features. Furthermore, for BHM2020, the level five classes nested under "Other Open Water" were not speciated out from one another. See section Baylands Habitat Map 2020 Effort for more information.

1.3.3 Non-Aquatic Diked Baylands

Non-Aquatic Diked Baylands are areas that historically were tidal connected baylands, but no longer have a nexus to the tide due to the construction of levees, dikes, sea walls, or other water control structures. They represent areas that are not aquatic habitats and are largely used primarily for anthropogenic purposes. Examples include farmed baylands and urban development.

During the BHM2020 mapping effort, the level five classes nested under "Non-Aquatic Diked Baylands" were differentiated by using other available GIS datasets such as C-CAP and Land IQ Agriculture data. It is not the priority of the WRMP to invest in the mapping of these classes within Non-Aquatic Diked Baylands" and thus relies on other mapping efforts to delineate these classes. See section "Baylands Habitat Map 2020 Effort" for more information.

1.3.3.1 Low Intensity Agriculture (lvl 5 class)

Low Intensity Agriculture areas represent portions of diked baylands that have no tidal nexus and are utilized for agricultural purposes that require limited agricultural infrastructure investment, such as livestock pastures and grain/hay crops. The use of "Intensity" in this classification system is not meant to directly reflect the level of output of agricultural products.

For BHM2020 mapping, Land IQ agricultural data was used to identify "Low Intensity Agriculture" within "Non-Aquatic Diked Baylands" by intersecting features classified as "Pasture" or "Grain/Hay".

1.3.3.2 High Intensity Agriculture (lvl 5 class)

High Intensity Agriculture areas represent portions of diked baylands that have no tidal nexus and are utilized for agriculture that require larger investment in infrastructure such as irrigation, water control structures etc. The use of “Intensity” in this classification system is not meant to directly reflect the level of output of agricultural products.

For BHM2020 mapping, Land IQ agricultural data was used to identify “High Intensity Agriculture” within “Non-Aquatic Diked Baylands” by intersecting features classified as “Unspecified Crops”, “Citrus and Subtropical”, “Deciduous”, “Field Crops”, “Rice”, “Truck Crops”, “Vineyard”, and “Young Perennial”

1.3.3.3 Developed/Urban (lvl 5 class)

Developed/Urban areas represent portions of diked baylands that are dominated by roads, buildings and other significant maintained man-made infrastructure on them. These areas could also be considered part of the “built environment”. They often have greater coverage of impervious surfaces and have more limited wildlife habitat value.

For BHM2020 mapping Land IQ “Urban” features, Microsoft Buildings, and C-CAP 2021 “Impervious” layers were used to determine Developed/Urban areas within the Non-Aquatic Diked Baylands classification.

1.3.3.4 Undetermined Non-Aquatic Diked Bayland (lvl 5 class)

Undetermined Non-Aquatic Diked Baylands represent portions of diked baylands that no longer have a nexus to tidal action. These areas are not used for agricultural purposes nor are they dominated by man-made infrastructure. However they do not support aquatic habitats.

1.4 Supratidal

Supratidal estuarine areas have elevations above the Highest Astronomical Tide (HAT), but are nonetheless strongly influenced by estuarine processes such as tides and waves. Supratidal estuarine areas include dunes and levees. For BHM2020 this class doesn’t include other upland areas such as Terrestrial or Riparian, which in the WRMP Habitat Classification system are noted as being classes to be mapped by other existing or future initiatives.

During BHM2020 mapping, a two year annual flood extent, using the 1983-2001 tidal epoch, was used as a proxy for HAT because the 1983-2001 tidal epoch doesn’t include recent sea level rise.

1.4.1 Levee

Levees are natural or artificial embankments that mostly consist of natural sediments (although they might be unnatural and imported), and that extend above the attendant usual high water line, meaning the bankfull stage of rivers and creeks, the Highest Astronomical Tide (HAT) of tidal channels and tidal baylands. During BHM2020 mapping, a two year annual flood extent, using the 1983-2001 tidal epoch, was used as a proxy for HAT because the 1983-2001 tidal

epoch doesn't include recent sea level rise. Geomorphon lidar derivative layers were used to identify levees by pulling out peaks and ridges in these Supratidal elevation zones with additional work to grow into flat and shoulder, and spur land forms when overlapping with engineered shorelines. Furthermore, an internal review of the San Francisco Bay Shore Inventory dataset was done to create an interim version with limited updates that helped to confirm signatures detected in both imagery and LiDAR datasets used in the BHM2020 algorithm.

