Annual Report (Year One) on the Habitat Evolution Mapping Project for the South Bay Salt Pond Restoration Project

Submitted by:

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Design, Community & Environment

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YEAR ONE: SUMMARY OF WORK COMPLETED

This report outlines the work conducted during Year One (2009-2010) for the Habitat Evolution Mapping Project (HEP). Our efforts to develop a semi-automated model for using satellite based remote sensing to map vegetation across the south bay of San Francisco have been largely successfully. As of the end of April 2010, the HEP project team has developed a working (draft) "habitat model" and has produced a set of draft habitats and sediment maps for the entire south bay.

Our work during Year One has indicated that our strategy has been largely effective. Using a combination of remote sensing, ground truthing, and some manual interpretation, our approach will meet the project's objectives to effectively track changes to vegetation and sediment in subsequent years. In addition, we believe that the 1 meter multispectral imagery acquired from the Ikonos satellite is more then adequate to map changes to vegetation within the study area at appropriate scales to meet overall South Bay Salt Pond (SBSP) project goals and to assist in the adaptive restoration process. Although our year one analysis has indicated that the Ikonos imagery should meet project goals, we do recommend, at the very least, reviewing the costs and benefits of switching to higher resolution satellite imagery such as GeoEye1 in future years. As of the end of April 2010, we have successfully completed Tasks 1 to Task 3, continue to work on Tasks 4 and 5, and are nearing completion of Task 6.

Although we are currently behind schedule for Year One (largely due to circumstances beyond our control), we are confident as we move into Year Two of the three year project, that we will be on time for completing tasks in 2010 as well for producing our final "habitat" model by the end of Year Three (2011).

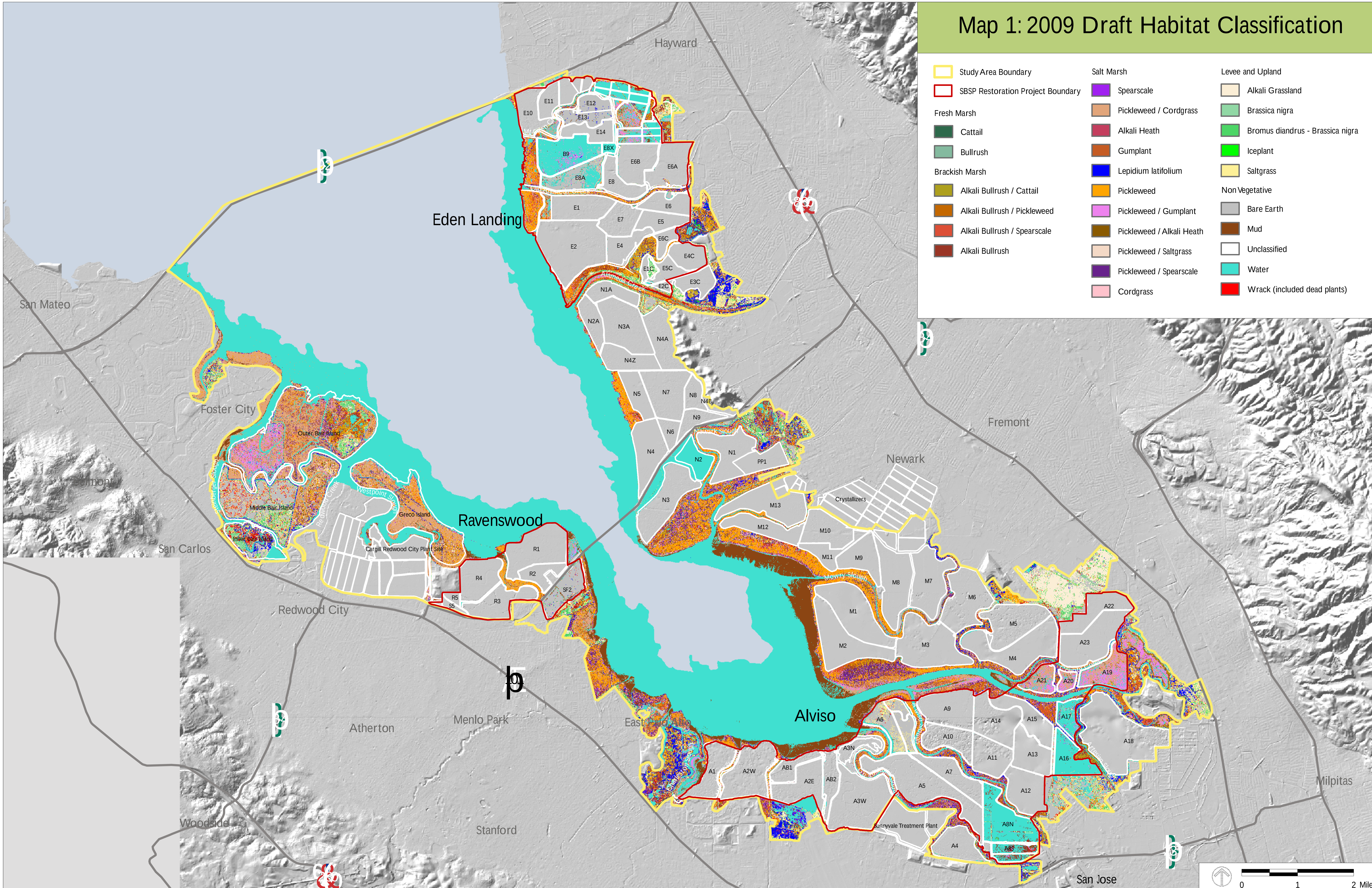
Our methods and process have been largely preserved in our implementation of the project. After some careful thought among the two Co-PIs of the HEP project (Brian Fulfrost and David Thomson), we determined that the timing of the acquisition of the Ikonos satellite imagery should occur as closest to Mean Lower Low Water (so no vegetation was submerged) and during the time of the year when the vegetation was most green overall (June/July). Unfortunately, during 2009 we had a very short time frame to make decisions about imagery acquisition (a full month before the final contract was signed). Additionally, in our haste, the image was acquired at mean tide (as opposed to MLLW). In preparation for Year Two, we identified only one day at which the Ikonos image could be acquired closest to MLLW (Ikonos has a return date of 2-5 days and acquired images only around noon to reduce shadowing and atmospheric affects). As a result, we are considering relaxing our criteria for future years.

Largely due to delays in Year One, we were unable to perform a final “validation” step for the results of our final Year One habitat model. Validation here refers to visting a stratified random sample of locations to verify the accuracy of the habitat model. However, we have been able to perform a significant degree of verification during Spring 2010. The major difference between validation and verification is that the verification points are not a “random sample” – they are qualitatively assessed to assist the HEP team in testing and calibrating the habitat model. In our efforts to perform some type of validation, although not a statistically random sample, we will take a series of ground truthing points not used as training sites for the draft habitat model, and use these to assess the accuracy of our Year One results. However, we will perform a statistically random validation of the results of the model in both Year Two (2010) and Year Three (2011). In future years (after 2011) we anticipate that there will be a minor amount of verification required to calibrate the model followed by a standardized (stratified random sample) validation step to ensure the model is continuing to perform accurately.

