San Francisco Estuary

Wetlands Regional Monitoring Program

# 2024 Wetland Condition Survey Report

## *Using the California Rapid Assessment Method*

SF ESTUARY
Wetlands
Regional
Monitoring
Program

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**A PRODUCT OF**

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San Francisco ESTUARY PARTNERSHIP    SFEI San Francisco Estuary Institute

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# Summary of Key Findings

The California Rapid Assessment Method (CRAM) for Estuarine Wetlands is a monitoring tool that has been built into the Wetlands Regional Monitoring Program's (WRMP) Science Framework because it is an established, cost-effective, and scientifically defensible method that characterizes the overall ecological health, or condition, of wetlands in California. CRAM provides numerical scores of wetland condition that estimate the potential of a wetland to provide expected ecological services (e.g. flood control, support of endemic biological diversity), given the wetland's type and environmental setting. Within the WRMP, CRAM is being used to help to address Guiding, Management, and Monitoring Questions such as:

What is the distribution, abundance, diversity, and condition of tidal marsh ecosystems, and how are they changing over time?

How do policies, programs, and projects to protect and restore tidal marshes affect the distribution, abundance, and health of plants and animals?

This report summarizes two efforts:

1. A retrospective analysis of existing historical CRAM data to evaluate and compare the spatial and temporal distribution of wetland conditions across the San Francisco Estuary (estuary), and

2. CRAM results from the 2024 field monitoring effort that began to fill key data and information gaps within the WRMP's Priority Network sites.

In 2023, the overall ecological condition of tidal wetlands in the estuary was characterized using existing estuarine CRAM data. The evaluation used two groups of data:

1. All estuarine CRAM data from the estuary (All Data, n = 183), and

2. Estuarine CRAM data only from WRMP Priority Site Network locations (WRMP Data, n = 39).

Three questions were evaluated to guide CRAM data collection in 2024.

1. **What is the overall ecological condition of tidal wetlands?** Overall, tidal wetlands are in Fair to Good condition across the entire estuary. However, both groups of data represent targeted assessments, which were completed for reasons other than characterizing the region-wide ambient condition; because these two groups of data include many impacted and project sites, they trend towards slightly lower condition than the ambient condition captured within the San Francisco Bay Estuarine cumulative distribution function (CDF) curve. A CDF curve estimates the proportion of estuarine wetlands that are in Good, Fair, or Poor condition based upon an ambient survey of condition. The CDF curve shows that the ambient condition of wetlands in the estuary includes 50% in Good condition; however, only 37% of the targeted, existing individual assessments are in Good condition. For further detail see *CRAM and the Cumulative Distribution Function Curve* in the Results section below.
2. **How does the condition vary across the estuary?** Patterns of condition are similar for the Suisun, San Pablo, and South sub-embayments; however, the Lower South sub-embayment

has the highest percentage of Good condition tidal wetlands, while the Central sub-embayment has the lowest percentage. Comparing scores by WRMP Site Types (Benchmark, Reference, and Project) shows that, with significant overlap between Types, Benchmark sites tend to be in better condition than Reference sites, which tend to be in better condition than Project sites, as expected. For further detail see Question 2 in the Results section below.

3. **Where are the data gaps?** The existing data show that several spatial and temporal gaps exist. The largest limitation of the existing data is the inadequate characterization of tidal wetlands using CRAM assessments; this existing data provides a foundation for the WRMP, but additional CRAM data will need to be collected to meet the WRMP's needs. For further detail see Question 3 in the Results section below.

CRAM was chosen as one of two initial monitoring activities to be implemented by the WRMP in 2024. A total of 33 CRAM assessments were completed in 18 individual Priority Network sites between July and October 2024. The Priority Network sites primarily include Project and Reference sites, but also include two Benchmark sites. Of these 2024 assessments, 73% are in Fair condition while 27% are in Good condition. The CDF curve shows that 60% of the 2024 assessments are in the lowest 15th percentile of condition, and 15% are in the lowest 1st percentile of condition. These lowest scores occur within WRMP Project sites; this result is expected because most of the projects are young, and are being assessed after only a few years since tidal restoration was completed. One would not expect a tidal wetland to be very complex and in Good condition after only a few years of maturation.

The 2024 CRAM data were also compared to the San Francisco Estuary estuarine habitat development curve (HDC), another CRAM-based decision support tool. An HDC displays the expected rate of improvement in the overall ecological condition of a wetland restoration or mitigation project based on the age of the project since its completion. Despite being in relatively low condition, scores plotted on the HDC illustrate that almost all of the Project site assessments are currently plotting on or above the curve, indicating that they are maturing at the expected rate.

The San Francisco Bay Restoration Authority is funding the WRMP to continue to conduct CRAM assessments over the next three years (2025-2028) at a level similar to the 2024 monitoring. The WRMP is currently developing near-term monitoring plans employing CRAM, including assessments that support status and trends monitoring, and restoration project performance tracking and success evaluation. The versatility and utility of CRAM within a broader WRMP monitoring framework will be key for helping to answer some of the WRMP's most important guiding, management, and monitoring questions.

# Introduction

The San Francisco Estuary's Wetlands Regional Monitoring Program (WRMP) brings together the region's tidal wetland community to bridge the gap between:

1. ambient monitoring necessary to assess the influence of landscape-scale drivers such as climate change and watershed management on tidal wetlands across multiple spatial and temporal scales, and
2. site-specific monitoring that is typically required of tidal wetland restoration project implementers by regulatory and resource agencies.

The WRMP's mission is to deliver coordinated regional monitoring of San Francisco Estuary (estuary) tidal wetlands to:

1. inform science-based decision-making for wetland restoration and adaptive management, and
2. increase the cost-effectiveness of permit-driven monitoring associated with wetland restoration projects.

The WRMP has developed a Science Framework that structures the tidal wetland monitoring, including Guiding and Management Questions. The WRMP has also established a Monitoring Site Network[1] of Benchmark, Reference, and Project sites across the estuary to provide organizational structure for the collection of new monitoring data and synthesis of existing data.

WRMP Site Types have been defined in the WRMP Program Plan (WRMP 2020):

- Benchmark Sites: mature millennial marshes that represent the target endpoint of condition. These are known or assumed to be in approximate equilibrium with existing sediment supplies, salinity regimes, and tidal regimes, such that changes in any of these parameters can be detected using WRMP indicators.
- Reference Sites: marshes at mid to late stages of evolution and can include relatively mature centennial marshes that represent reasonable mid-term condition targets for new tidal wetland restoration and mitigation projects.
- Project Sites: restoration projects implemented over roughly the past 20 years. They include existing and planned tidal wetland restoration and compensatory mitigation projects to recover tidal wetland acreages, functions, and values.

[1] In January 2023, the WRMP TAC released the WRMP Priority Monitoring Site Network Memo, which summarizes the spatial monitoring framework in the Program Plan and describes and maps out the Benchmark, Reference, and Project Sites that form the WRMP's initial, near-term priority monitoring site network.

The California Rapid Assessment Method (CRAM) for Estuarine wetlands was chosen as one of two initial monitoring activities to be implemented in 2024—CRAM and Surface Elevation Table-Marker Horizon (SET-MH) monitoring—because it meets a number of the WRMP's science priorities, and is a foundational Level 2 assessment method (rapid assessment method for determining resource condition within the US Environmental Protection Agency's Wetlands Monitoring and Assessment Level 1-2-3 Framework) for establishing baseline and subsequent routine surveys of the overall ecological condition of estuarine wetlands in the estuary.

Specifically, CRAM has been built into the WRMP's Science Framework because it is an established, cost-effective monitoring tool that helps to address the ecological condition and vegetation components of Guiding Questions 1 and 4, and one or more underlying Management and Monitoring Questions:

**Guiding Question 1:** Where are the region's tidal marsh ecosystems, including tidal marsh restoration projects, and what net changes in ecosystem area and condition are occurring?

**Management Question 1A:** What is the distribution, abundance, diversity, and condition of tidal marsh ecosystems, and how are they changing over time?

***Monitoring Questions:***

- What is the overall condition and health of the estuary's tidal wetlands? (Note, for this Monitoring Question, CRAM is specifically identified as the primary WRMP monitoring method.)
- Where do tidal wetlands support complex habitat diversity and connectivity?
- Where are non-native species a significant component of the dominant tidal wetland vegetation community? Where are they expanding?
- How do tidal bayland morphology and vegetation qualitatively change over time?

Priority Recommended Action: Conduct regional baseline and subsequent routine surveys and inventories of the distribution, abundance, diversity, and condition of tidal wetlands throughout the region, using existing tools and metrics to the extent practicable and developing new tools and metrics where necessary.

**Guiding Question 4:** How do policies, programs, and projects to protect and restore tidal marshes affect the distribution, abundance, and health of plants and animals?

**Management Question 4A:** How are habitats for assemblages of resident species of fish and wildlife in tidal marsh ecosystems changing over time?

Priority Recommended Action*:* Repeat surveys (detect change) of living organisms and their habitats (indicators), and standardize the metrics and reporting for indicators that are common to projects and baseline/subsequent ambient monitoring across the range of project designs and restoration practices.

In addition to directly contributing to addressing these questions, the underlying CRAM Attributes, Metrics, associated plant species lists, and stressor checklists can serve as screening tools to identify locations where additional Level 3 (more intensively sampled and detailed data within the US Environmental Protection Agency's Wetlands Monitoring and Assessment Level 1-2-3 Framework) might be collected.

CRAM data collection could help detect early changes or trends, or could help answer other monitoring questions such as:

- What is the distribution and abundance of tidal wetland habitats that can support special-status species?
- What are the rates of change over time in the spatial extent and distribution of dominant vegetation communities along the primary and secondary salinity gradients of the estuary?

# CRAM Background

CRAM is a foundational component of the WRMP's site-scale monitoring activities that has been applied in estuarine wetlands across the estuary since 2005. It is an established, cost-effective, and scientifically defensible rapid assessment method for characterizing the overall ecological functional capacity or condition of wetlands in California. It was developed by the California Wetlands Monitoring Workgroup (CWMW) to support consistent biological monitoring and reporting throughout the state (www.cramwetlands.org; CWMW 2013a, 2019). CRAM has been applied and demonstrated at several landscape-scales to support regional and statewide baseline ambient surveys and monitoring programs (Lowe et al., 2020; SCCWRP, 2008). Baseline assessments provide a scientific standard for comparing subregional conditions and/or evaluating the performance of compensatory mitigation or restoration projects in a landscape context. CRAM is also being used as a standardized ecological condition assessment tool to inform project planning and tracking of pre- and post-project conditions to evaluate project performance over time compared to expected habitat development curves. The EcoAtlas toolset (www.ecoatlas.org) includes a number of interactive tools designed specifically to provide public access to CRAM results including data visualization and exploration on an interactive map, data download services, and a Landscape Profile tool that summarizes the amount, distributions and conditions of wetland resources at a landscape scale based on aquatic resource geospatial datasets, and CRAM data.

CRAM provides numerical scores that estimate the overall potential of a wetland and its adjacent upland area to provide levels of the ecological services expected given its type, condition, and environmental setting. CRAM scores are based on visible indicators of physical and biological form and structure relative to statewide reference conditions. Attribute and Index Scores range from 25-100, where a score of 25 indicates the lowest possible condition, and 100 indicates the best possible condition. CRAM scores can be grouped into three standard ecological health classes (condition classes) to characterize wetland condition as 1) Poor (scores of 25-50), 2) Fair (scores of 51-75), or 3) Good (scores of 76-100; CWMW, 2019). Results are often reported using these condition classes as a way to facilitate comparison and evaluation. CRAM also includes dominant plant lists and a Stressor Checklist that can be helpful ancillary information for evaluating how anthropogenic pressures impact tidal wetlands. Although the CRAM Stressor Checklist does not factor into the quantitative condition score, it is an important part of every assessment. The Stressor Checklist allows the practitioner to identify possible causes for low condition scores and possible corrective actions, and develop testable hypotheses relating scores to stressors. In other words, the Stressor Checklist can help explain the reasons behind low scores and identify solutions to reduce stress on the site, and thus increase the condition score. A stressor in this context is defined as an anthropogenic perturbation within the assessment area or its immediate environmental setting that is likely to negatively influence condition and function of the wetland (CWMW, 2013a).