While levees are not wetlands, they can provide important functions for adjacent wetlands or the wildlife that they support. Levees can control the amount of tidal influence that the habitat feature receives, and also the depth of water within the feature. They can also protect habitat features from waves, boat wake, or poor water quality from an adjacent channel, slough or open water area. Levees can provide refugia for birds, small mammals and reptiles during high tides or flooding events. But levees can also provide an entryway for predators or humans to access sensitive habitats.

Figure 27: Levee, Santa Clara County. Sarah Pearce, SFEI.

1.4.2 Dune

Dunes occur above the Highest Astronomical Tide (HAT) and represent an active accumulation of sand immediately landward of the shoreline or slightly inland due to wind-transport of sand. Sand deposition, accretion and erosion can cause various dune morphologies. Dunes can be vegetated or unvegetated, with vegetation typically increasing the stability of the dune. Dune vegetation is adapted to the low moisture and nutrient content of the sand, as well as the windy

conditions. Dunes provide habitat for a variety of adapted plant species such as lupine and monkeyflower species, as well as wildlife such as lizards, voles, sand wasps, and bumblebees.

During BHM2020 mapping, a two year annual flood extent, using the 1983-2001 tidal epoch, was used as a proxy for HAT because the 1983-2001 tidal epoch doesn't include recent sea level rise.

Figure 28: Dune (not from the Bay Area). Sarah Pearce, SFEI.

2. Upland

In the BHM2020 mapping effort there is an "Upland" class to cover areas within the Subregion, that are above the Highest Astronomical Tide (HAT), and are not as strongly influenced by estuary processes. This divergence from the WRMP Habitat Classification system is due to the fact that Terrestrial and Riparian habitat types are designated, by the WRMP, as being classes to be mapped by other existing or future initiatives. Upland areas include adjacent lands and waters of the watersheds draining above ground or below the ground surface to the Estuary, including the portions of the OLUs above and inland of the baylands. These regions are not the focus of the BHM2020 or WRMP and thus have been left in this more inclusive and more general "Upland" Class.

During BHM2020 mapping, a two year annual flood extent, using the 1983-2001 tidal epoch, was used as a proxy for HAT because the 1983-2001 tidal epoch doesn't include recent sea level rise.