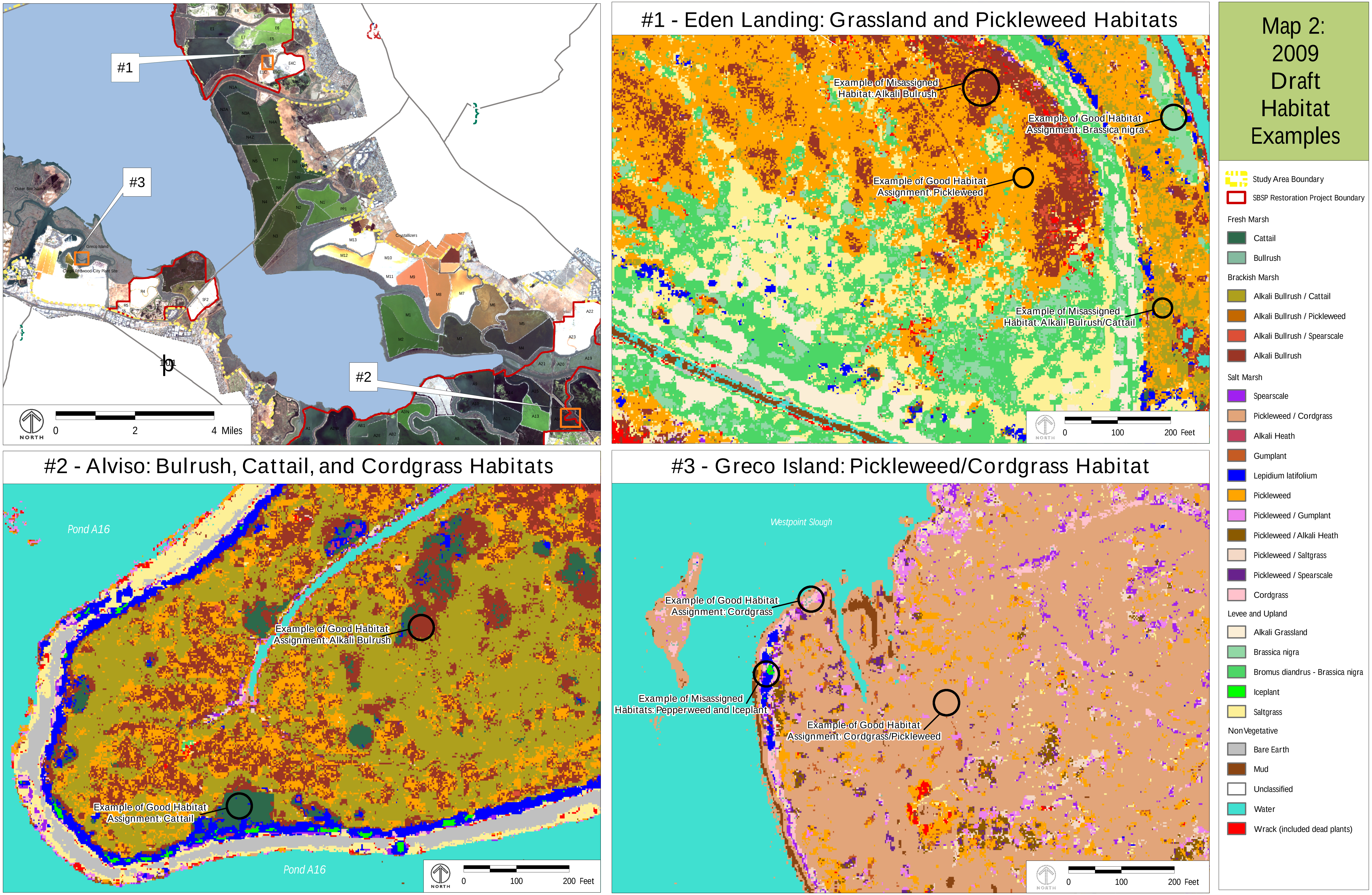
Year One Status of Mapping Products

Habitats (i.e. Vegetation Types and Associations)

As of April 2010, we have a draft 2009 habitat map of the entire study area (see Map 1). DC&E delivered this draft map as a hard copy poster to the USFWS members of the SBSP project team in late March 2010. Based on initial feedback from the USFWS and early verification in the field, we have identified significant overall success of our model as well as areas and habitats types in need of improvement (see Map 2). There were obvious successes in the identification of important invasions from *Lepidium latifolium*. At the same time, our lack of field based data differentiating different species of pickleweed have made it difficult for our model to detect these differences. We are currently nearing completion of our Year One field verification ground truthing of our initial habitat model. As a result, we are also refining our training sites for our habitat model (and possible impacts to our habitat classifications) based on our verification ground truthing. We anticipate producing a final 2009 habitat map by the end of May 2010.



Map prepared by DC&E on May 28, 2010.



Map prepared by DC&E on May 28, 2010.

Sediment

As of April 2010, we have a draft 2009 sediment map of the entire study area. This sediment classification was one part of our overall "habitat model" and therefore is included in the overall classification result. Although the acquisition of the Ikonos image at mean tide did not provide us an optimal image, we have supplemented the derived sediment with Normalized Difference Vegetation Index (NDVI) analysis to extract sediment "missing" from the original image (see Map 3). NDVI values are an index of the near-infrared and red bands of a satellite image that provide a measure of whether a location contains live green vegetation or not.

Channels

As of April 2010, we have a draft set of channels for the entire south bay that contained some water based on the timing of our 2009 satellite image. This channel classification was one part of our overall "habitat model" and therefore is included in the overall classification results. Although we have done preliminary image processing to derive channels within restored ponds within the study area, we have not fully completed our analysis of channels (with and without water). However, we do not anticipate any problems completing this task and are certain that a remote sensing approach to mapping these features will be efficient (in both cost and labor) and effective (producing excellent results).

Year One – Verification Ground Truthing

Between March 2010 and May 2010, we conducted late verification ground truthing of a variety of habitats across the study area. With the assistance of Gavin Archibald of San Francisco State University (SFSU), we have ground truthed approximately 100 verification locations which we accessed mostly by a boat provided by Gavin. The location of these verification points is shown in Map 4. Normally we would conduct this verification soon after we have run the habitat model on the acquired satellite image and send out our field biologist repeatedly to "verify" a whole set of points in order to iteratively improve the model. However, due to the delays discussed elsewhere in this report, we were unable to even get in the field until early October 2009 to do out preliminary ground truthing. In addition, the onset of rainy weather prevented field verification of our supervised classification (the result of using the "habitat model") until very late in March 2010. As a result we did not get to the Alviso area for verification until May and June of 2010 and will be including Alviso in our Year Two verification and ground truthing.

Draft Supervised Classification (Habitat Model)

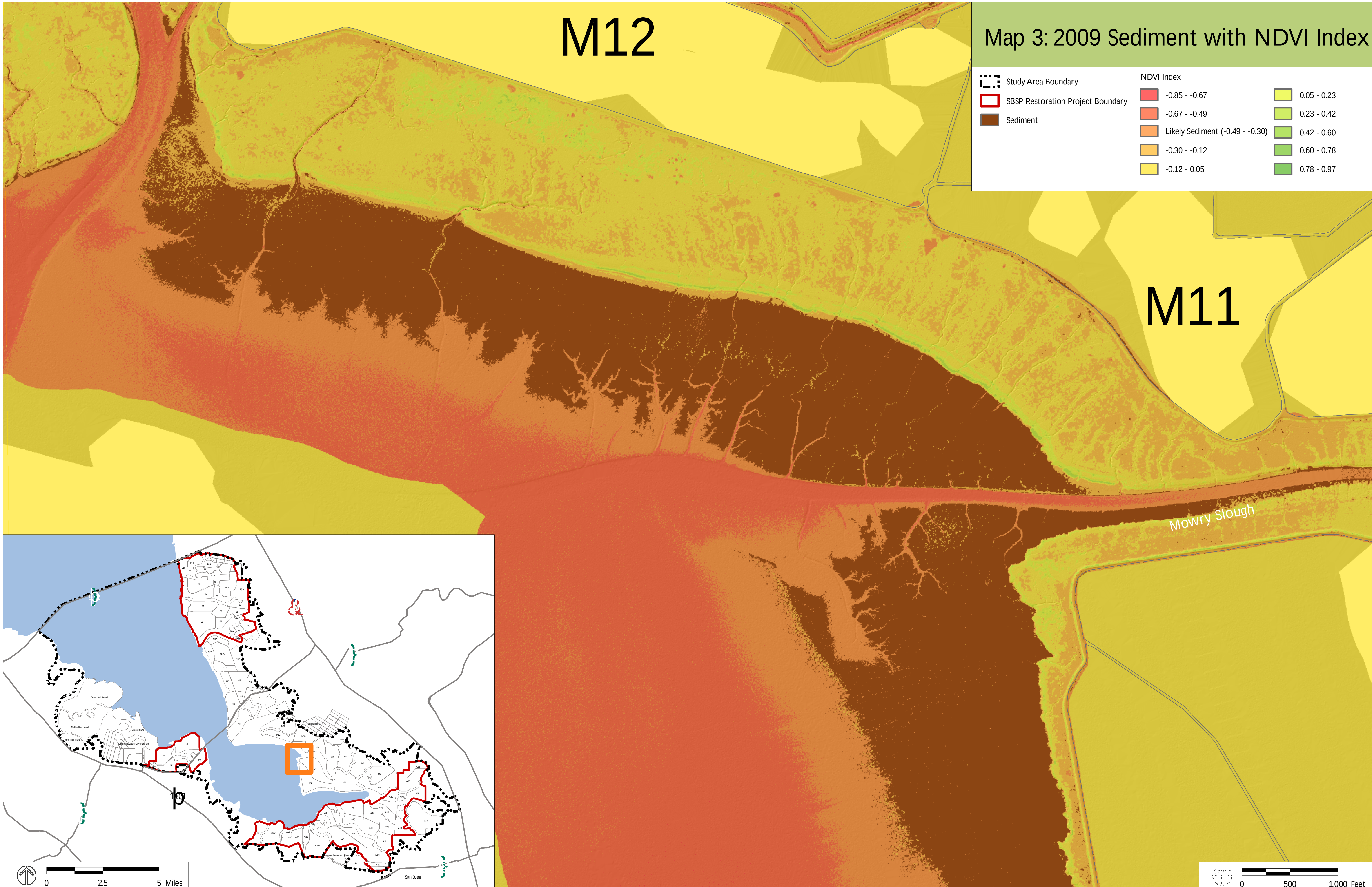
As of the end of April 2009, our supervised classification of the Ikonos imagery has been largely successful and we are now focusing on refining our model based on our verification ground truthing. The "habitat model" is made of three primary components: (1) a supervised classification of the satellite imagery, (2) a systematic manual review of the supervised classification, and (3) field based ground truthing of the supervised classification.