**Rationale**

CRAM was evaluated by the WRMP's science team and Technical Advisory Committee (TAC) for implementation in 2024 because it met a number of criteria related to the program's science priorities and information needs including, but not limited to its ability to:

- **Support broad regional assessment** of the distribution, abundance, and condition of San Francisco Bay estuary tidal wetlands
- **Address funder and regulator interest** in evaluating restoration projects within a regional context
- **Identify opportunities to develop WRMP monitoring methods and strategies** to address required project monitoring and regulatory permitting requirements
- **Address the near-term science priorities** that are articulated in the 2020 Program Plan
- **Leverage legacy data and existing data** from ongoing ambient monitoring, project monitoring, and special studies
- **Fill key data and information gaps** across space and time
- **Support a high return on investment** and develop key information products with relatively minimal additional funds/effort (i.e., "picking the low-hanging fruit")
- **Inform planned tidal wetland restoration** and nature-based adaptation projects
- **Pilot data collection and interpretation at various scales** (regional, aerial imagery; rapid-assessment; and site-based)

## WRMP and CRAM

In 2023 and 2024, the WRMP staff and San Francisco Estuary Institute's (SFEI) CRAM team began to address some of the program's near-term science priorities and information needs by:

1. evaluating existing historical data from other studies, and
2. beginning to fill key data and information gaps within the WRMP's Priority Network sites with CRAM field monitoring.

This report summarizes these two efforts. Specifically, SFEI leveraged existing estuarine CRAM data by completing a retrospective analysis of data collected between 2007 and 2022 to evaluate and compare the spatial and temporal distribution of wetland conditions across the estuary. That analysis helped the WRMP staff develop the 2024 CRAM sampling plan that focused on beginning to fill information gaps within the program's Priority Network sites across the estuary.

# WRMP CRAM Tidal Wetland Analysis

## Research Questions and Goals

In 2023, SFEI staff characterized the overall ecological condition of tidal wetlands in the estuary using existing estuarine CRAM data sourced from EcoAtlas. The goal of the analysis was to compile and utilize existing data to begin to address three questions that could guide the initial design and implementation of WRMP CRAM data collection in 2024:

1. What is the overall ecological condition of tidal wetlands?
2. How does the condition vary across the estuary?
3. Where are the data gaps?

The SFEI team conducted a visual spatial analysis to evaluate patterns within the existing CRAM data. To begin, the team gathered four primary Level 1 (geospatial) and Level 2 (CRAM) data sources:

- San Francisco Bay sub-embayments (Suisun, San Pablo, Central, South, Lower South);
- WRMP Network Site Class (Priority, Secondary, Future);
- WRMP Site Types (Benchmark, Reference, Project);
- All existing CRAM estuarine assessment data (reported between 2007 and 2022).

The San Francisco Bay sub-embayments and the WRMP Network Site Classes are shown in Figure 1.

Each individual CRAM assessment was attributed with the sub-embayment where it was located, and, if the assessment was located within a WRMP site, the Site Type and its Priority Network. This newly attributed data comprised the dataset for analysis.

The evaluation divided the dataset into two groups: 1) all CRAM data from the entire estuary (All Data), and 2) CRAM data only from WRMP Priority Site Network locations (WRMP Data) (Figure 2). A total of 183 estuarine CRAM assessments in the estuary were downloaded from EcoAtlas (www.ecoatlas.org).

The data were collected for a variety of purposes at a variety of site types from earlier non-WRMP efforts. Of the 183 pre-existing assessments (All Data), 39 were located within 21 of the WRMP Priority Site Network locations and comprise WRMP Data. These assessments were collected between 2007 and 2022 and for a variety of purposes. It is important to note that none of the WRMP assessments were collected with the intent of characterizing the ecological conditions of the full site, which often included extensive wetland areas of between 7 to 1,285 ha (17 to 3,175 acres).


**Figure 1.** WRMP Network locations (Primary, Secondary, and Montezuma) and the corresponding five sub-embayments (demarcated by the dark grey line segments and labeled in black).

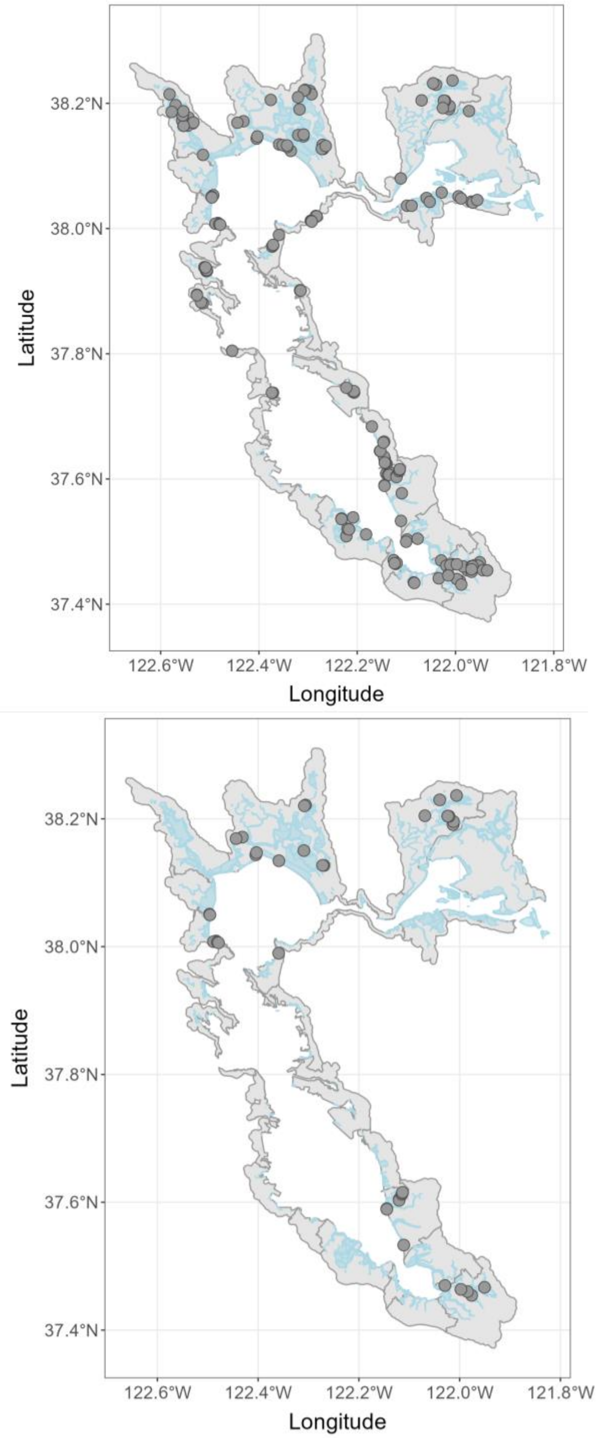


**Figure 2.** Location of CRAM assessments for All Data (top) and the WRMP Data subsets (bottom).

# Results

## Question 1: What is the overall ecological condition of tidal wetlands?

The overall ecological condition of tidal wetlands was characterized at the CRAM Index Score and CRAM Attribute Score levels. Overall, tidal wetland condition is in Fair to Good condition across the entire estuary. At the Index Score level for All Data, just over one-third of the assessments are in Good condition (37%), almost two-thirds are in Fair condition (62%), and only 1% are in Poor condition (Figure 3). Of note, the two assessments in Poor condition both have Index Scores of 50, which is at the top of the Poor condition health class. Within the WRMP Data subset, the percentage of assessments in each condition is nearly identical to All Data, with 41% of the assessments in Good condition and 59% in Fair condition (Figure 3).

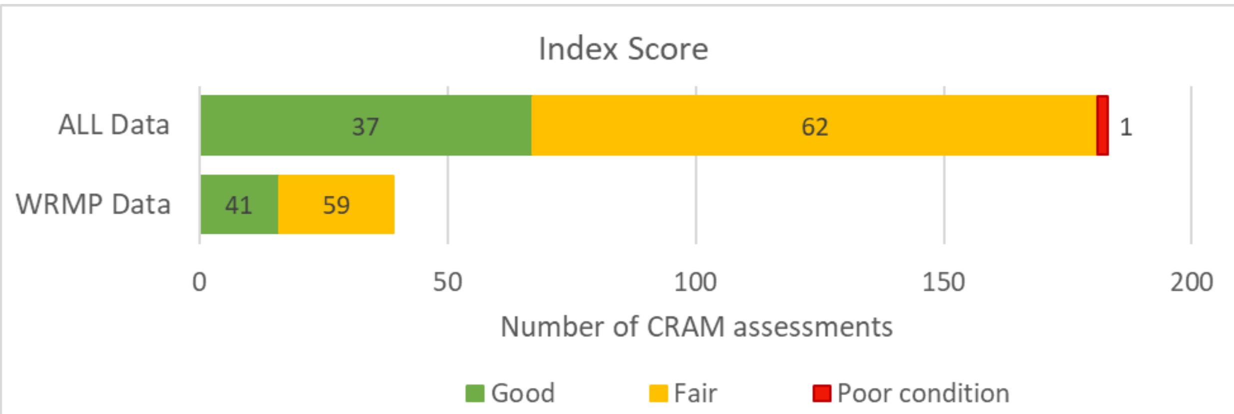


**Figure 3.** Overall ecological condition of tidal wetlands in the estuary using all existing (pre-2024) estuarine CRAM data (All Data, n = 183) and the subset of existing (pre-2024) CRAM data at WRMP sites (WRMP Data, n = 39). The numbers overlaid on the bars indicate the percent of Good, Fair, and Poor condition scores.

### CRAM and the Cumulative Distribution Function Curve

An alternative way to visualize the range of wetland conditions is to plot CRAM assessment scores on a cumulative distribution function (CDF) estimate, or curve. A CDF curve characterizes the percent of the aquatic resource (e.g., tidal wetland area) that has a specific CRAM score (or lower, as the curve is a cumulative estimate) with a known level of confidence. The x-axis of a CDF curve shows the CRAM Index Score, while the y-axis shows the percent of the aquatic resource in the area of interest (e.g., the percent of the estuarine wetland resources in the estuary). CDF curves can provide context for the range of conditions observed across the area of interest. The median CRAM Index Score can be found by selecting the 50th percentile on the y-axis, following it across horizontally until reaching the curve, then tracing straight down to read the corresponding CRAM Index Score on the x-axis. In addition, a CDF curve shows the percent of aquatic resources in each of the three condition classes (Poor, Fair, and Good). The shape and location of a CDF curve on the graph provides information about the overall condition of the tidal wetland area within the estuary. For example, a CDF curve that is shifted toward the right (towards higher CRAM Scores) reflects relatively better ecological conditions as compared to a curve that is shifted towards the left. A convex downward curve (one that starts on the left with a steep slope upward that then decreases towards the right) would indicate a higher proportion of wetland acres with low CRAM condition scores, compared to a convex upward curve (one that starts on the left with a gradual upward slope that increases towards the right) indicates a higher proportion of aquatic resources with high condition scores.

The CDF curve can be used to visualize the wetland conditions across the estuary by plotting the Index Scores for All Data on the San Francisco Bay Estuarine CDF curve (Figure 4). This CDF curve was developed from an ambient survey completed under a Region 9 Environmental Protection Agency (EPA) Wetland Program Development Grant in 2007 (SCCWRP, 2008). All Data (black diamonds) represents sites with Index Scores that span the full range of condition (Figure 4). The CDF curve shows that the 50th percentile (or median) condition has a CRAM Index Score of 75. For the region, the CDF curve estimates that 1% of the tidal wetland area is in Poor condition, 49% in Fair condition, and 50% in Good condition. Interestingly, many of the All Data assessments were part of the ambient survey that developed the CDF curve (with scores ranging between 60 and 93), and thus it is not surprising to see the CDF curve reflect this range of scores. However, the 17 plotted assessments with Index Scores less than 60 are all from tidal wetlands that are restoration sites assessed after 2008, thus none were included in the development of the San Francisco Bay Estuarine CDF curve.