Appendix A - WRMP Habitat Type Classification System Table

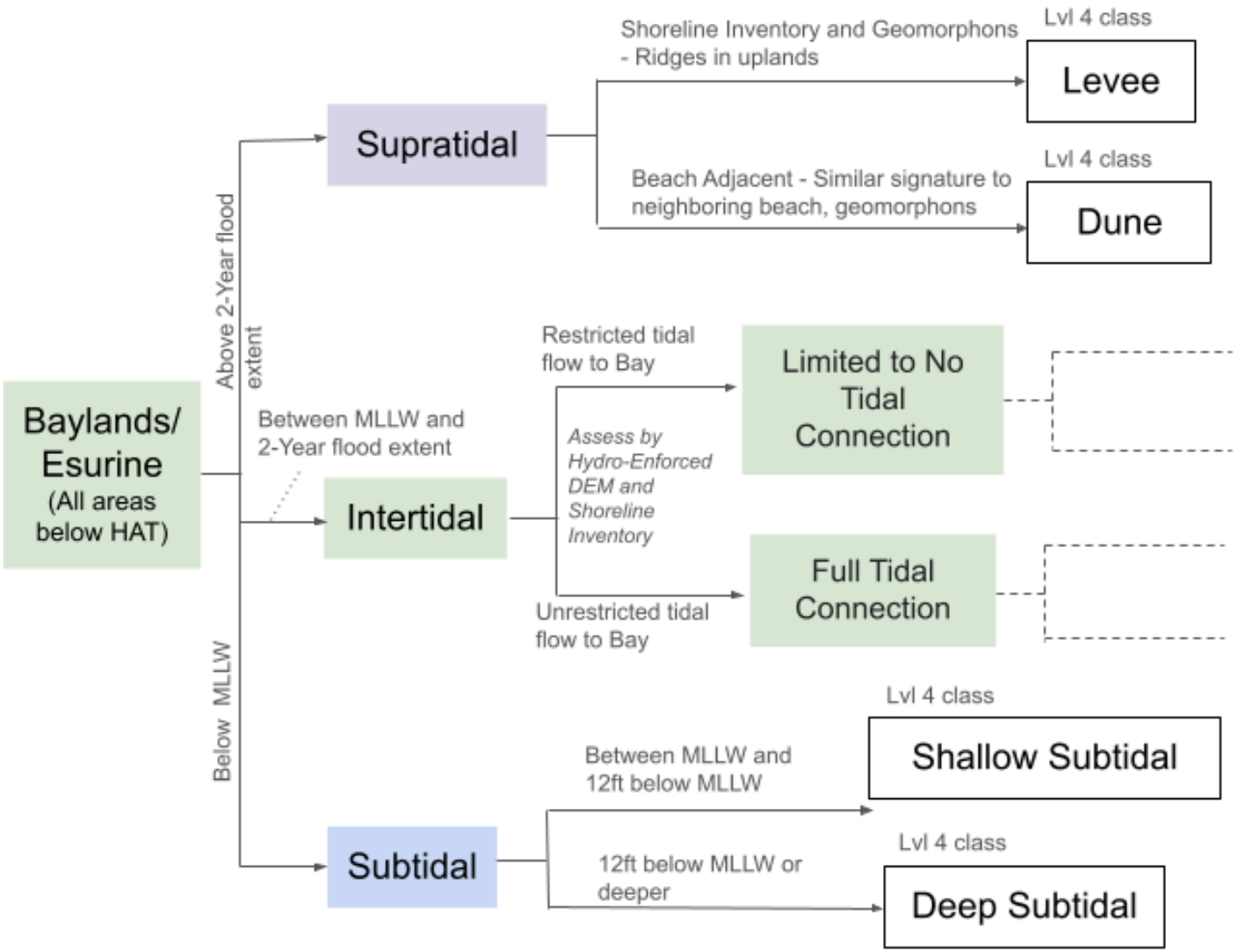
Level 1: Geography	Level 2: Landscape Complex	Level 3: Hydrogeomorphic Setting	Level 4: Ecosystem Complex/Habitat Type	Level 5: Functional Habitat
Subregion	Estuarine (Derived)	Subtidal	Shallow Subtidal	SAV/FAV Beds
				Shallow Subtidal Without SAV
			Deep Subtidal	
		Intertidal, Full Tidal Connection	Tidal Flat	
			Tidal Pond/Panne	
			Intertidal Channel	Intertidal Channel
				Intertidal Borrow Ditch
			Tidal Marsh	High Marsh
				Low Marsh
			Beach	
		Intertidal, Limited to No Tidal Connection	Other Marsh	Muted Tidal Marsh
				Managed Marsh
				Undetermined Other Marsh
			Other Open Water	Managed Open Water
				Salt Pond
				Playa
				Wastewater Pond
				Undetermined Other Open Water
			Non-Aquatic Diked Baylands	Low Intensity Agriculture
				High Intensity Agriculture
				Developed/Urban
				Undetermined Non-Aquatic Diked Bayland
		Supratidal	Levee	
			Estuarine-Terrestrial Transition Zone	
			Dune	
	Riverine (Acquired)	Fluvial Channel	River/Stream	River/Stream
			Flood Control Channel	Flood Control Channel
		Floodplain	Floodplain	Low Intensity Agriculture
				High Intensity Agriculture
				Woody Riparian
				Point Bars/Unvegetated Flats