In addition to the supervised classification itself, the DC&E team has continued to explore supplementing the supervised classification with a combination of (a) neighborhood analyses for reducing unnecessary complexity and improving overall accuracy and (b) suitability analysis – primarily either the use of NDVI, elevation (from LIDAR) and tidal datum where available.

The primary components of the supervised classification is a series of training sites, also called Areas of Interest (AOI) in the remote sensing literature, that characterize the vegetation and vegetation associations included in our "habitat classifications" (and that meet overall project goals). These sites, which are examples of areas and their related spectral signatures for each type of vegetation or vegetation association, are used to "supervise" the classification of the satellite imagery into habitat types or other abiotic features like sediment and water.

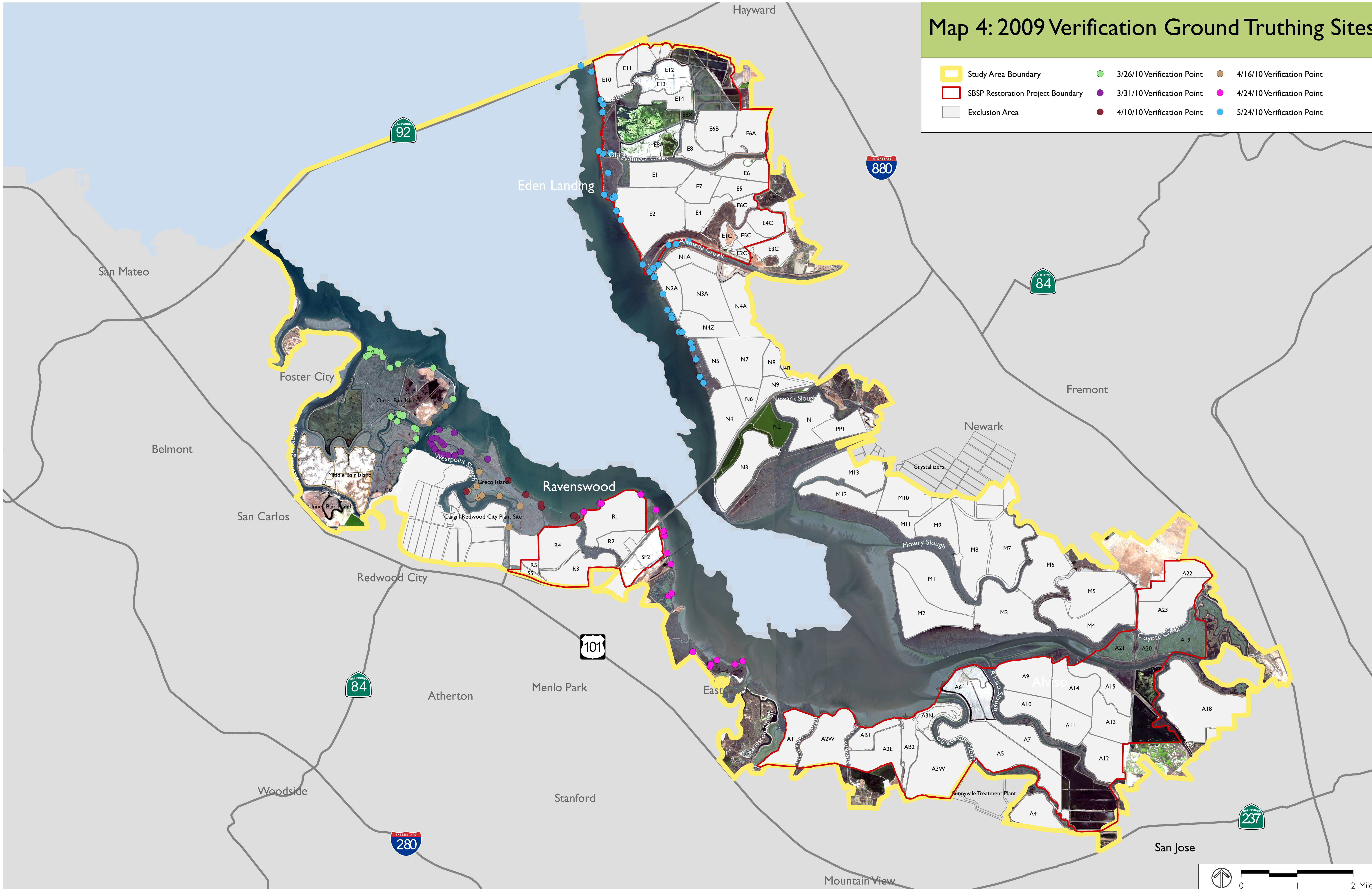
Habitat Training Sites

For each "habitat" type, the DC&E mapping team identified preliminary ground truthing points with the highest percent cover (or mix of high percent of covers) and with the most recognizable spectral and spatial signature. Each habitat type was assigned one or more training sites, based on our review of the variability of the given habitat both in the field and on the satellite image (both true color and false color), the geographic distribution across the study area, and the variability of observed plant associations identified for a given habitat. DC&E spent the majority of November digitizing these training sites (or AOI) around existing ground truthed rapid assessments points. The initial habitat "training" polygons were based on both these preliminary ground truthing points, existing datasets (i.e. Invasive Spartina Council 2009 mapping and HT Harvey vegetation mapping in 2008), and other secondary data sources like LIDAR and Bing Maps. Once a set of training sites was finalized, they



Map prepared by DC&E on May 28, 2010.

Map 4: 2009 Verification Ground Truthing Sites



Map prepared by DC&E on May 28, 2010.

were converted into Erdas AOI and signature files for use in supervised image classification as well as for updating the habitat interpretation guide.

Supervised Classification Review

The study area was divided into a set of 1 square kilometer grid cells to facilitate a systematic review of the supervised vegetation classification for a sample of selected grids. Team members identified all the habitat types within the selected grid cells and qualitatively measured the accuracy of the habitat assignment according to a standard set of review parameters. The reviewers based their assessments on our preliminary ground truthing datasets, the habitat interpretation guide, and existing GIS data available for the study area (2004 existing conditions and 2008 HT Harvey data for the Alviso area). The primary analysis focused on how each habitat classification within the grid cell was assessed to be over, on, or under classified. If the given habitat type was over or under classified, the reviewer estimated the percentage of error within a set number of classes. Team members also rated their confidence of the accuracy of the habitat assignment on a scale of low, medium, and high. The results of our review were recorded directly onto a spreadsheet for ease of analysis and to assist in quickly summarizing the results of the review. Team members recorded their observations about each habitat type within the grid cell in the spreadsheet and prepared a general summary of the general trends of supervised vegetation classification assignment review. Brian Fulfrost worked interactively with the DC&E mapping team to identify, revise, and edit the training sites based on the assignment review. This review was performed for each iteration of the supervised vegetation classification.

Our review of the draft habitat maps indicate that our preliminary ground truthing captured a great deal of the habitat variability found within the study area. However, it also became clear that some of the habitat variability was still missing (an outcome of our shortened field season) or mis-assigned. The DC&E team is now in the process of modifying our training sites in an effort to improve the supervised classification based on our on-screen review as well as our field based verification ground truthing (currently underway).

Habitat Interpretation Guide

During Year One we successfully developed a working version of our habitat interpretation guide to assist our satellite image interpreters to identify training sites, guide their reviews of our supervised classifications, and suggest changes and improvements, resulting in improved model accuracy (see Appendix). The habitat interpretation guide is a "living" document used as a guide for manually interpreting different types of vegetation and vegetation associations that are being mapped as part of the study. Although we have designed the process to include some automation in the use of supervised image classification, there will always be a need for some manual interpretation of the imagery for verification purposes. We also believe that institutionalizing knowledge about how to interpret satellite and aerial photos of the study area will greatly assist in overall monitoring and tacking of habitat changes.