In comparison to Figure 4, the Index Scores for the pre-existing assessments at WRMP sites can also be plotted on the CDF curve (Figure 5). The WRMP site assessments, which include Benchmark, Reference, and Project Site Types also almost span the full range of conditions across the estuary (though not the top 15th percentile of wetland area), meaning that this subset of data is fairly representative of conditions across the full estuary. However, the WRMP scores are skewed lower than the All Data scores; over half of the 39 existing assessments have scores in the lower 30th percentile of wetlands across the estuary (Index Scores less than 73) while only 15% are in the top 30th percentile of wetlands in the estuary (Index Scores of 82 or higher) plotted above the 70th percentile.

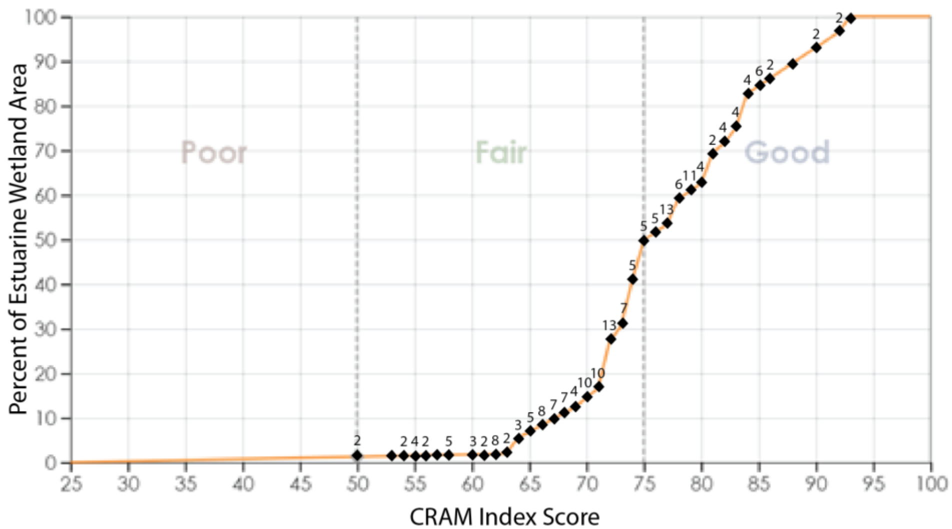


**Figure 4.** Cumulative distribution function (CDF) curve for the estuary with the CRAM Index Score plotted for All Data (n = 183). Many of the black diamonds represent multiple assessments with the same Index Score; numbers above each diamond indicate how many individual assessments have that same Index Score.

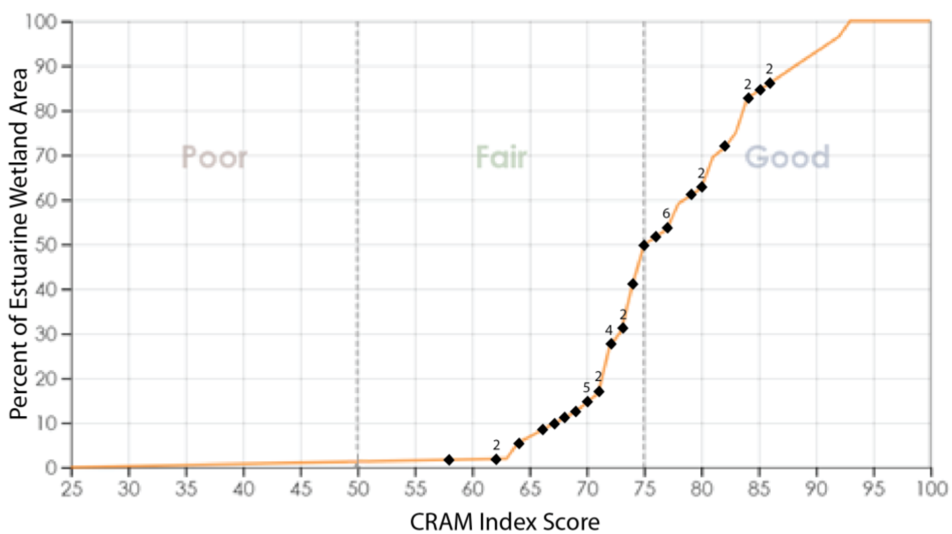


**Figure 5**. Existing WRMP Data subset plotted on the San Francisco Bay Estuarine cumulative distribution function (CDF) curve. Some of the black diamonds represent multiple assessments with the same Index Score; numbers above each diamond indicate how many individual assessments have that same Index Score.

## CRAM Attribute Scores

CRAM Attribute Scores are subcategories that provide additional information about specific aspects of estuarine wetland conditions (Buffer and Landscape Context, Hydrology, Physical Structure, and Biotic Structure) that are combined to make up the overall Index Score (Figure 6). For assessments included in All Data, differences between Attributes are readily apparent.

### Buffer and Landscape Context Attribute

The Buffer and Landscape Context Attribute has the largest percentage of assessments in Good condition, reflecting the fact that many of these tidal wetlands exist within a larger landscape of other aquatic features. These Good condition scores also reflect the relative dearth of data within the Central sub-embayment, where tidal wetlands tend to be located closer to development and thus would have lower condition.

### Hydrology Attribute

The relatively even distribution of scores within the Hydrology Attribute reflects the spectrum of hydrologic impacts that exist across the estuary. Some tidal wetlands exist within larger wetland areas that are far removed from urban runoff and impacts associated with levees. Other wetlands are located immediately adjacent to urban areas, have controls that affect the tidal regime, and are fully contained within levees (resulting in lower Hydrology Attribute Scores).

### Physical Structure Attribute

The Physical Structure Attribute has the highest percentage of Fair and Poor scores, likely reflecting the long history of tidal wetland simplification, dissection, and management, which tend to reduce the amount of complexity in its physical structure.

**Each of the four Attributes considers different aspects of condition.**

- **The Buffer and Landscape Context Attribute** considers the connectivity of the wetland to other aquatic resources (e.g., other tidal wetland areas), as well as the amount, width and condition of buffer area that serves to protect the wetland from anthropogenic stress.
- The **Hydrology Attribute** considers the sources, quantities and movements of water, plus the quantities, transport, and fates of water-borne materials, particularly sediment, because the physical structure of a wetland is largely determined by characteristics of water movement. It also considers any muting of the tidal prism and barriers to hydrologic connectivity (e.g., levees and berms).
- The **Physical Structure Attribute** considers the spatial organization of living and non-living surfaces that provide habitat for biota (Maddock, 1999).
- And finally, the **Biotic Structure Attribute** considers the composition and structure of the plant community, including vegetation height classes, co-dominant plant species, invasive plant species, and the 2-D and 3-D organization of the community.

### Biotic Structure Attribute

The Biotic Structure Attribute has a high percentage of assessments in Fair condition; the plant communities often reflect hydrologic impacts, restoration stage, and physical structure simplification.

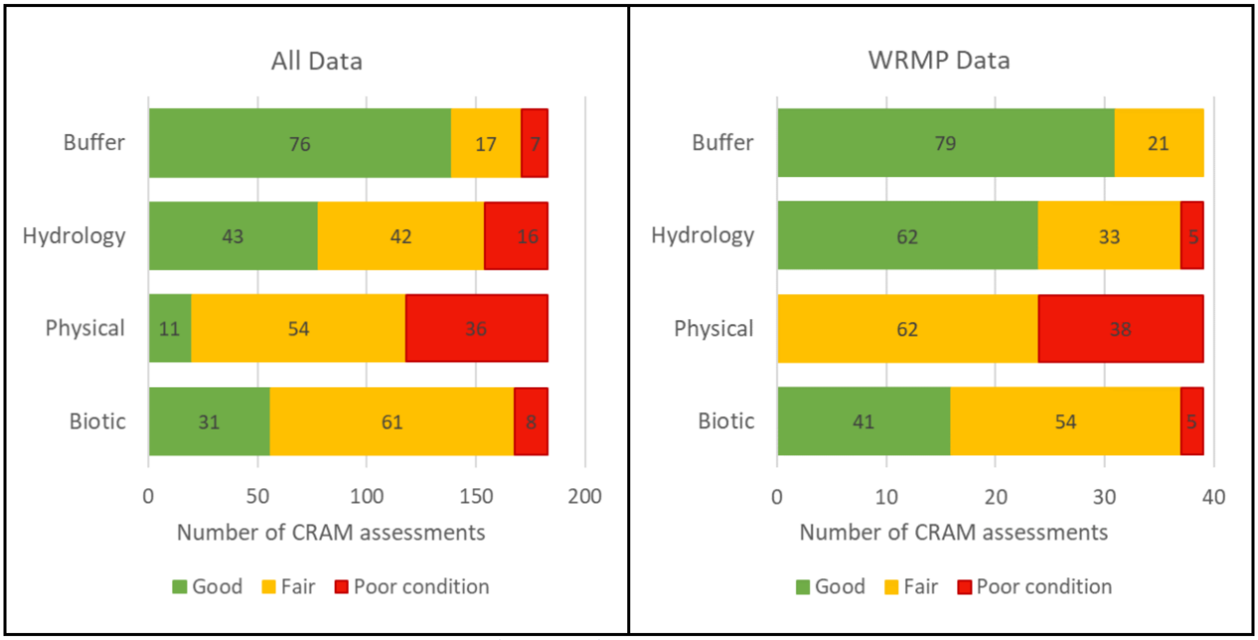


**Figure 6.** Left: Percentage of All Data (n = 183) CRAM assessment Attribute Scores in Good, Fair and Poor condition classes across the four CRAM Attributes. Right: Percentage of pre-existing WRMP Site Data (n = 39) CRAM assessment Attribute Scores in Good, Fair and Pool condition classes. The numbers overlaid on each bar indicate percentage.

## Question 2: How does the condition vary across the Estuary?

Existing data were used to begin to characterize how tidal wetland conditions vary spatially by sub-embayment and WRMP Site Type. Figure 7 (left) illustrates the spatial distribution of CRAM Index Scores by sub-embayment for All Data. CRAM data are available in all five sub-embayments; however, the Central sub-embayment has the fewest assessments. Figure 7 (right) summarizes the number of assessments by sub-embayment and percent of assessments in each condition class. The percentage of assessments in Good and Fair condition are roughly similar among the Suisun, San Pablo, and South sub-embayments. The Central sub-embayment only has a single assessment in Good condition, while the Lower South sub-embayment has the highest percentage (53%) of assessments in Good condition. This high percentage of Good condition is largely driven by Good condition Landscape and Buffer Context and Hydrology Attribute scores, along with Fair condition Physical Structure and Biotic Structure scores, representing the landscape position of these wetlands and large size of the marshes and adjacent aquatic resources. The WRMP Data subset shows a similar pattern by sub-embayment, except that there are no WRMP data for the Central sub-embayment (no associated Figure shown); this could be a consideration for future data collection.