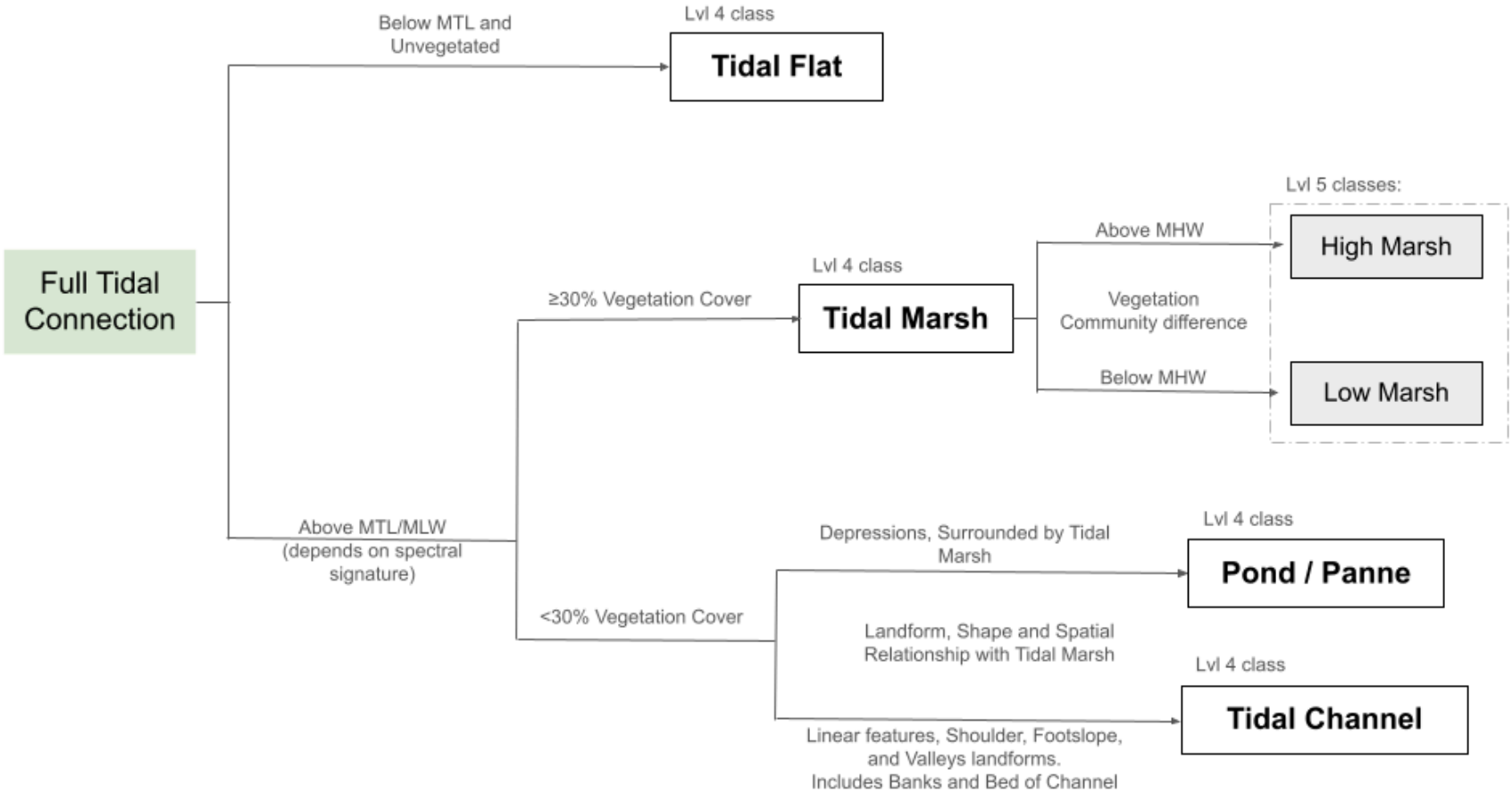
				Floodplain Marsh
	Terrestrial (Acquired)	Depressional Wetland	Depressional Wetland	Seasonal Wetlands
				Vernal Pools
		Hillslopes	Hillslopes - Natural	Grassland
				Shrubland
				Woodland
			Hillslopes - Developed	Low Intensity Agriculture
				High Intensity Agriculture
				Parks/Open Spaces