For each habitat classification being mapped there is (or will be) an equivalent "chapter" in the habitat interpretation guide. Since the focus of the guide is to assist in allowing HEP staff (and SBSP staff in future years) to consistently interpret "habitats" from the imagery, the foundation of the guide is to have "image snapshots" that capture both "characteristic" and "un-characteristic" examples that exemplify key habitat variability. Image examples of habitats were extracted from both the true and false color satellite imagery at two general scales: "site context" and "patch /stand." The "site context" images allow the imagery interpreter to gain both abiotic and biotic context to a given habitat type and highlights key adjacent habitats. The "patch/stand" scale closely resembles the scale at which the model allows us to identify vegetation patterns over the entire study area (which is a result of the resolution of the imagery and scale at which the imagery can identify vegetation patterns). For each habitat, the images have accompanying text that (a) provide general descriptions and tips for identifying the habitat and (b) a standard set of characteristics of the image (color, shape, texture, and pattern) that distinguish the habitat from others.

Images from the satellite imagery are supplemented by images taken from Bing Maps online (http://maps.bing.com). This website contains oblique "birds-eye" image at relatively high resolutions. These additional images enabled the DC&E team to significantly improve our identification of a given plant habitat alliance/associations (for training sites and for the habitat interpretation guide). The oblique nature of the bird's eye photos combined with the varied lighting conditions from the four cardinal angles enabled an increased variability of color, texture, and pattern to interpret the plant patch/stand with greater accuracy. Currently the Guide has examples of 23 out of the 25 project alliance/associations with certain plant alliance/associations more complete owing to the focus of the project goals (e.g. Perennial Pickleweed, Cordgrass, Perennial Pepperweed, Pickleweed /Alkali Heath, and Cordgrass -/ Pickleweed). As we have received feedback during our verification process about the success of our habitat model, the HEP team has also developed a couple of image interpretation guides for specific locations, such as the Pre-Phase One Island Ponds and Outer Bair Island, which have greatly assisted the HEP team in interpreting vegetation colonizing these restored ponds.

Habitat Classifications

We have developed a working set of habitat classes (see Figure 1), that meet project goals and provide a basis for deriving habitats from Year One as well as during Years Two and Three. The use of the term "habitat" is a misnomer (clarified during the kick-off meeting) and we use the term throughout this project to refer to vegetation (e.g. Pickleweed) and vegetation associations (e.g. Pickleweed / Cordgrass).

Out list of habitats conform to classifications set by the Manual of California Vegetation (MCV), although they expand on those classes with regards to marsh vegetation associations within the south bay of San Francisco. Our habits classes were based on expert review of existing habitat types, the MCV listing of marsh habitats, previous vegetation studies in the south bay and a review of available literature on marsh vegetation. Our primary focus was to create a list of habitat classes that could be distinguished based on the resolution of the satellite imagery and that also met project goals over time. We believe we have developed a good set of classes that meet those goals. However, as we move into Year Two, we plan to supplement the habitat list based on additional ground truthing and a review of work completed during Year Two.

The majority of the work on developing a working set of habitat classifications has been completed. However, as we move into Year Two, we will further refine these classifications based on additional ground truthing and feedback obtained from the SBSP Project team as well as affiliated organizations such as the Invasive Spartina project (ISP) and the local chapters of the California Native Plant Society (CNPS).

Preliminary Ground Truthing

Once we acquired the necessary hardware (Trimble Yuma GPS enabled field computer) and necessary software (Terrasync), we quickly utilized the remaining good field days to perform our preliminary grounds truthing. Normally we would do this either before or around the same time as the satellite acquisition, but due to delays as

HABITAT EVOLUTION PROJECT (HEP)-- HABITAT COMMUNITIES LIST 05/28/10

#	CNDDB Code	Vegetative Classification*	Marsh Community (Tidal)	Species	Mapped	Observed in Field	Number of Field Observations**
	52.100.01	**Coastal and Valley Freshwater Marsh**		general type			
1	52.101.00	Bulrush	Low	*Scirpus spp.*	Yes	Yes	2
2	52.102.01	Bulrush - Cattail	Low	*Scirpus spp - Typha spp.*	Yes	Yes	5 (HTH)
3	52.103.00	Cattail Wetland	Low	*Typha spp.*	Yes	Yes	3
	52.100.02	**Coastal Brackish Marsh**		general type			
5	*52.112.00	Alkali Bulrush	Low	*Scirpus maritimus/Scirpus robustus(SCRO/SCMA)*	Yes	Yes	4
6		Alkali Bulrush /- Pepperweed	Ecotonal	*(SCRO/SCMA)/Lepidium latifolium*	Yes	Yes	2
7	*52.112.01	Alkali Bulrush / Pickleweed	Ecotonal	*(SCRO/SCMA)/Salicornia spp.*	Yes	Yes	3
8	52.205.00	Perennial Pepperweed	High	*Lepidium latifolium*	Yes	Yes	2
	52.200.00	**Salt - Alkali Marsh**		general type			
9		Cordgrass	Low	*Spartina spp.*	Yes	Yes	4, 8 (ISP)
10		Cordgrass - Annual Pickleweed	Low	*Spartina spp.- Salicornia europaea OR (spp.?)*	Yes	Yes	3
11	*52.201.00	Perennial Pickleweed	Middle	*Salicornia virginica*	Yes	Yes	17
12		Annual Pickleweed	Low	*Salicornia europaea*	No	No	0
13	*52.201.03	Perennial Pickleweed / Saltgrass	Middle	*Salicornia spp. / Distichlis spicata*	Yes	Yes	1
14	52.205.00	Perennial Pepperweed	High	*Lepidium latifolium*	Yes	Yes	7
15	52.205.01	Pepperweed - Saltgrass	Ecotonal	*Lepidium latifolium - Distichlis spicata*	No	No	*0*
16		Pickleweed /- Pepperweed	Ecotonal	*Salicornia spp. / Lepidium latifolium*	Yes	Yes	3 (HTH)
17	52.206.00	Gumplant	High	*Grindelia stricta stricta*	Yes	Yes	5
18	52.211.00	Spearscale	Middle	*Atriplex triangularis*	Yes	Yes	1
19		Pickleweed / Spearscale	Ecotonal	*Salicornia spp. / Atriplex triangularis*	Yes	Yes	3 (HTH)
20	52.500.00	Alkali Heath Dwarf Scrub	Middle	*Frankenia salina*	Yes	Yes	3
21		Pickleweed / Alkali Heath	Middle	*Salicornia spp. / Frankenia salina*	Yes	Yes	1, 4 (HTH)
22	*52.201.02	Perennial Pickleweed /- Gumplant	Ecotonal	*Salicornia spp. / Grindelia stricta*	Yes	Yes	1
23		Pickleweed - Jaumea - Saltgrass	Ecotonal	*Salicornia spp. - Jaumea carnosa - Distichlis spicata*	No	No	0
24		Salt Grass	High	*Distichlis spicata*	Yes	Yes	1
25				*Jaumea carnosa*	No	No (donimant observations)	0
26				*Salsola soda*	No	Yes	1
		Levee Communities		general type			
27		Ice plant mats	High	*Carpobrotus chilensis*	No		0
28				*Mesembryanthemum nodiflorum*	Yes	Yes	1
29				*Mesembryanthemum nodiflorum/Tetragonia Te*	No	Yes	1
30		Fennel patches	High	*Foeniculum vulgare*	No	No	0
31		Brassica nigra	High	*Brassica nigra*	Yes	Yes	1
32		Bromus diandrus	High	*Bromus diandrus*	Yes	Yes	1
33		Salt Grass flats	High	*Distichlis spicata*	Yes		0
34		Peripheral halophtyes?	High	*Salicornia/Frankenia/Sal Soda/MeNo*	No	Yes	1
		Upland Communities		general type			
35		Lolilium mulitflorum	High	*Lolium mul*	Yes	Yes	1
36			High	*Lomu/Disp*	Yes	Yes	1
37		Baccaris pilularis	High	*Baccaris pilularis*	No		0
		Non-vegetative		general type			
38		mudflat		unvegetated intertidal areas between veg and MLLW	Yes	no (visually identified on sattellite image)	0
39		wrack (includes dead veg)		deposited materials	Yes	no (visually identified on sattellite image)	0
40		bare earth		dirt/soil/salty soil	Yes	no (visually identified on sattellite image)	0
		Water					
41		panne		unvegetated intertidal areas w/in veg	Yes	Yes	2
42		water (sloughs)		intertidal waterway w/out riverine input	Yes	no (visually identified on sattellite image)	0
43		estuary		intertidal riverine area (fresh water input)	No	no (visually identified on sattellite image)	0

* /=subdominant -- = co-dominant

** Data collected by Habitat Evolution Project (HEP) team members except where noted. HTH = Data collected by HT Harvey in 2008 for The City of San Jose. ISP = Data collected by Invasive Spartina Project 2009 well as access restrictions we did not to go into the field to perform our ground truthing until September and October of 2009 (more then three months after the satellite image was acquired). However, largely due to the experience and knowledge of our field biologist (David Thomson), our time in the field was quickly productive. Our preliminary ground truthing, which was based on the CNPS's Rapid Assessment methodology, provided sub meter GPS locations of approximately 85 locations of vegetation types and vegetation associations found throughout the study area. These data of vegetation associations were used to inform our habitat classifications, develop training sites for our habitat model, and as the foundation for our habitat interpretation guide (see above). Map 5 displays the habitat locations assessed by David Thomson as part of our preliminary ground truthing conducted between September 17, 2009 and October 16, 2009.