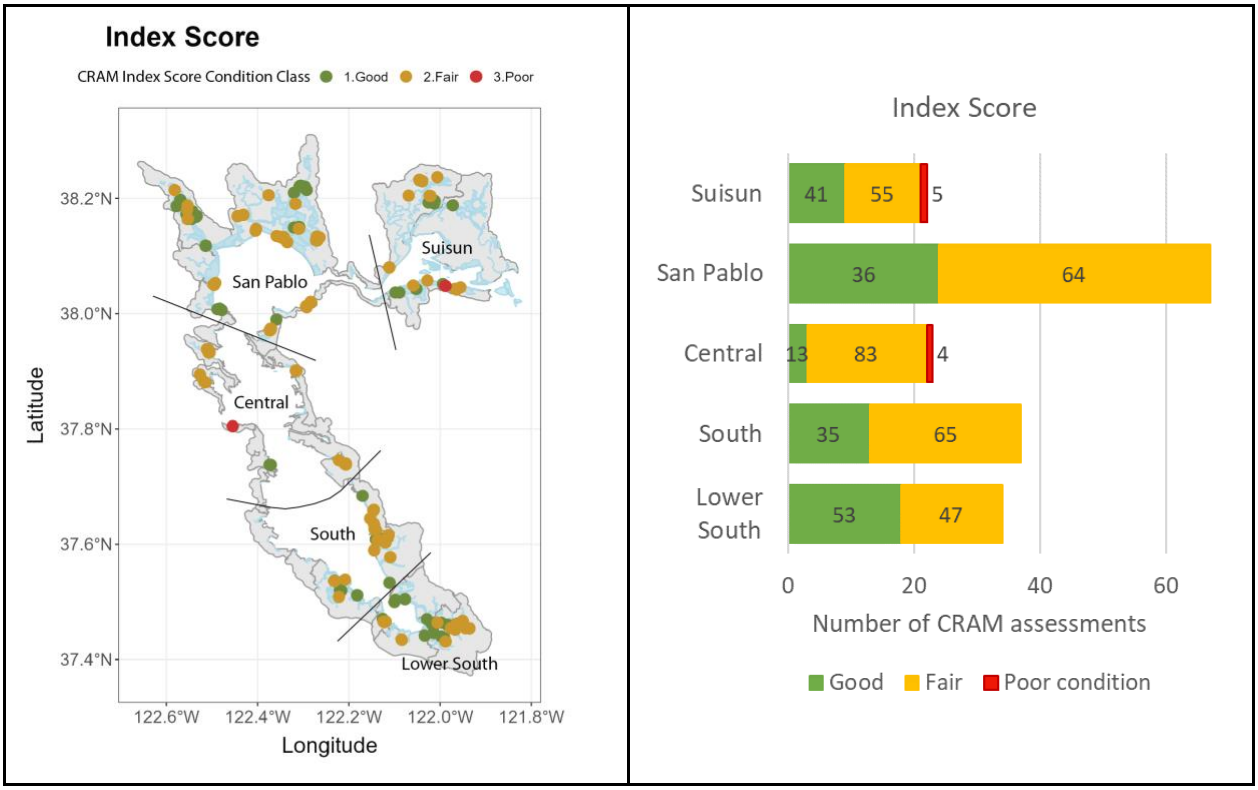


**Figure 7**. Left: Map showing condition at the Index Score level for All Data. Lines demarcate the five sub-embayments. Right: Bar charts illustrating the proportions of assessments in Good, Fair, or Poor condition at the Index Score level for the five sub-embayments for All Data. The numbers overlaid on each bar indicate percentages.

A comparison of the existing data by WRMP Site Types (Benchmark, Reference, and Project) was evaluated at the Index Score level between non-WRMP and WRMP sites. Figure 8 shows box and whiskers plots (boxplots) of the range of Index Scores among the three WRMP Site Types. With significant overlap in scores among the different groups, the median scores (bold horizontal lines within each boxplot) indicate that Benchmark sites tend to be in better condition than Reference sites, which tend to be in better condition than Project sites, matching expectations. Scores are expected to improve in restoration sites as they develop over time. Comparing non-WRMP and WRMP sites within each Site Type, the median for non-WRMP Benchmark sites is higher than the WRMP Benchmark sites, similar for Reference sites, and lower than the WRMP Project sites. For the Benchmark sites, this suggests that either 1) WRMP Benchmark sites are not inclusive of the best condition tidal wetlands in the estuary, or 2) the existing data for WRMP Benchmark sites is not adequate, and has not yet quantified the full range of conditions for this Site Type. For Project sites, there are not enough CRAM assessments at WRMP Project sites to compare because only two have existing, historical data.

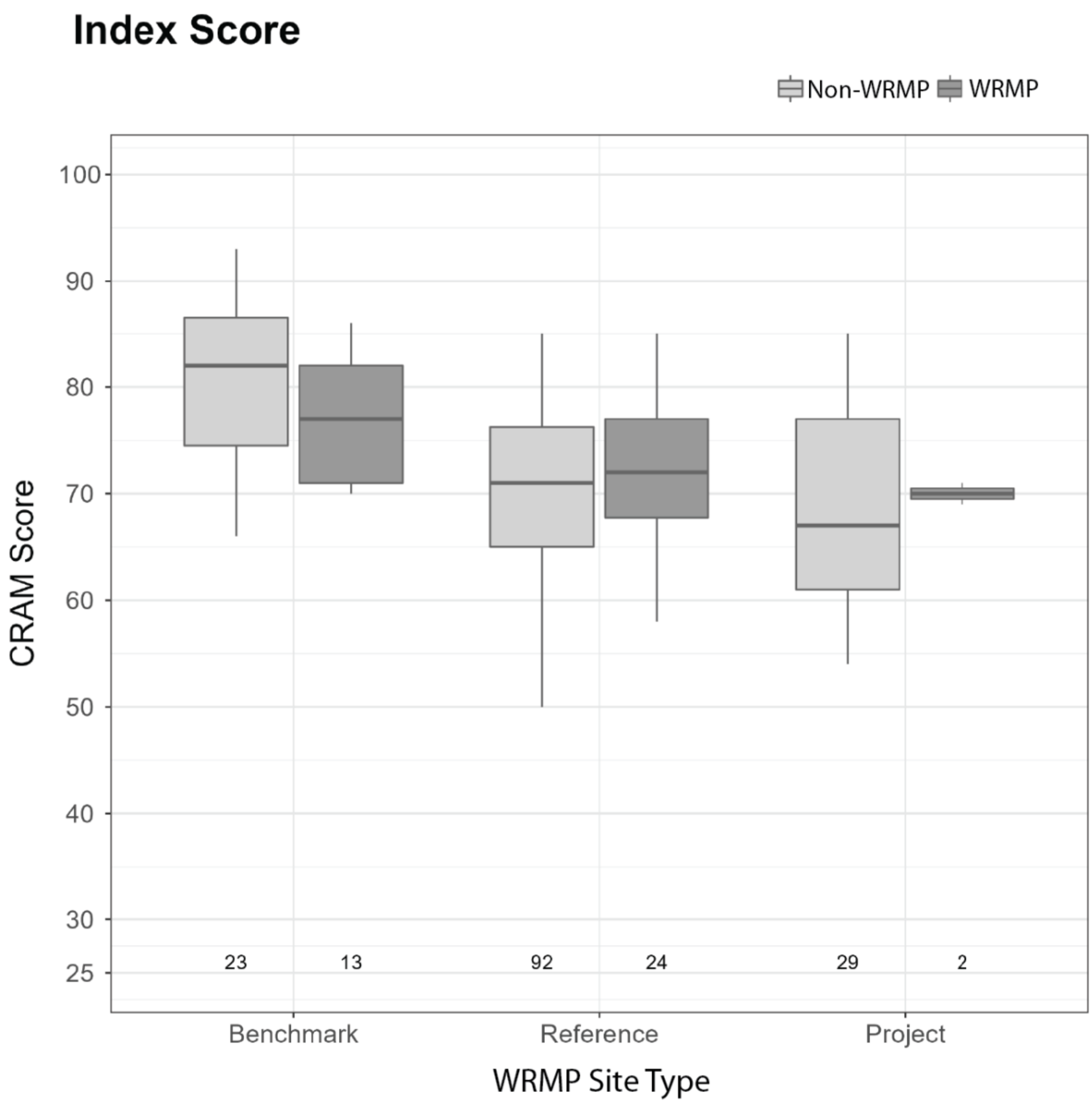


**Figure 8.** Plots showing the median (horizontal line), the inter-quartile range (box), and the minimum and maximum values that lie within 1.5 times the inter-quartile range (whiskers) for non-WRMP and WRMP sites, for the three WRMP Site Types (Benchmark, Reference, and Project sites). Numbers at the bottom of the figure list the number of CRAM assessments included in each boxplot.

## Question 3: Where are the data gaps?

The data gaps in available CRAM assessments fall into three categories: spatial gaps, temporal gaps, and inadequate characterization.

### Spatial Gaps

1. As of early 2023, only 21 of the 85 WRMP Priority Network sites had any CRAM data.

2. The distribution of existing CRAM data across the estuary shows several areas that have tidal wetlands that have never been assessed. For example, spatial gaps exist in the Central Bay, along the peninsula, along the Berkeley to Richmond waterfront, in the Sonoma Baylands, in the Carquinez Strait, and in the western portion of Suisun.
3. The WRMP Priority Network sites are not spatially distributed across the estuary. The majority of sites are located around the San Pablo Bay, Suisun, near Alameda Creek, and in the Lower South Bay; there are many areas of the Bay that do not have any WRMP sites. In the long-term, only collecting data within WRMP sites will miss large areas of the estuary.

## Temporal Gaps

1. The temporal distribution of existing assessments is highly variable. Some years—2009, 2010, 2012, 2014, 2015, and 2020—have very few or no assessments. Since 2007, only four years have had 20 or more assessments collected during that year.

## Inadequate Characterization

1. An overall low total number of CRAM assessments for WRMP Priority Network sites (n = 39), which limits characterization and ability to assess trends, only using this existing data.
2. A very low number of CRAM assessments exist within WRMP Project sites, indicating that the WRMP is poised to fill data gaps in restoring wetlands in both space and time. The recommended size for a single assessment area (AA) is 1 hectare; the WRMP Priority Network site total area is over 10,800 hectares, meaning that the existing data has not adequately characterized the condition of WRMP sites. However, similar to how discreet vegetation plots are used to characterize the vegetation in a larger wetland, CRAM AAs are intended to represent the condition of the larger wetland, without having to sample the full wetland. This data gap is simply highlighting that the WRMP will need to continue to conduct assessments beyond the existing data, to characterize the WRMP Project sites.
3. Many of the 21 WRMP Priority Network sites have only one or two CRAM assessments within the entire site, which generally will not adequately characterize the overall ecological condition of a large tidal wetland area. Rush Ranch has the highest number of assessments: six.
4. Inadequate characterization of each of the five sub-embayments based upon the limited amount of existing data. For All Data, the total number of assessments from each sub-embayment ranges between 22 and 67 assessments. For the WRMP Data subset that number drops between zero (in the Central sub-embayment) and 17 assessments.
5. Many Project Sites have not yet been assessed using CRAM, or have not recently been reassessed. CRAM could be utilized across Projects to compare project conditions across the estuary and to track how projects are maturing over time compared to the expected habitat development curve.
6. Existing CRAM assessments from WRMP Benchmark sites likely do not adequately capture the full range of condition of this Site Type; current Index Scores range from 70 to 86, meaning that there are likely higher condition sites, or possibly other portions of the wetland within sites that have some CRAM data, that have not yet been assessed.

7. The existing CRAM data were collected for a variety of purposes, and at select targeted wetlands. These data may not adequately represent the true ambient condition of the full population of estuary tidal wetland areas.
8. No CRAM assessments have been collected with the purpose of updating the CDF curve since the initial CDF curve was developed in 2008.

# 2024 WRMP CRAM Field Monitoring

## 2024 Planning and Implementation

The WRMP began implementing the WRMP 2024 Monitoring Plan in the summer/fall of 2024, guided by the 2024-2025 Implementation Work Plan. This included the collection of wetland condition data employing CRAM. Informed by the December 2023 CRAM Data Review for WRMP presentation to the TAC, the WRMP project leads identified 21 WRMP Priority Network sites that did not yet have any CRAM assessment data (Figure 9). The majority of the 21 sites are classified as Project or Reference sites, although the selection did include two Benchmark sites.