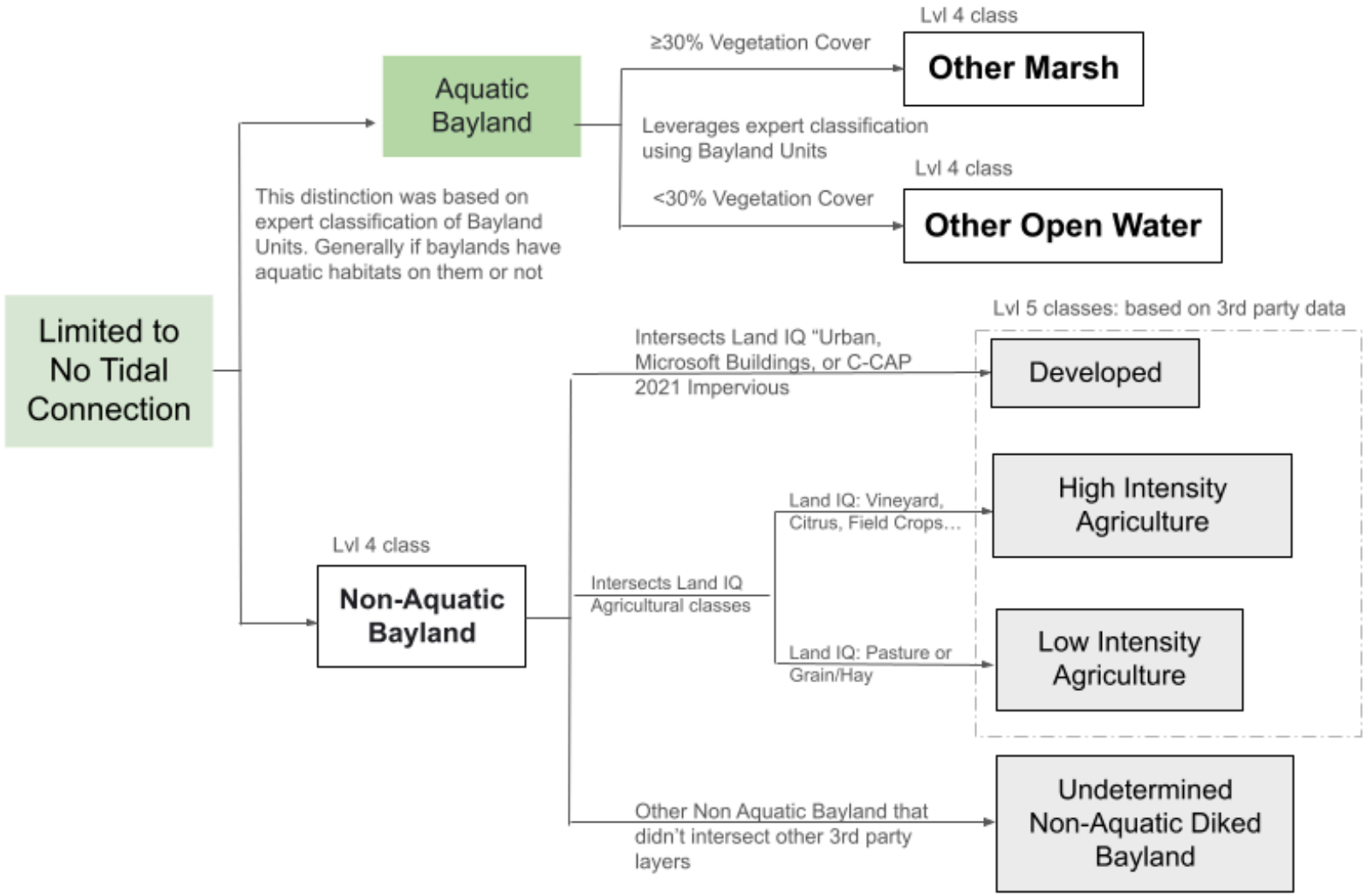
This is a table of the WRMP Habitat Type Classification System. Light blue fields represent classes that were mapped by the Baylands Habitat Map 2020 effort using remote sensing. An exception includes the level 5 classes that are included in BHM2020, under the level 4 classes “Non-Aquatic Diked Baylands”. Level five classes under “Non-Aquatic Diked Baylands” were attributed using other available datasets (e.g. Land IQ agriculture, C-CAP imperviousness), and were not derived in the BHM2020 effort using remote sensed signatures. Their definitions rely more upon the methodology and accuracy of those third party datasets. BHM2020 accuracy assessment and change detection analysis should occur at the level 4 Habitat Type level.