Mapping Standards

The primary goals of developing standards for both (a) the field mapping (ground truthing) and (b) the satellite based habitat mapping have largely been met. As we move into Year Two of the mapping project, and gain even more access to marshes throughout the study area, certain protocols (such as using "clean technology" in the field) will be further refined as needed.

1. <u>Ground Truthing</u>

   The DC&E team developed and codified procedures, methods and protocols for the three of types of ground truthing being conducted for the project (preliminary ground truthing, verification, and validation) that ensure consistency and effective data collection. Our procedures include pre-field, in-field, and post-field protocols and procedures required for effective field data collection focused on assisting with our satellite image interpretation and classification. Our in-field procedures provide a reference guide for collecting data in the field, choosing a method based on the type of ground truthing being conducted, standard protocols for ground truthing (rapid assessment, verification point or polygon or validation point radius), and using a standard set of procedures to follow, while collecting data in the field.

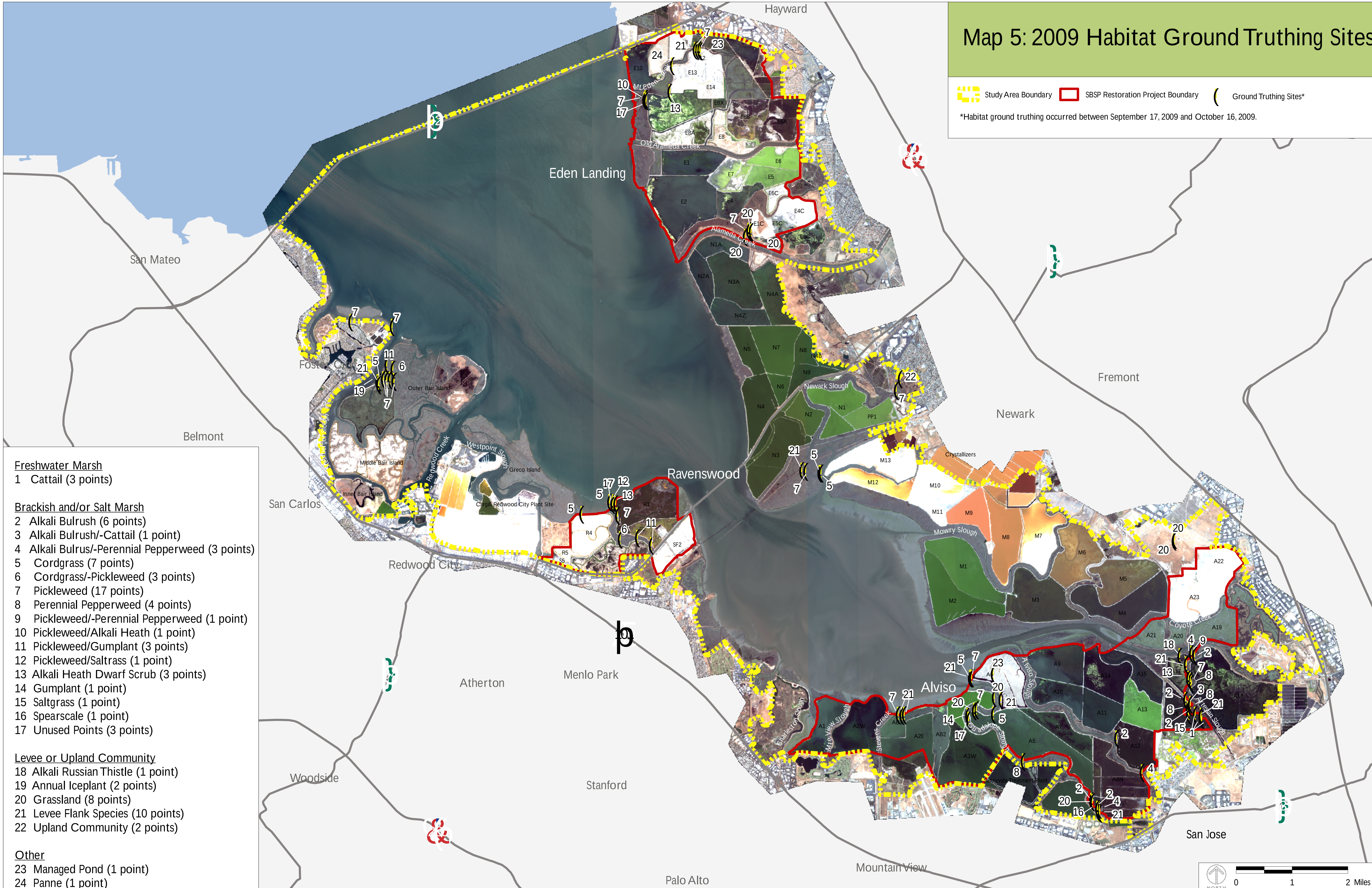
   The DC&E team modified the CNPS rapid assessment protocol to comply with mapping in marsh environments. We transformed this written protocol into a Terrasync data dictionary for efficient and precise data collection while in the field.

The collection of field data in an entirely digital format also allowed for efficient post-field data processing. This data dictionary was iteratively improved and modified based on experience applying the method in a range of marsh habitats throughout October and November.

For our field verification based ground truthing (the field validation is identical in regard to protocols and methods), we also developed an additional Terrasync data dictionary. The method we are using for verification (and validation) ground truthing is a simple point radius based approach to determine the types of dominant vegetation at ground truthed locations. Both type of field methods, and their associated field procedures, provide our field crew the flexibility to map the field sites using the appropriate type of geographic shape (points, lines, or polygons) in order to best inform potential improvements to training sites used in our habitat model.

2. Satellite Image Interpretation

We have successfully codified a set of satellite image based mapping standards in order to ensure consistency and accuracy of the overall habitat model. These standards primarily apply to (a) identifying optimal training sites for our supervised classification; (b) building a habitat interpretation guide and producing habitat maps that meet project goals; and (c) our review of initial supervised classifications. The two key (and closely related) elements is the scale at which we can either digitize or identify a given vegetation type as well as the minimum mapping unit (MMU) used for each habitat type. The scale used for digitizing training sites is much larger (and therefore more detailed) then we are using for our habitat interpretation guide (and resulting habitat maps). In order to obtain clear spectral and spatial signals in our training sites, we had to focus on smaller areas then the resulting overall habits maps (and guide). Polygons used for training the satellite image were digitized between 1:900 and 1:500 while the scale of the overall habitat maps (and guide) was around 1:800 to 1:2400. This closely conforms to our expectations. Our working MMU is still approximately ¼ hectare (that is, no vegetation association smaller then 14 hectare will mapped) – although we do believe that as we move into Year Two that these MMU might vary from habitat to habitat as a result of the resolution of the image and the variety of vegetation associations occurring.



Map prepared by DC&E on May 28, 2010.

Quality Assurance Project Plan (QAPP) / Hardware and Software Purchases

In August 2009, the HEP project manager spent a week developing and writing the Quality Assurance Project Plan (QAPP) for the EPA Region 9. Once this was approved by the EPA, at end of August DC&E moved ahead with purchasing the Trimble Yuma GPS enabled field computer with external ProXT antenna as well as the necessary software (Terrasync, Pathfinder Office and ERDAS Imagine). The hardware and software wasn't received and made fully operational until the end of September 2009

Year One: Challenges

Work on the HEP encountered delays in the beginning of Year One. These delays include:

- ♦ Delays in finalizing the contract;
- ♦ Unanticipated time required for EPA approval of our Quality Assurance Project plan (QAPP);
- ♦ Subsequent delays in the purchase of required hardware and software;
- ♦ Impact of these delays on limiting our field season and ability to conduct ground truthing.