A list of these sites was created and provided to SFEI staff to allow for evaluation of each site and for site access permissions to be gained. Sears Point (a Priority Network site, but not a part of the original 21 targeted sites) was opportunistically included because it is immediately adjacent to one of the other targeted sites and could be surveyed from the levee, bringing the total evaluated Priority Network sites to 22. The sampling plan was to collect a single CRAM assessment at each of the targeted sites. However, review of aerial photographs and discussions with land managers identified four sites that required boat access (Wings Landing, Napa-Sonoma Pond 3, Napa-Sonoma Pond 6A, and Pond A21), which was beyond the scope of the 2024 field plans. Those sites will be sampled in subsequent years.

Sarah Pearce (SFEI), a geomorphologist, CRAM practitioner with 20 years of experience, and the statewide lead CRAM trainer, was the lead CRAM practitioner for this effort. Sarah gained site access and prepared all field materials for the assessments, including datasheets, aerial photographs, and topographic maps based upon the provided tidal wetland locations. David Peterson and Emma Sevier, both trained CRAM practitioners from SFEI, and Jemma Williams, a trained practitioner from the San Francisco Bay Joint Venture, provided their expertise as the second practitioner for the assessments (Figure 10). Other non-trained people were opportunistically able to join the field team to observe the methodology and gain a better understanding of how CRAM scores capture each aspect of tidal wetland condition. These people included: Sarah Lowe, Lisa Beers, and Aviva Rossi from SFEI; Sasha Harris-Lovett, Alex Thomsen, and Hannah Kempf from the San Francisco Estuary Partnership; and Dajanae Stitts and Loren Roman-Nunez from the California Department of Fish and Wildlife.

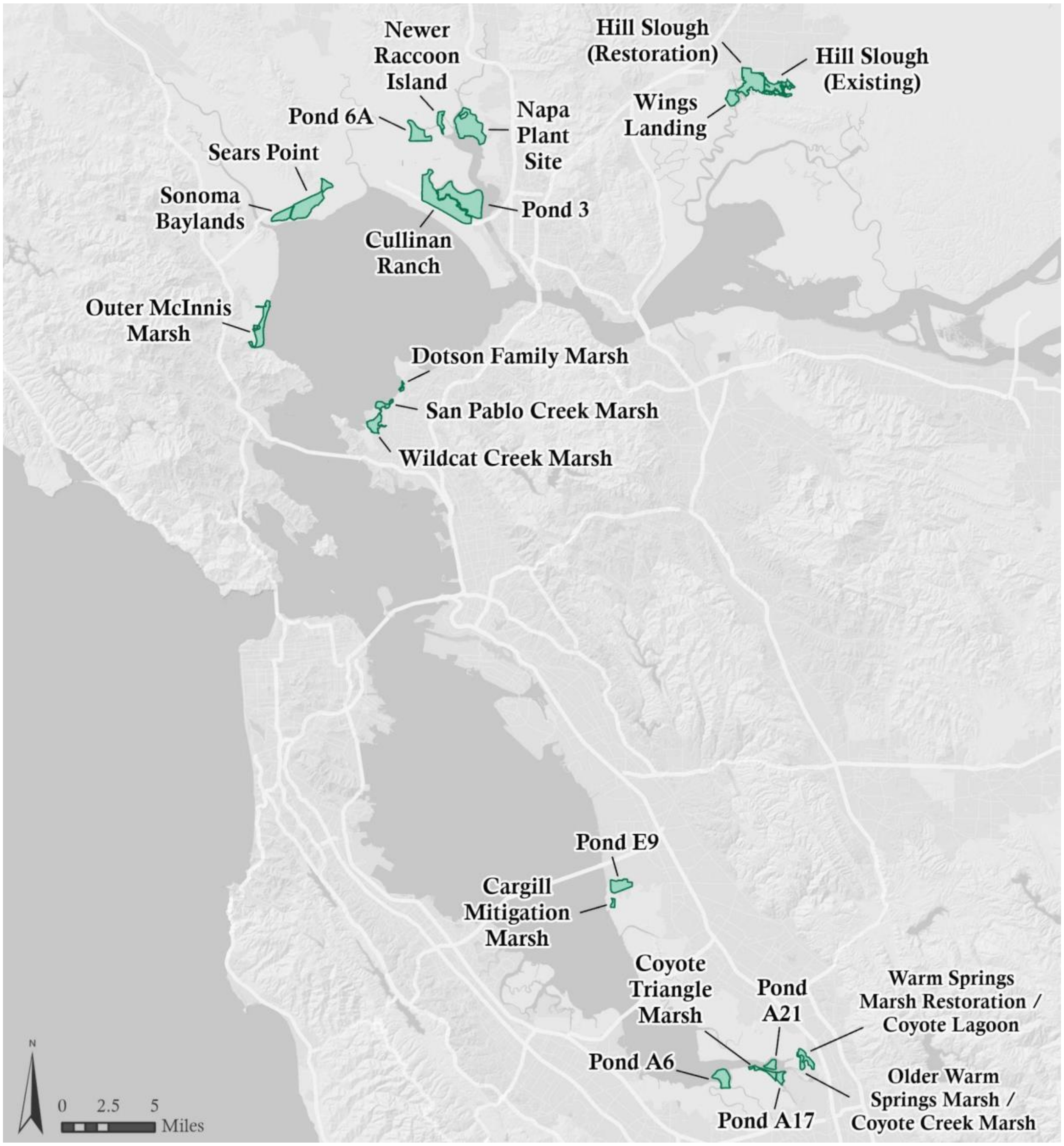


**Figure 9**. Map of the 22 WRMP Priority Network sites evaluated for CRAM assessments during the 2024 field season.

**Figure 10.** CRAM Practitioners collecting CRAM assessment data. Clockwise from the upper left: Sarah Pearce, David Peterson, Jemma Williams, and Emma Sevier.

An estuarine CRAM AA has a recommended size of 1 hectare, and is typically circular, although the shape can be slightly adjusted so that it does not include any upland or channels greater than 30 m wide. For these surveys, exact placement of the AA within each site was not decided in advance (e.g., an ambient random sample draw was not utilized). Rather, Sarah Pearce roughly placed each AA based upon (a) areas of the tidal wetland that were accessible on foot, and (b) areas that appeared to be representative of the larger wetland based upon review of aerial imagery and best professional judgment. Final, exact AA boundaries were established in the field, following the rulesets developed within the methodology.

CRAM assessments were completed using the CRAM Estuarine Field Book version 6.1 (CWMW, 2013b). Data were collected on paper data sheets while in the field, and were checked each evening for completeness and accuracy. In addition, each evening digital field photographs from each site were downloaded and any unknown co-dominant plant species were identified. After returning to the office, the paper datasheets were scanned and electronically filed. Assessment data were entered into eCRAM, the on-line electronic CRAM database (www.cramwetlands.org), by one staff member and later verified by another.

After the data were entered and verified, the full dataset was accessed from the statewide CRAM data management database within EcoAtlas (www.EcoAtlas.org). EcoAtlas is an online wetlands decision support website that includes interactive map viewer, and data summary and data download tools. CRAM data can be explored through the interactive map and downloaded in several formats, or can be summarized in a condition report for a user-defined area using the Landscape Profile Tool. The completed assessments are currently publicly viewable and downloadable from EcoAtlas under the Project Name “SF Estuary WRMP 2024”.

# 2024 CRAM Results

## Sites and Assessment Areas

A total of 18 individual Priority Network sites were visited during 13 field days from July to October 2024. Depending on factors such as property access within each site, the practitioner’s ability to safely walk in each tidal wetland, wetland complexity, and the timing of low tides, the field team was able to assess one to two Network sites each field day. Although the field team was only expected to collect a single CRAM assessment at each site, up to three individual assessments were able to be completed at each site, resulting in 33 assessments completed in 2024 (Table 1 and Figures 11a and b). The field team was able to complete the additional assessments due to the experience and efficiency of the team, as well as the relatively easy access to the AA within the larger tidal wetland area. Field photographs of select AAs are shown in Figure 12.

**Table 1.** List of 33 CRAM assessments completed during the summer and fall of 2024 for the WRMP. The CRAM Assessment Area (AA) Name and eCRAM ID can be used to access the site on EcoAtlas.

| CRAM AA Name | Date Assessed | Practitioners | eCRAM ID |
|---|---|---|---|
| 2024WRMP Cargill Mitigation Marsh A | 9/5/2024 | Sarah Pearce, Emma Sevier, Jemma Williams | 10086 |
| 2024WRMP Cargill Mitigation Marsh B | 9/5/2024 | Sarah Pearce, Emma Sevier, Jemma Williams | 10087 |
| 2024WRMP Cullinan Ranch A | 10/1/2024 | Sarah Pearce, David Peterson | 10093 |
| 2024WRMP Cullinan Ranch B | 10/1/2024 | Sarah Pearce, David Peterson | 10094 |
| 2024WRMP Cullinan Ranch C | 10/1/2024 | Sarah Pearce, David Peterson | 10095 |
| 2024WRMP Dotson Family Marsh B | 7/24/2024 | Sarah Pearce, David Peterson | 10069 |
| 2024WRMP Dotson Family Marsh C | 7/24/2024 | Sarah Pearce, David Peterson | 10033 |
| 2024WRMP Dotson Family Marsh E | 7/24/2024 | Sarah Pearce, David Peterson | 10070 |
| 2024WRMP Hill Slough Existing A | 10/2/2024 | Sarah Pearce, Emma Sevier, Dajanae Stitts | 10096 |
| 2024WRMP Hill Slough Existing B | 10/2/2024 | Sarah Pearce, Emma Sevier, Dajanae Stitts | 10097 |
| 2024WRMP Hill Slough Restoration | 9/6/2024 | Sarah Pearce, David Peterson, Dajanae Stitts, Loren Roman-Nunez | 10090 |
| 2024WRMP McInnis Marsh A | 10/4/2024 | Sarah Pearce, David Peterson, Sasha Harris-Lovett, Alex Thomsen, and Hannah Kempf | 10101 |
| 2024WRMP McInnis Marsh B | 10/4/2024 | Sarah Pearce, David Peterson, Sasha Harris-Lovett, Alex Thomsen, and Hannah Kempf | 10102 |
| 2024WRMP Napa Plant Site A | 9/30/2024 | Sarah Pearce, David Peterson, Sarah Lowe, Loren Roman-Nunez | 10091 |
| 2024WRMP Newer Raccoon Island | 9/30/2024 | Sarah Pearce, David Peterson, Sarah Lowe, Loren Roman-Nunez | 10092 |
| 2024WRMP Older Warm Springs Marsh | 9/3/2024 | Sarah Pearce, David Peterson | 10082 |
| 2024WRMP Pond A17-1 | 7/26/2024 | Sarah Pearce, Jemma Williams | 10078 |
| 2024WRMP Pond A17-2 | 7/26/2024 | Sarah Pearce, Jemma Williams | 10079 |
| 2024WRMP Pond A6 | 9/4/2024 | Sarah Pearce, David Peterson | 10085 |
| 2024WRMP PondA6B | 10/22/2024 | David Peterson, Emma Sevier | 10104 |
| 2024WRMP PondA6C | 10/22/2024 | David Peterson, Emma Sevier | 10103 |
| 2024WRMP Pond E9 | 9/5/2024 | Sarah Pearce, Emma Sevier, Jemma Williams | 10088 |
| 2024WRMP Pond E9 B | 9/5/2024 | Sarah Pearce, Emma Sevier, Jemma Williams | 10089 |
| 2024WRMP San Pablo Creek Marsh A | 7/25/2024 | Sarah Pearce, David Peterson | 10074 |
| 2024WRMP San Pablo G3 | 7/25/2024 | Sarah Pearce, David Peterson | 10072 |
| 2024WRMP Sears Point | 10/3/2024 | Sarah Pearce, David Peterson, Aviva Rossi, Lisa Beers | 10100 |
| 2024WRMP Sonoma Baylands A | 10/3/2024 | Sarah Pearce, David Peterson, Aviva Rossi, Lisa Beers | 10098 |
| 2024WRMP Sonoma Baylands B | 10/3/2002 | Sarah Pearce, David Peterson, Aviva Rossi, Lisa Beers | 10099 |
| 2024WRMP Triangle Marsh A | 9/4/2024 | Sarah Pearce, David Peterson | 10080 |
| 2024WRMP Triangle Marsh B | 9/4/2024 | Sarah Pearce, David Peterson | 10081 |
| 2024WRMP Warm Springs Restoration A | 9/3/2024 | Sarah Pearce, David Peterson | 10083 |
| 2024WRMP Warm Springs Restoration B | 9/3/2024 | Sarah Pearce, David Peterson | 10084 |
| 2024WRMP Wildcat Creek Marsh A | 7/25/2024 | Sarah Pearce, David Peterson | 10077 |