Appendix B - Habitat Class Decision Tree to level 4

BCB Habitat Classification Key - "Flow"




Full Tidal Connection
Below MTL and Unvegetated
Lvl 4 class
Tidal Flat
Above MTL/MLW (depends on spectral signature)
≥30% Vegetation Cover
Lvl 4 class
Tidal Marsh
Lvl 5 classes:
Above MHW
High Marsh
Vegetation Community difference
Below MHW
Low Marsh
<30% Vegetation Cover
Depressions, Surrounded by Tidal Marsh
Lvl 4 class
Pond / Panne
Landform, Shape and Spatial Relationship with Tidal Marsh
Lvl 4 class
Tidal Channel
Linear features, Shoulder, Footslope, and Valleys landforms. Includes Banks and Bed of Channel


Limited to No Tidal Connection
Aquatic Bayland
This distinction was based on expert classification of Bayland Units. Generally if baylands have aquatic habitats on them or not
Leverages expert classification using Bayland Units
≥30% Vegetation Cover
Lvl 4 class
Other Marsh
<30% Vegetation Cover
Lvl 4 class
Other Open Water
Lvl 4 class
Non-Aquatic Bayland
Intersects Land IQ "Urban, Microsoft Buildings, or C-CAP 2021 Impervious
Lvl 5 classes: based on 3rd party data
Developed
Intersects Land IQ Agricultural classes
Land IQ: Vineyard, Citrus, Field Crops…
High Intensity Agriculture
Land IQ: Pasture or Grain/Hay
Low Intensity Agriculture
Other Non Aquatic Bayland that didn't intersect other 3rd party layers
Undetermined Non-Aquatic Diked Bayland

Appendix C - Additional Definition notes:

Estuarine-Terrestrial Transition Zone

Estuarine-Terrestrial Transition Zone is critical to map for future planning and management of Bayland habitats. The BHM2020 mapping effort was not scoped to include mapping of this critical habitat zone. It's important to note that this zone may overmap fully or partially with multiple habitat types that are captured in the BHM2020 mapping effort. The WRMP intends to map it using methods outlined in the WRMP SOP for Indicators 1 and 3.

The following habitat types Fall under 1.2.2 Tidal Pond/Panne and are level 5 categories that were not mapped in the Baylands Habitat Map 2020 effort published in 2024. The definitions listed below represent a starting point for further refinement and definition of these functional habitat types.

Panne

Pannes are features of high tidal marshes that tend to store water between inundations by the tide. They may be perennial or seasonal. Most pannes have a persistent average depth over time less than 12 inches. They usually support less than 30% cover of vascular vegetation, although some brackish pannes support dense colonies of submergent vegetation, especially Ruppia maritima. 30% vegetated cover is used due to the high spatial resolution of the four band imagery (60cm) and is consistent with the cutoff used by U.S. Fish & Wildlife Service for National Wetland Inventory mapping when determining which vegetation type is dominant and determines class type. Pannes often form on tidal marsh plains equidistant from tidal channels, and along the upland margins of tidal marshes.

Perennial Pond

A perennial pond is a natural or artificial uncovered impoundment of standing water in diked baylands or adjacent uplands that lasts to some aerial extent throughout the year during most years. The non-vegetated, perennial, open water area of a salt pond, diked marsh, or depressional upland wetland qualifies as a perennial pond.

Seasonal Pond

A seasonal pond is a natural or artificial uncovered impoundment of standing water in diked baylands or adjacent uplands that does not last throughout the year during most years. Its occurrence usually corresponds to some portion of the wet season. The non-vegetated, non-perennial, open water area of a salt pond, diked marsh, or depressional upland wetland qualifies as a seasonal pond.