Other challenges include:

- ♦ Identifying optimal days for Ikonos satellite image capture in June/July that match up closest to MLLW; and
- ♦ Obtaining adequate preliminary ground truthing data to identify the range of vegetation and to differentiate key species (e.g. finding good training sits to differentiate types of Pickleweed).

Year Two: Current Status

As we move into Year Two, we anticipate accomplishing our tasks in a much more efficient and timely fashion. The HEP team is beginning to prepare for Year Two and we have already developed a relatively detailed timeline for completing our Year Two tasks. As of the end of April, we have worked with the Don Edwards USFWS staff to coordinate our need to access marshes within the study area and to prepare a ground truthing plan that will last into future years. The HEP team spent considerable time and effort developing an effective process for identifying optimal days for satellite acquisition, and based on this research, we have already ordered the 2010 satellite data.

Appendix

Habitat Interpretation Guide Examples

Pickleweed /- Cordgrass

Pickleweed /- Cordgrass

Genus species	*Salicornia spp./ Spartina spp*
Alliance/Association (MCV & CNNDB Code)	*Sarcocornia pacifica – Spartina foliosa (various)*
Proposed	Pickleweed / Cordgrass

Color	Gray-green (true), red-dark gray (false)
Shape	Circular clumps intermixed with indistinguishable patches
Texture	Mottled
Pattern	patchy, with circular patches

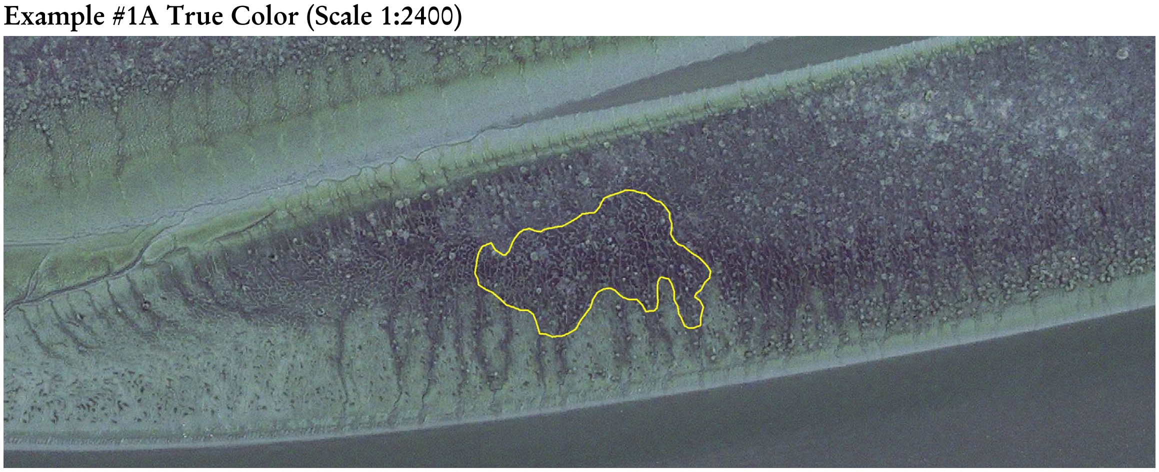
GENERAL NOTES: Cordgrass and pickleweed intermix at the lower mid-marsh plain where the species tend to be co-dominant. As cordgrass extends from the lower marsh (at channel edges) it mixes with pickleweed at the mid-marsh level. For *Sarcocornia pacifica (Salicornia virginica)* Alliance membership rules MCV states, "In northern California *Sarcocornia pacifica* dominates with *Cuscuta salina* in the high marsh zone slightly above those dominated by the non-native *Spartina densiflora*: in central California, *Sarcocornia pacifica* dominates in the high- and mid-marsh zones above those dominated by *Spartina foliosa.*" (Page 1023 of MCV 3rd ed.)

HABITAT DESCRIPTION: Intermixing of the cordgrass and pickleweed typically occurs at the ecotonal transition between the low and mid-marsh where the species tend to be more co-dominant. Cordgrass stands are clumped together, often in circular patches, and are easy to distinguish in both the true and false color images by sage green patches in the true color image and rosy-pink/red patches in the false color image. This particular example shows a typical Pickleweed-/Cordgrass establishment right at the low-mid marsh transition along a major brackish slough edge.

<u>Example #1</u>

Location: Interior mouth of Coyote Creek (Polygon_st: cc w A9 CL)

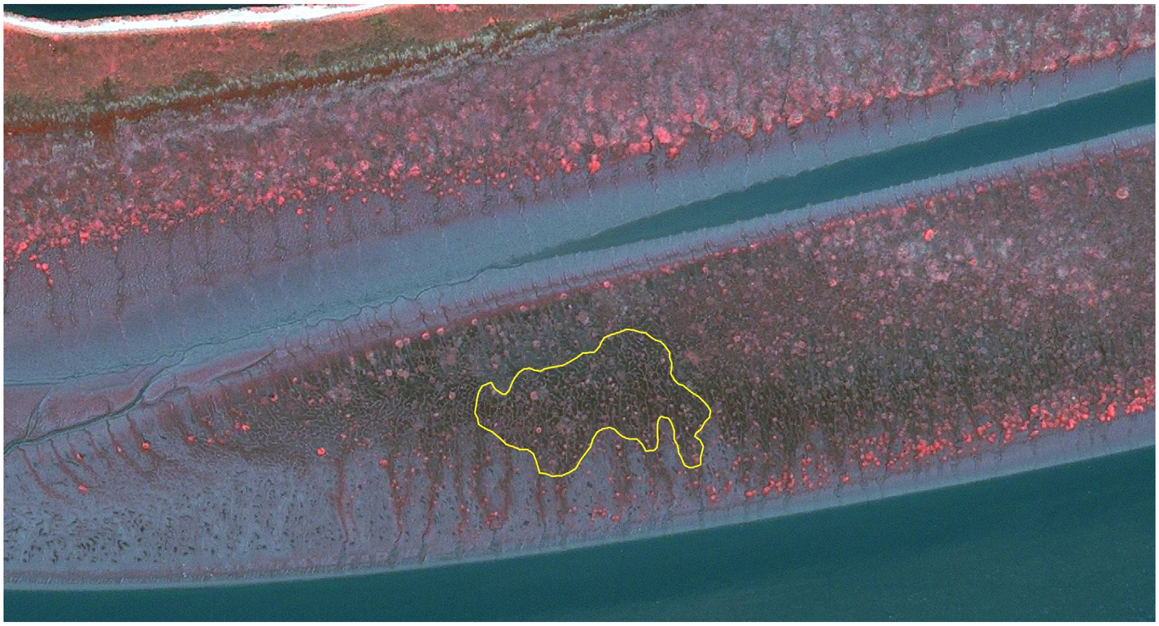
Example #1A True Color (Scale 1:2400)



Example #1 False/True Color Notes: Cordgrass is distinguished by the sage green patches (true) and red/pink (false); pickleweed is distinguished by the dark gray/green mottling in-between the Cordgrass.

% Cover: Spartina spp. (25-50), Salicornia spp. (25-50). (estimated from satellite image)

Example #1B False Color (Scale 1:2400)



Example #1 Bing Maps

Looking South (Best orientation for most recent plant growth and best lighting)

Bing Map Example Notes: Cordgrass is distinguished by yellow/brown clumps and Pickleweed is distinguished by forest green established (and establishing?) along the mudflat.