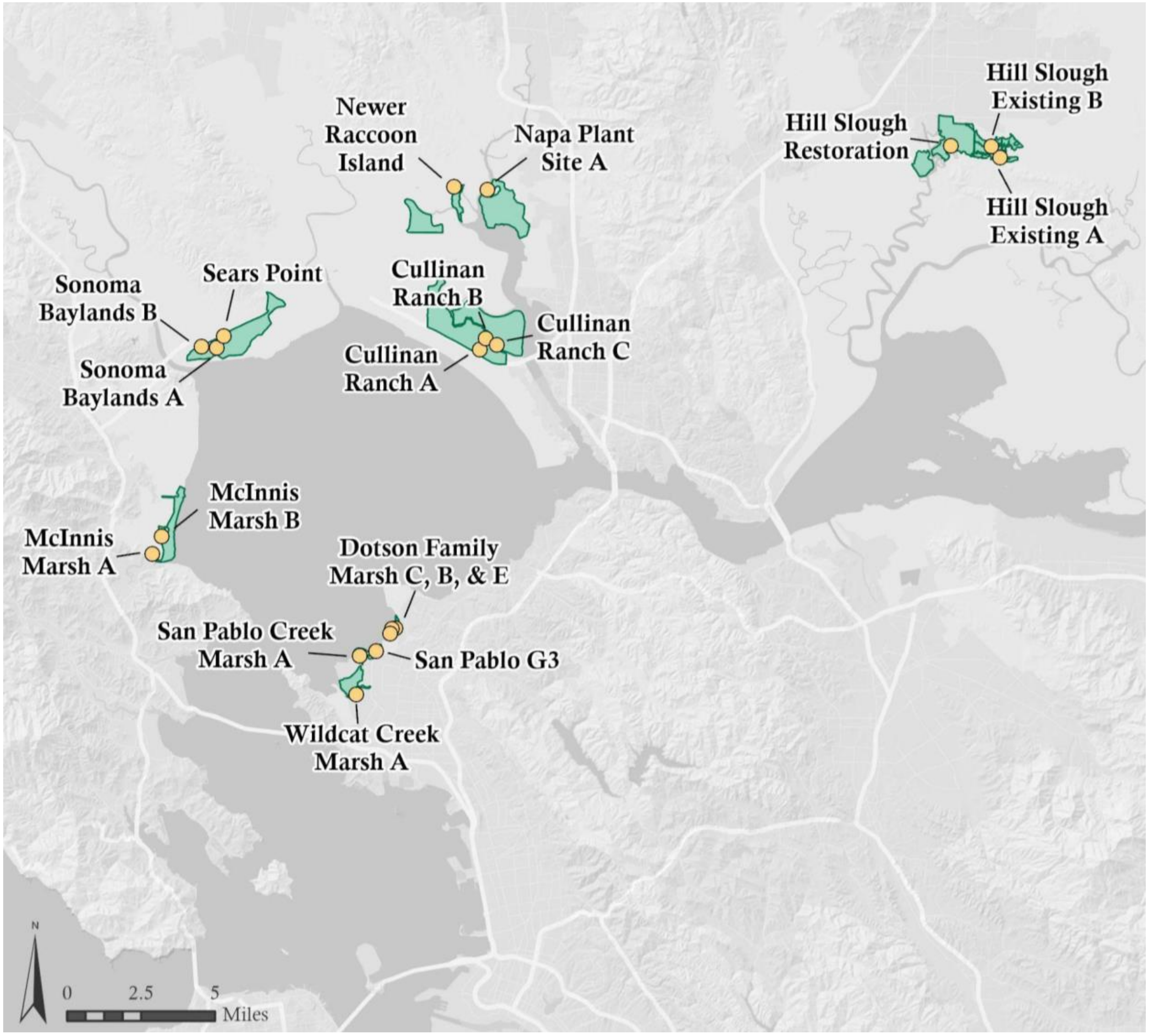


**Figure 11a**. Map showing the distribution of 19 CRAM assessments, completed in 2024, at San Pablo Bay and Suisun Bay WRMP Priority Network site

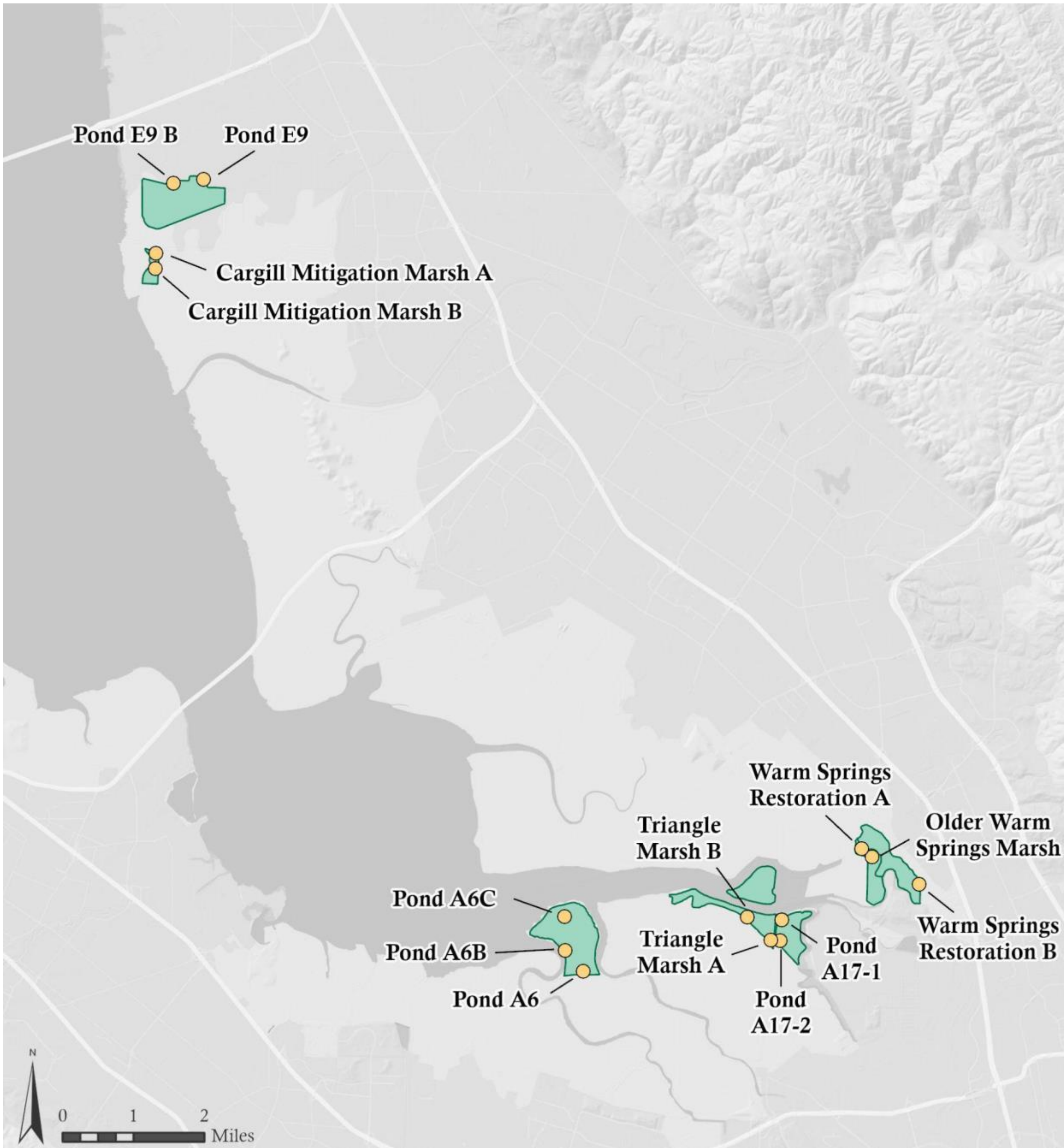


**Figure 11b.** Map showing the distribution of 14 CRAM assessments completed in 2024, at South and Lower South Bay WRMP Priority Network sites.

**Figure 12.** Photographs of selected WRMP Priority Network sites assessed in 2024. Top left: San Pablo G3. Top right: Cargill Mitigation Marsh A. Middle left: Pond A17-1. Middle right: Hill Slough Existing A. Bottom left: Sonoma Baylands B. Bottom right: Dotson Family Marsh C.

## 2024 CRAM Index Scores

### CRAM Index Scores

Overall CRAM Index Scores for the 33 assessments range from a low of 51 to a high of 88; however, most scores are in the 60s and 70s (Table 2). Translating these scores into their corresponding condition class reveals that 73% of the assessments are in Fair condition and 27% are in Good condition. At the Index Score level, none of the assessments are in Poor condition, likely because the selected sites are (1) Reference or Benchmark sites, (2) older and established Project sites, or (3) are younger Project sites that have Good Landscape and Buffer Context and Hydrology Attribute scores, which keeps the Index Score high.

### Attribute Scores

#### *Buffer and Landscape Context Attribute*

For the 33 assessments, the Buffer and Landscape Context Attribute Scores are almost exclusively in Good condition, with just a single assessment in Fair condition. These scores reflect the landscape setting of the WRMP Priority Network sites that are typically surrounded by other tidal wetlands or other aquatic habitats. These sites often have a buffer that protects the wetland from anthropogenic access and encroachment of non-native species, among other buffer functions.

#### *Hydrology Attribute*

The Hydrology Attribute Scores span the full range of conditions, from Poor to Good. These scores quantify the variability of 1) delivery of runoff to the wetland from nearby developed areas, 2) muting of tidal prism due to water control structures and features, and 3) lack of hydrologic connectivity due to levees surrounding the tidal wetlands.

#### *Physical Structure Attribute*

The Physical Structure Attribute Scores also span the full range of condition, however only the Cargill Mitigation Marsh AAs are in Good condition. Most of the assessments are in lower condition due to a relative lack of structural patch types (e.g., pannes, bank slumps, pools in channel, soil cracks or algae), and relatively simple topographic complexity, without large variation in channel sizes and lacking features such as natural levees, pannes, plant hummocks and animal burrows.

#### *Biotic Structure Attribute*

And finally, the Biotic Structure Attribute Scores tend to be in Poor to Fair condition, with only the older, established tidal wetlands in Good condition. Especially for the younger project sites, these lower scores reflect the developing plant community that has yet to reach maturity.