<u>Example #2</u>

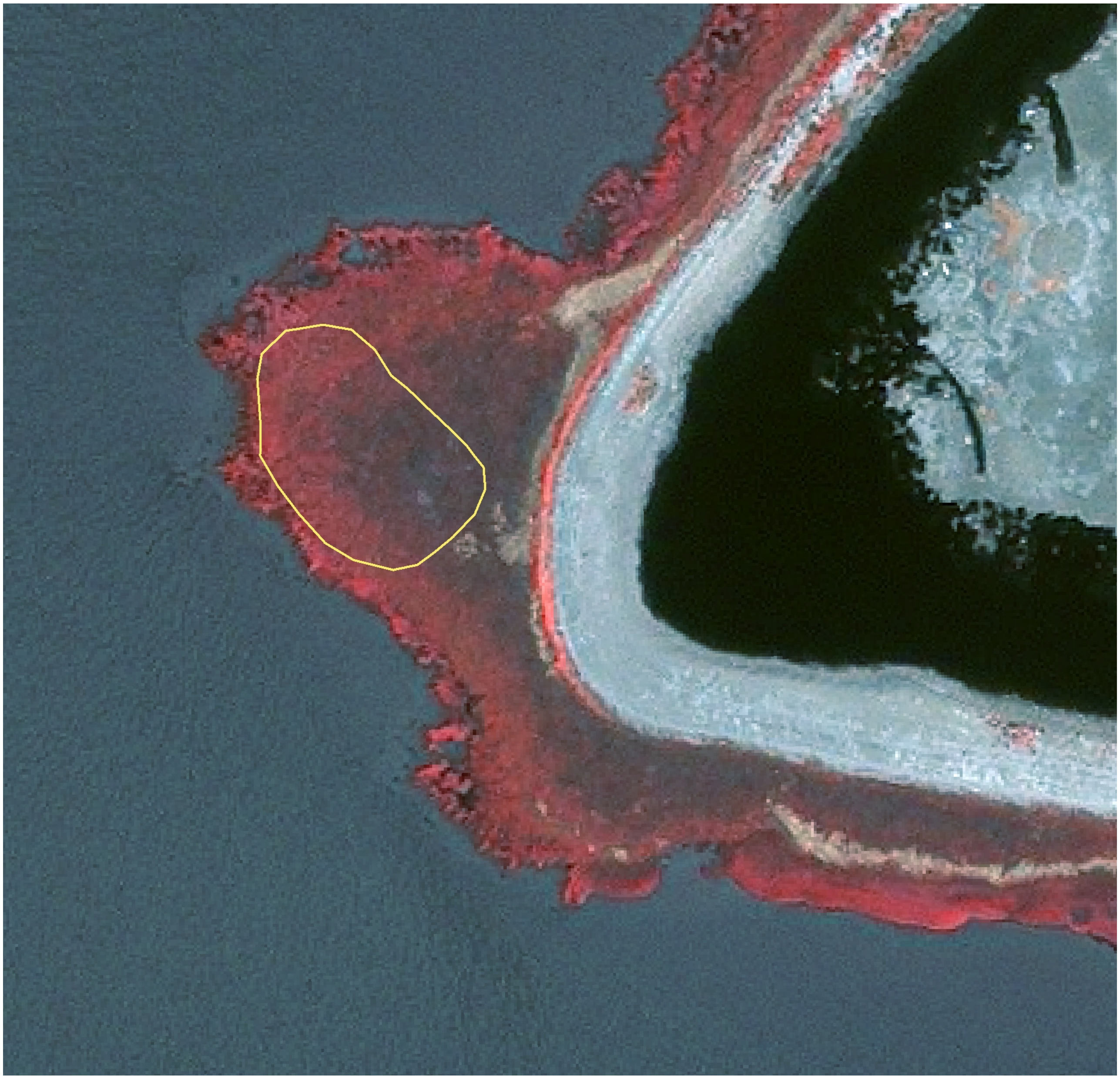
Location: Pond A6 in the Alviso Complex (Polygon_st: gse 1)

Example #2A True Color (Scale 1:1800)

%Cover: Spartina foliosa (spp.) (25-50), Salicornia virginica (spp.) (1-5). (GTY1)

Example #2A True Color Notes: Cordgrass is distinguished by the light sage green patches; pickleweed is distinguished by the dark green/gray clumps intermixed within the stand. Note the pure cordgrass stands (sage green patches in a linear row with fluffy texture) that follows the bay edge.

Example 2B False Color (Scale 1:1800)



Example 2B False Color Notes: Cordgrass is distinguished by the rosy-pink/bright red patches; pickleweed is distinguished by the dark red-grey clumps intermixed within the stand. Note the pure cordgrass stands (bright red in a linear row with fluffy texture) that follows the pond edge.

Example #2 Bing Maps

Looking North

Looking West

Bing Map Example Notes: Cordgrass is distinguished by lime green (looking north) and forest green (looking west) clumps along bay edge. Pickleweed is distinguished by sage green (looking north) and olive green (looking west) vegetation that is closer to the levee.

Example #3

Location: Outer northwest Bair Island (Polygon_st: out bair 11 b CS)

Example #3A True Color (Scale 1:1800)

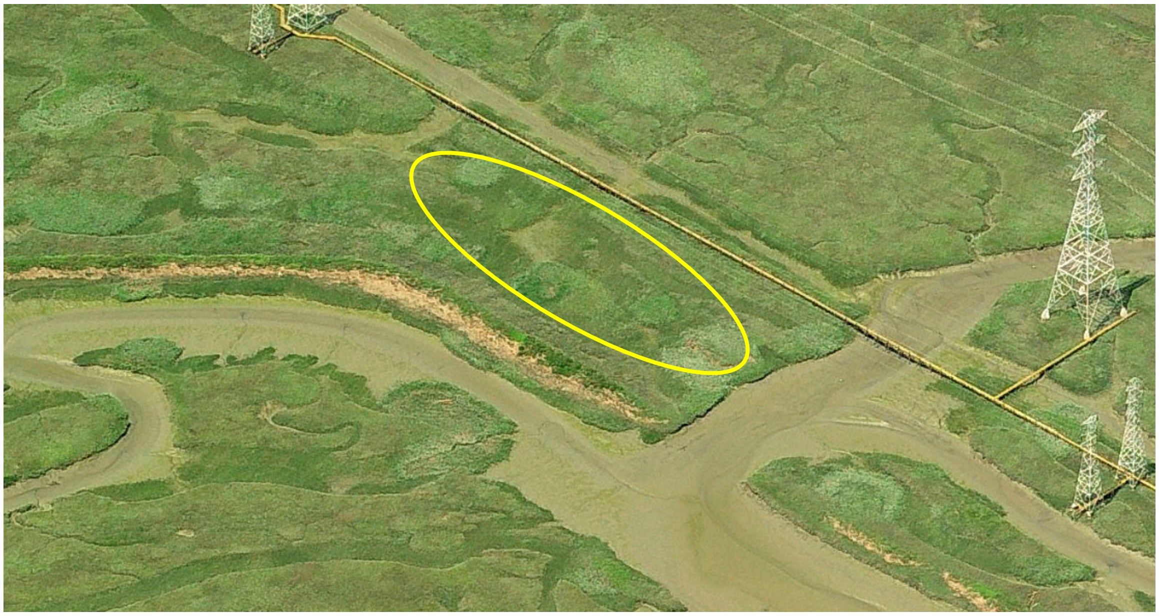
Example #3A True Color Notes: Cordgrass is distinguished by the light sage green patches; pickleweed is distinguished by the dark green/gray clumps intermixed within the stand.

%Cover: Spartina foliosa (spp.) (25-50), Salicornia virginica (spp.) (25-50). (estimated from satellite)

Example #3B False Color (Scale 1:1800)

Example #3B False Color Notes: Cordgrass is distinguished by the rosy-pink/bright red patches; pickleweed is distinguished by the dark red-grey clumps intermixed within the stand.

Example #3 Bing Maps
Looking North



Bing Map Example Notes: Cordgrass is distinguished by taller, circular patches in lighter green; pickleweed is distinguished by darker green clumps mixed amongst cordgrass patches.

<u>**Example #4**</u>
Location: Halfway up Ravenswood Slough (Polygon_st: raven 7)

Example #4A True Color (Scale 1:1800)

Example #4 True/False Color Notes: Cordgrass is distinguished by the light sage green patches(true color) and pink/red patches(false color) and brown patches in both true and false because of burned/dead foliage from spraying in this image; pickleweed is distinguished by the dark green/gray mottled clumps intermixed within the stand.

%Cover: Spartina foliosa (spp.) (25-50), Salicornia virginica (spp.) (5-15). (GTY1)

Example #4B False Color (Scale 1:1800)

Example #4 Bing Maps

Looking North

Bing Map Example Notes: Cordgrass is distinguished by green circular clumps along slough edge. Pickleweed flat is distinguished by sage green that is closer to the levee. This image was taken before the ISP spraying was done. Multiple patches of Cordgrass can be seen along the sough edge pre-spray.

Perennial Pepperweed

Perennial Pepperweed

Genus species	*Lepidium latifolium*
Alliance/Association (CNNDB Code)	*Lepidium latifolium* (52.205.00)

Color	Moss green (true), rosy pink (false)
Shape	Linear, curvilinear, large strips
Texture	Fluffy cotton/wool
Pattern	Uniform, large patches

GENERAL NOTES: Pepperweed appears at the mid and high marsh areas, typically invading disturbed areas and quickly spreading to other marsh areas.(PB suggests Levee's as a possible source disturbance for LELA in the SBSP) When the plants seed heads die after seeding, tall semiwood stems remain which greatly affects their appearance in the aerial image, making them appear more "fluffy" than Pepperweed rosettes with no seed heads. Pepperweed rosettes with no seed heads can also appear to be more pink/red in the false color aerial image than pepperweed with seed heads, and is more easily confused with patches of Alkali Heath which tend to be very bright pink/red in the false color image during our annual image acquisition time.