**Table 2.** CRAM Index and Attribute Scores for the 33 CRAM assessments collected in 2024, listed alphabetically by CRAM Assessment Area (AA) Name.

| CRAM AA Name | WRMP Site Type | Index Score | Index Score Condition Class | Landscape and Buffer Context Attribute Score | Hydrology Attribute Score | Physical Structure Attribute Score | Biotic Structure Attribute Score |
|---|---|---|---|---|---|---|---|
| 2024WRMP Cargill Mitigation Marsh A | Reference | **80** | Good | **93.29** | **83.33** | **87.50** | **55.56** |
| 2024WRMP Cargill Mitigation Marsh B | Reference | **79** | Good | **93.29** | **75.00** | **87.50** | **58.33** |
| 2024WRMP Cullinan Ranch A | Project | **56** | Fair | **93.29** | **33.33** | **50.00** | **47.22** |
| 2024WRMP Cullinan Ranch B | Project | **51** | Fair | **93.29** | **50.00** | **37.50** | **25.00** |
| 2024WRMP Cullinan Ranch C | Project | **55** | Fair | **93.29** | **50.00** | **37.50** | **38.89** |
| 2024WRMP Dotson Family Marsh B | Project | **65** | Fair | **80.79** | **75.00** | **62.50** | **41.67** |
| 2024WRMP Dotson Family Marsh C | Project | **67** | Fair | **80.79** | **75.00** | **75.00** | **36.11** |
| 2024WRMP Dotson Family Marsh E | Project | **68** | Fair | **68.29** | **83.33** | **75.00** | **47.22** |
| 2024WRMP Hill Slough Existing A | Reference | **81** | Good | **93.29** | **91.67** | **62.50** | **77.78** |
| 2024WRMP Hill Slough Existing B | Reference | **88** | Good | **100.00** | **91.67** | **62.50** | **97.22** |
| 2024WRMP Hill Slough Restoration | Project | **66** | Fair | **90.29** | **58.33** | **50.00** | **63.89** |
| 2024WRMP McInnis Marsh A | Reference | **65** | Fair | **80.79** | **58.33** | **62.50** | **58.33** |
| 2024WRMP McInnis Marsh B | Reference | **72** | Fair | **80.79** | **75.00** | **75.00** | **55.56** |
| 2024WRMP Napa Plant Site A | Project | **70** | Fair | **80.79** | **83.33** | **50.00** | **66.67** |
| 2024WRMP Newer Raccoon Island | Reference | **84** | Good | **93.29** | **83.33** | **75.00** | **83.33** |
| 2024WRMP Older Warm Springs Marsh | Benchmark | **75** | Fair | **93.29** | **58.33** | **62.50** | **86.11** |
| 2024WRMP Pond A17-1 | Project | **66** | Fair | **93.29** | **83.33** | **62.50** | **25.00** |
| 2024WRMP Pond A17-2 | Project | **63** | Fair | **93.29** | **83.33** | **50.00** | **25.00** |
| 2024WRMP Pond A6 | Project | **69** | Fair | **93.29** | **83.33** | **50.00** | **50.00** |
| 2024WRMP PondA6B | Project | **77** | Good | **93.29** | **91.67** | **75.00** | **50.00** |
| 2024WRMP PondA6C | Project | **83** | Good | **100.00** | **91.67** | **75.00** | **66.67** |
| 2024WRMP Pond E9 | Project | **70** | Fair | **93.29** | **91.67** | **37.50** | **58.33** |
| 2024WRMP Pond E9 B | Project | **70** | Fair | **93.29** | **91.67** | **37.50** | **58.33** |
| 2024WRMP San Pablo Creek Marsh A | Benchmark | **66** | Fair | **100.00** | **66.67** | **37.50** | **61.11** |
| 2024WRMP San Pablo G3 | Benchmark | **70** | Fair | **80.79** | **66.67** | **75.00** | **58.33** |
| 2024WRMP Sears Point | Project | **59** | Fair | **80.79** | **83.33** | **37.50** | **36.11** |
| 2024WRMP Sonoma Baylands A | Project | **70** | Fair | **93.29** | **75.00** | **62.50** | **50.00** |

| CRAM AA Name | WRMP Site Type | Index Score | Index Score Condition Class | Landscape and Buffer Context Attribute Score | Hydrology Attribute Score | Physical Structure Attribute Score | Biotic Structure Attribute Score |
|---|---|---|---|---|---|---|---|
| 2024WRMP Sonoma Baylands B | Project | **72** | Fair | **80.79** | **83.33** | **50.00** | **72.22** |
| 2024WRMP Triangle Marsh A | Reference | **69** | Fair | **93.29** | **83.33** | **50.00** | **50.00** |
| 2024WRMP Triangle Marsh B | Reference | **81** | Good | **93.29** | **91.67** | **62.50** | **75.00** |
| 2024WRMP Warm Springs Restoration A | Project | **72** | Fair | **93.29** | **58.33** | **62.50** | **72.22** |
| 2024WRMP Warm Springs Restoration B | Project | **65** | Fair | **80.79** | **58.33** | **50.00** | **69.44** |
| 2024WRMP Wildcat Creek Marsh A | Reference | **77** | Good | **93.29** | **75.00** | **62.50** | **77.78** |

## CRAM Stressor Checklist

In addition to quantifying the overall ecological conditions of tidal estuarine wetlands, the methodology collates different types of anthropogenic stress present within each AA. Stressors that were regularly identified in 2024 include: dikes/levees, ditches, trash, lack of treatment of invasive plants, urban residential, industrial/commercial, transportation corridor, rangeland, and passive and active recreation. Obviously some of these stressors exist in the larger landscape and cannot easily be removed or addressed. However some items, such as levees, ditches, and treatment of invasive plant species, can be addressed in individual tidal wetlands, and possibly contribute to improving conditions.

## Cumulative Distribution Function and Habitat Development Curves

As presented in the Analysis of Existing CRAM Data section (above), the 2024 CRAM results were plotted on the San Francisco Bay Estuarine CDF curve as black diamonds to compare these scores to the larger population of estuary tidal wetlands (Figure 13). Values range between the 1st percentile to the 89th percentile of condition for all estuarine resources. Sixty percent of the 2024 assessments are in the lowest 15th percentile with Index Scores of 70 (or less), and 15% are in the lowest 1st percentile of tidal wetland conditions across the Estuary (with scores of 63 or less). However, understanding the Site Type (i.e., Benchmark, Reference, Project) of each of these assessments provides some context. Figure 14 builds from the previous figure by color-coding each of the 33 assessments based upon its WRMP Site Type. This illustrates that almost all the WRMP Project site AAs (orange diamonds) are in Fair condition, comprising those lowest Index Scores. This result is expected because most of the projects are young, being assessed after only a few years since construction was completed. One would not expect a tidal wetland to be very complex and in Good condition after only a few years of maturation. The exception is the Pond A6 Project, which was completed in 2010 and has two of the three assessments in the project footprint in Good condition, suggesting that the project is successfully maturing. Drilling down to the Attribute Scores for this project shows that all three assessments have Good condition Buffer and Landscape Context Attribute scores and Good condition Hydrology Attribute scores, both directly related to the project's location within the Lower South sub-embayment. However, both the Physical Structure and the Biotic Structure Attribute scores are in Fair condition, illustrating that the project is still developing topographic and patch type complexity, and the vegetation community is still maturing and increasing in number of height classes, species, and horizontal complexity.

Figure 14 also overlays the WRMP Reference and Benchmark sites in blue and purple diamonds, respectively. The assessments within Reference sites, as might be expected, are mostly in Good condition, comprising the best Index Scores in the 2024 dataset. However the two assessments in McInnis Marsh and one of the two assessments in Triangle Marsh are all in Fair condition, with Index Scores ranging between 65 and 72. Within Benchmark sites, the three assessments located in San Pablo Creek Marsh and Older Warm Springs Marsh are all in Fair condition, with Index Scores ranging from 66 to 75.

The six assessments within Reference and Benchmark sites that are in Fair condition are a surprising result, warranting additional explanation. In inspecting the Metric (described below) and Attribute Scores for these assessments, a common theme emerges: each of the assessments is located near the "back edge" of the larger tidal wetland area. These areas were chosen for surveys this year primarily because they were accessible on foot; boat access to other areas of the tidal wetland will occur in future years. Tidal wetland areas at the back edge are not as dynamic or complex as the front edge due to the lesser magnitude of tidal prism that reaches these areas. This reduced tidal prism can have several effects, ranging from smaller channels, a less dense channel network, reduced topographic complexity, more homogenous plant communities, reduced vegetation height, and reduced vigor of the plant community. These effects are observed and quantified within specific CRAM Metrics: Structural Patch Richness, Topographic Complexity, Number of Co-dominant Species, Horizontal Interspersion, and Vertical Biotic Structure. With only one to two AAs collected within each very large wetland site, the condition of the full site has not been adequately characterized. It is unknown if AAs placed in other portions of each site would score similarly, however, based upon previous experience and aerial imagery review, it is likely that AAs placed in the middle or near the front edges of wetlands would score slightly higher. The Index Scores from the AAs that exist along the back edge of these wetlands raise the question “Are conditions within an individual tidal wetland variable based upon the location relative to the front or back edge of the wetland, and if so, is the condition along the back edge consistently lower than condition in the middle or along the front edge?”. Based upon the existing and the 2024 CRAM data, this question is currently unable to be answered.

The 2024 CRAM data were also compared to the San Francisco Bay estuarine habitat development curve (HDC), which is another previously developed CRAM-based decision support tool. An HDC displays the expected rate of improvement in the overall ecological condition of a wetland restoration or mitigation project based on the age of the project since its completion. Restoration or mitigation projects can use CRAM to assess the overall ecological conditions of their wetland project, and plot the scores on the HDC to evaluate if the wetland is meeting the expected rate of natural ecological development. CRAM scores should plot on or above the curve, providing confidence that the wetland will continue to mature and reach reference condition. If scores plot below the curve, managers can explore the underlying Attribute and Metrics scores to identify potential adaptive management actions that might be implemented to improve low-performing aspects of the project.

HDCs can also be used to forecast the expected ecological condition that a project will likely achieve at any given future date after the project is completed, or to estimate the number of years that it will take for a wetland to reach reference condition. An HDC can also be used to develop project performance targets. For example, a project may set a performance target that aims for the wetland’s CRAM Index Score to be on or above the curve by Year 5, or five years after construction is completed.

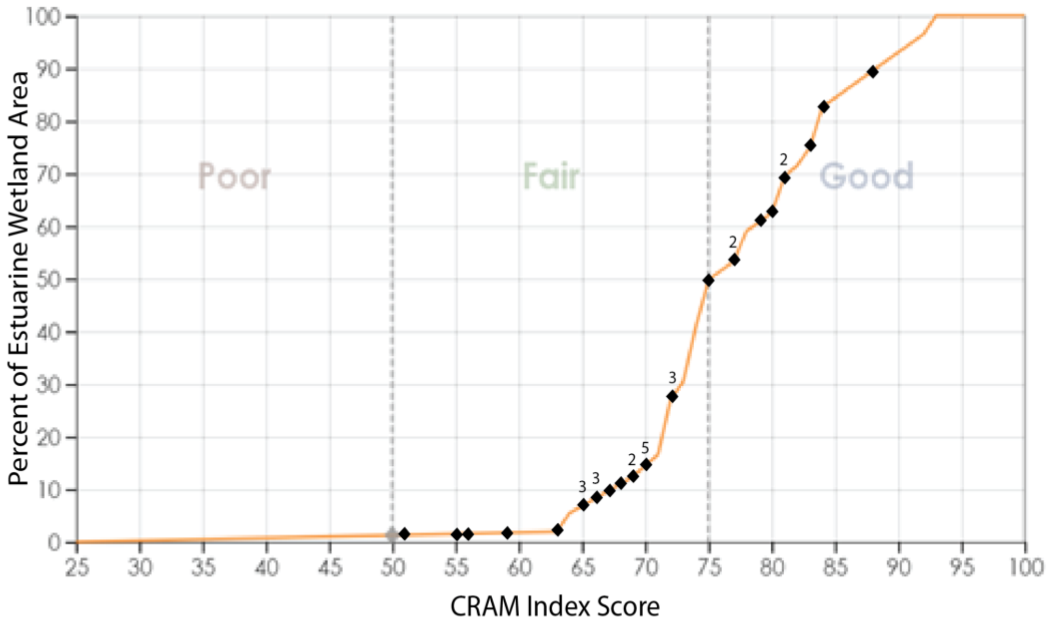


**Figure 13.** San Francisco Bay Estuarine cumulative distribution function (CDF) curve, with 2024 WRMP CRAM AA Index Score data (n = 33) plotted as black diamonds.