<u>Satellite Images Examples</u>

HABITAT DESCRIPTION: Pepperweed appears sage green in true color and rosy pink in false color. Pure stands appear fluffy and cotton-candy like and are easy to identify at a scale of 1:1800. Two reasons pepperweed are easy to identify is that there are large stands and because the texture is so distinct (the texture of pepperweed is unlike any other plant in the Project Area). The taller flower/seed heads give peppperweed its unique texture.

Example #1

Location: West side of Artesian Slough adjacent to Pond A17 in the Alviso complex (Polygon: as w 11)

Example 1A True Color (Scale 1:1800)

EXAMPLE #1A TRUE COLOR NOTES: Pepperweed is distinguished by the sage green, fluffy patches. Alkali bulrush, dark grey/black red stands, is adjacent to the pepperweed.

Example 1B False Color (Scale 1:1800)

EXAMPLE #1B FALSE COLOR NOTES: Pepperweed is distinguished by the bright pink, fluffy patches. Alkali bulrush, dark/blood red stands, is adjacent to the pepperweed.

Example #1 Context View (True Color, Scale 1:8000)

Example #1 Bing Maps

Looking North

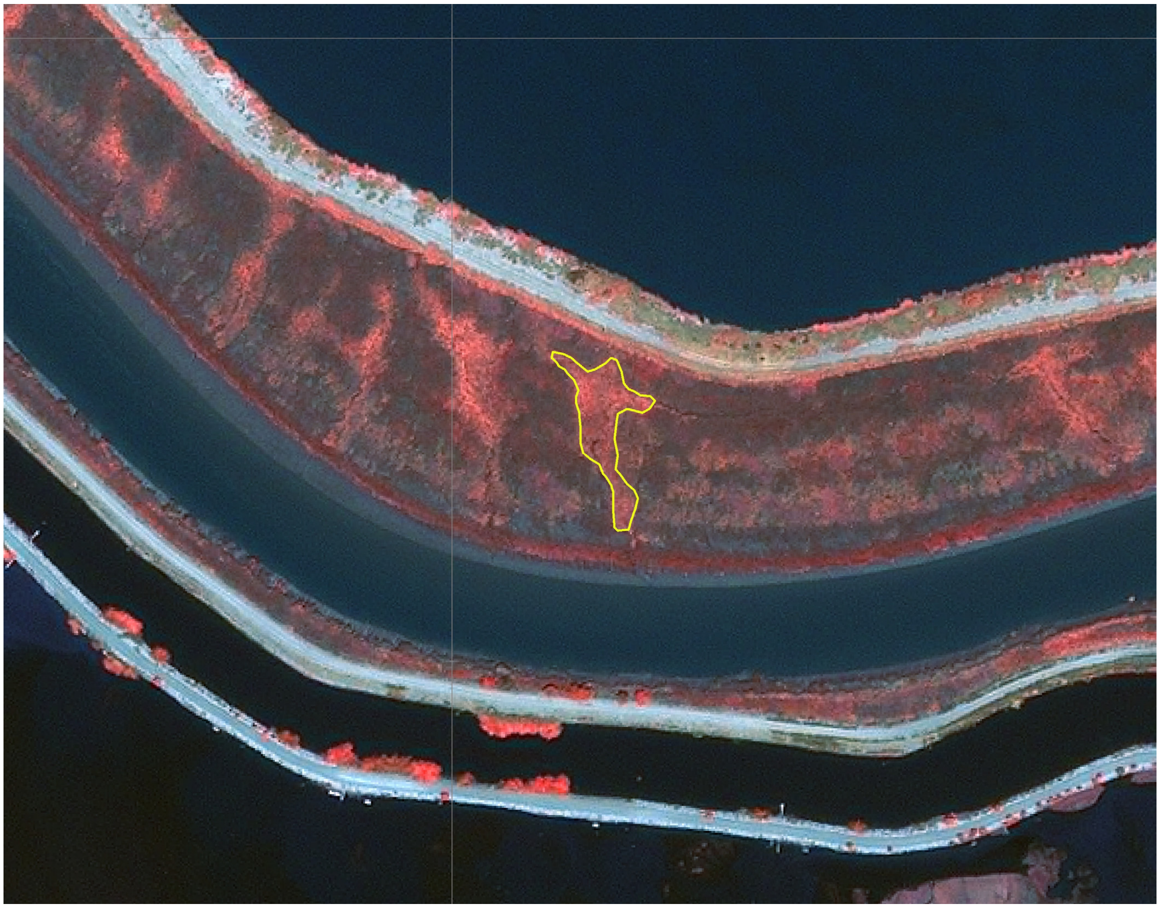
BING MAP EXAMPLE NOTES: Pepperweed is distinguished by the lighter green patches surrounded by darker green patches (Alkali bulrusy).

Example #2

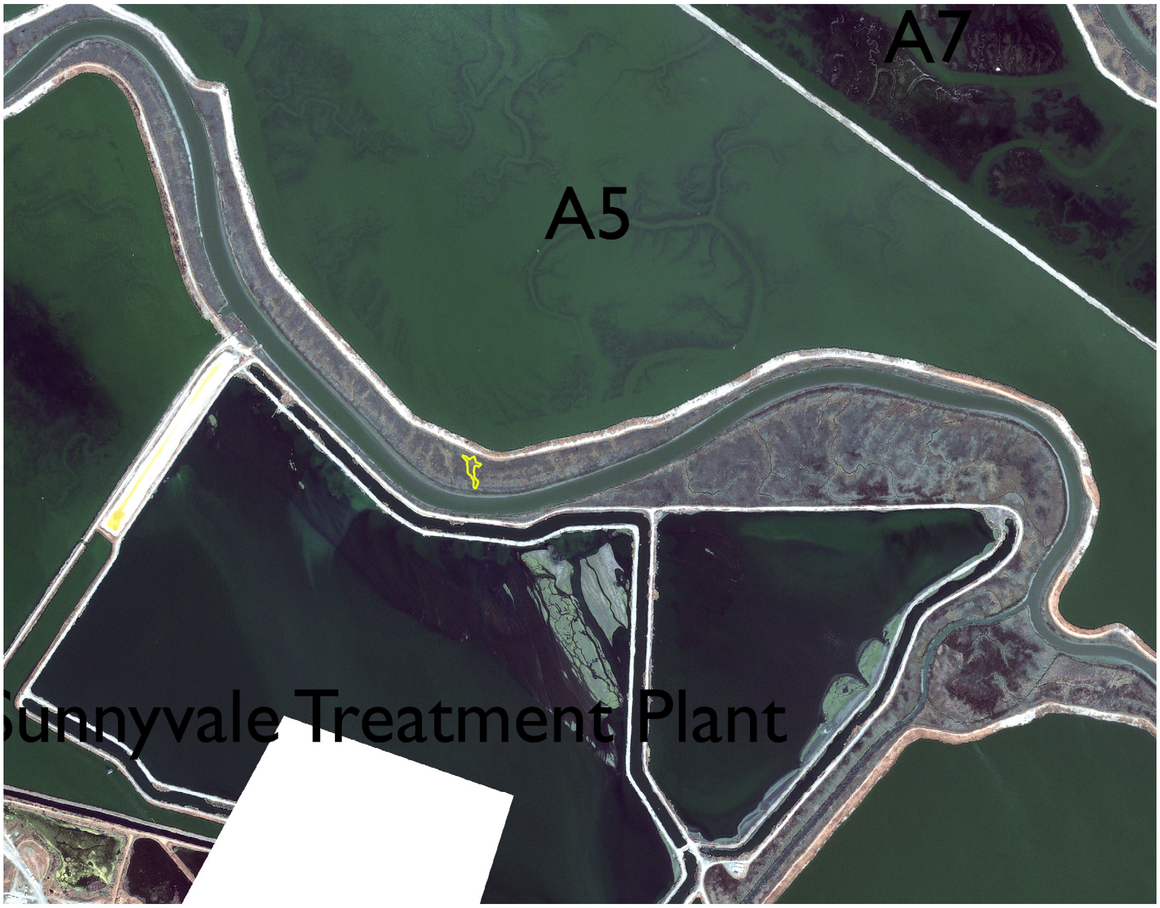
Location: East side of Guadalupe Slough on the southwest side of Pond A5 (Polygon: gse 11)

Example 2A True Color (Scale 1:1800)

Example 2B False Color (Scale 1:1800)



Example #2 Context View (True Color, Scale 1:10,000)



<u>Example #2 Bing Maps</u>

Looking North

Looking South