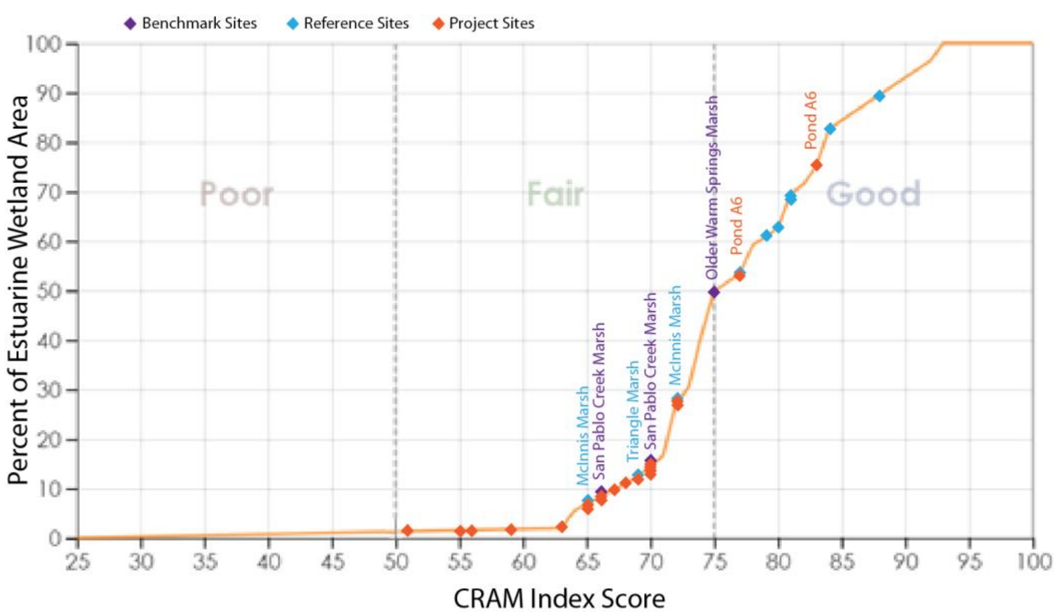


**Figure 14.** San Francisco Bay Estuarine cumulative distribution function (CDF) curve, with 2024 WRMP CRAM Index Score AA data (n = 33) plotted as diamonds and colored by Site Type. Purple diamonds are Benchmark Sites (n = 3), blue diamonds are Reference Sites (n = 10), and orange diamonds are Project Sites (n= 20).

Figure 15 plots the 2024 WRMP assessment data on the Estuarine wetland HDC. The WRMP Project site assessment Index Scores are plotted as orange diamonds, while the WRMP Reference and Benchmark site assessments are plotted as blue and purple diamonds, respectively. This figure illustrates that almost all of the Project site assessments are currently plotting on or above the curve. The only exceptions are the three assessments at the Cullinan Ranch restoration project (age 9 years), one assessment at the Sears Point restoration project (age 9 years, although its Index Score of 59 is within the 95% confidence interval), and one assessment at the Warm Springs Marsh restoration project (age 38 years). The Cullinan Ranch assessments understandably make sense, as the assessed project area was not open to the tides and was being prepared for the addition of beneficial reuse sediment to raise elevation at the time of the assessment. The Sears Point restoration project is still very young, and received low scores for its Physical and its Biotic Structure Attributes, reflecting the large, homogeneous, and relatively low elevation of the site. The Warm Springs Marsh restoration project is affected by its landscape position.

The Warm Springs Marsh restoration project is a good example for illustrating the benefit of drilling down into the CRAM Attribute and Metric scores to help managers identify specific components of a restoration project that may be in lower condition and warrant further consideration. This project is located near urban development, which affects its Buffer Condition and Water Source CRAM Metric scores. In addition, the AA also had a number of other low Metric scores including low Hydrologic Connectivity Metric scores that reflected the levees that fully surrounded the tidal wetland area, and the low amount of structural patches and topographic complexity in the AA. As outlined here, examining the CRAM Metric scores allows project managers to consider specific adaptive management actions that might improve overall ecological conditions within a project footprint. Some aspects of condition can not easily be changed (e.g., proximity to development) while other aspects could be addressed (e.g., vegetation complexity, invasive species, patch types). At a minimum, CRAM provides a common language for evaluating conditions and discussing specific wetland features.

The HDC also highlights that Pond A6 (age 14 years) already has AAs with Good condition Index Scores that fall within the reference envelope (reference mean +/- standard deviation). However, it is important to note that there is variation in the scores within that project extent; the three assessments completed in 2024 have Index Scores of 69, 77, and 83. The lowest scoring AA is located at the back edge of the wetland against a levee, and far from the levee breach locations. Again this observation directly relates to the question above regarding a potential relationship between AA condition and location within a larger tidal wetland area.

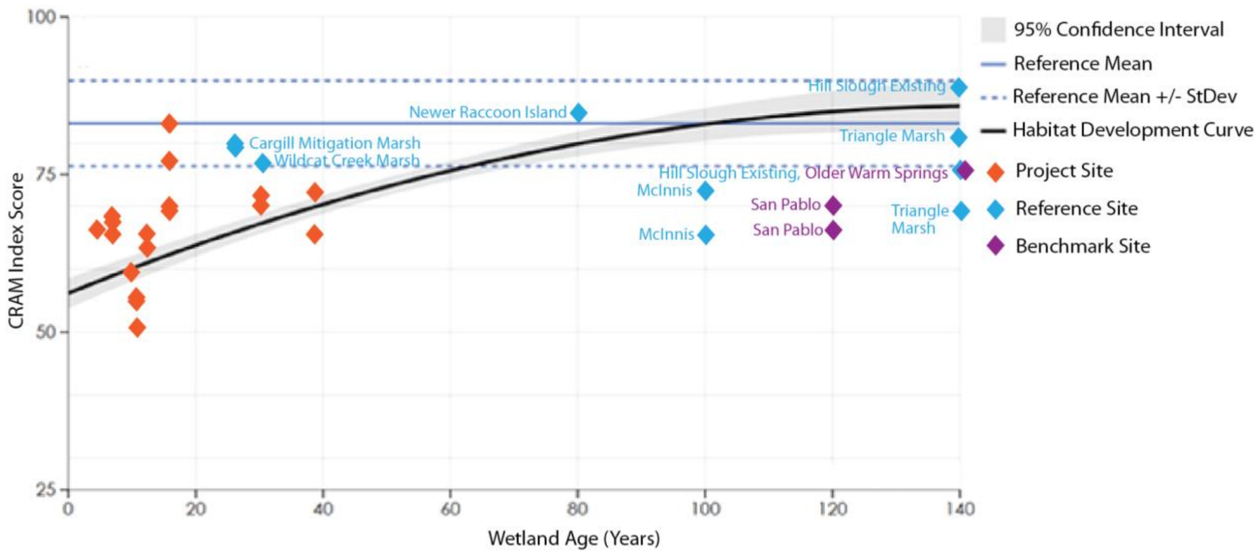


**Figure 15.** Estuarine Habitat Development Curve (HDC) with 2024 CRAM Index Scores plotted. The black curve shows the estimated rate of improvement in condition through time, while the grey shading around the curve indicates the 95% confidence limits. The Project assessments completed by the WRMP in 2024 are plotted on the curve as orange diamonds, while the Reference and Benchmark site assessments are plotted in blue and purple, respectively.

# Conclusions

The California Rapid Assessment Method (CRAM) for Estuarine wetlands is an established, cost-effective, and scientifically defensible monitoring method that characterizes the overall ecological health, or condition of wetlands in California. The method is being used within the WRMP to answer key questions about the current condition of tidal wetlands and how wetland condition is changing over time. The two efforts summarized in this report illustrate how CRAM data can be used to help answer these questions. First, the retrospective analysis of existing historical CRAM data reported that tidal wetlands are in Fair to Good condition across the entire estuary. There is no significant spatial trend in condition between sub-embayments, however the Lower South sub-embayment does have the highest percentage of assessments in Good condition, while the Central sub-embayment has the lowest. Analysis of condition by Site Type shows that Benchmark sites are in better condition than Reference sites, which are in better condition than Project sites. Spatial and temporal data gaps do exist; however, the relatively low number of CRAM assessments across the entire estuary is the largest information gap.

CRAM data collected in 2024 began to fill key data and information gaps within the WRMP's Priority Network sites. The 33 CRAM assessments from 18 Priority Network sites are in Fair (73%) to Good (27%) condition. The lowest condition sites are all WRMP Project sites that are young, and not expected to be in Good condition yet. Importantly, the majority of these Project site scores are all maturing at the expected rate, based upon the habitat development curve (HDC), a CRAM-based decision support tool. Continued CRAM monitoring is funded for the 2025-2027 field monitoring seasons, with decisions about the monitoring design currently being made by the WRMP.

# Next Steps

The San Francisco Bay Restoration Authority is funding the WRMP to continue to employ CRAM to monitor tidal wetlands over the next three years (2025-2028). Funding supports a similar level of implementation as what occurred in 2024, at approximately 30 AAs each year. The WRMP is currently developing the near-term CRAM monitoring plans, with an initial focus on the 2025 field season. For example, there are several ways that CRAM can be utilized by the WRMP, beyond just filling spatial gaps within the Priority Network sites, as was initiated in 2024. The current discussions between the WRMP staff and the SFEI staff are exploring how CRAM can most effectively contribute to answering the WRMP's questions. Current priorities likely include using CRAM for two primary purposes:

- Support status and trends assessments: helping to answer the Management Question "What is the condition of tidal marsh ecosystems, and how are they changing over time?". This can be implemented at different spatial and temporal scales including at WRMP Priority Network sites in the near-term, and at all tidal marshes across the estuary in the longer-term.
- Support restoration projects by employing CRAM to: 1) help set project performance goals, 2) track the overall ecological condition of projects as they mature (performance tracking), and 3) evaluate project success, including comparisons between projects, to WRMP Benchmark and/or Reference sites, or to estuary-wide ambient conditions as summarized in the CDF curves presented in this report.

To support these purposes, the WRMP will work with the TAC and SFEI staff to determine the sites that will be assessed during the 2025 monitoring and beyond.

In addition, future monitoring could consider using CRAM as a cost-effective method to support other WRMP priorities. CRAM assessments could:

- Support restoration project planning and design, and inform adaptive management actions.
- Be co-located with other site-scale Level 3 monitoring efforts to develop relationships between the two types of data collection. For instance, collecting Level 2 and Level 3 data concurrently might deepen our understanding of how specific aspects of condition and overall ecological condition relate. This understanding could help in future decision-making about where to collect additional Level 2 and/or Level 3 data, to help the program more effectively and efficiently characterize the many thousands of acres of tidal wetland area.
- Be used as a screening tool to detect early changes or trends, or to identify locations where additional detailed, site-specific Level 3 data should be collected. For instance, the Percent Invasive sub-metric within CRAM will identify sites with co-dominant plant species that are invasive. This sub-metric can serve as a screening tool for additional Level 3 data, such as vegetation transects, that could be collected at these sites where co-dominant invasive species have been identified. As an example, within the 2024 assessments, the Hill Slough Restoration site has *Phragmites sp.* as a co-dominant, and additional detailed vegetation monitoring would provide extra monitoring of the coverage and trend of that species. Of note, vegetation transects are planned for this location within the WRMP 2025-2027 Implementation Plan.

The above examples of how CRAM could be utilized within the WRMP are not a comprehensive list, but are intended to illustrate the versatility and utility of CRAM within a broader WRMP monitoring framework. Any of the data collection approaches can occur at the site-scale, sub-embayment scale, or estuary-wide scale, and can support ambient monitoring, project monitoring, or special studies. Current discussions and available funding will guide the near- and longer-term focus of CRAM within the WRMP.

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