5-27-2014

Memorandum: Quality Assurance of 2013 Great Bay Estuary Eelgrass Monitoring Program conducted by Kappa Mapping, Inc.

Matthew A. Wood
NH Department of Environmental Services

MEMORANDUM

To: Phil Trowbridge, Project Manager, PREP

From: Matthew A. Wood, DES

Date: May 27, 2014

Re: Quality Assurance of 2013 Great Bay Estuary Eelgrass Monitoring Program

PURPOSE

The purpose of this memorandum is to document the results of quality assurance checks on the 2013 Great Bay Estuary Eelgrass Monitoring Program.

The project consisted of three components:

- Collection of high-resolution (<1 ft), orthorectified aerial imagery,
- Independent ground truth observations, and
- Photointerpretation of the aerial imagery to delineate and classify eelgrass beds.

DES reviewed these data from each of these three components to ensure that they met data quality objectives for the approved Quality Assurance Project Plan, available online: http://prep.unh.edu/resources/qapps/PREP_Eelgrass_Monitoring_QUAPP_completed.pdf.

The following three tables contain assessments of the data quality objectives for each component of the project. Supporting tables and figures are provided at the end of the document.

DATA QUALITY OBJECTIVE ASSESSMENTS

1: Aerial Survey

Data Quality Objective	Criteria	Protocol	Assessment of Criteria	Data Quality Objective Status
Imagery Completeness	4-band source imagery obtained for 100% of study area	Extent of imagery will be compared to study area.	The aerial imagery received form KAPPA Mapping, Inc. was compared to the ArcGIS file identifying the extent of the study area. The aerial imagery covered 100% of the study area (**Figure 1**).	**Achieved**
Ground Pixel Resolution	Less than or equal to 0.30 meters (1 foot)	Pixel size of imagery will be compared to criteria.	The pixel (cell) size of the aerial imagery received form KAPPA Mapping, Inc. was compared to the 0.30 meter criteria. The pixel size was confirmed to be 0.304801 meters (one survey foot, **Figure 2**).	**Achieved**
Spatial Accuracy	Horizontal positional accuracy less than or equal to 0.62 meters (2 feet) Root Mean Square Error following guidance from NSSDA*	The positions of 20 known locations in the orthorectified imagery will be checked against the known coordinates.	The Root Mean Square Error (RMSE) was confirmed to be less than two feet (0.89 feet, **Table 1**).	**Achieved**
Environmental & Timing Conditions	Environmental & timing conditions met during flight - 7/1/13 to 9/30/13 - 7 AM to 10 AM - Low spring tide (+/- 2 hrs) - Low sun angle (25-50^{o}) - Low cloud cover (<10%) - Calm winds (<10 mph) - No preceding rain events - Good water clarity	Environmental & timing conditions during flight will be compared to criteria.	The environmental & timing conditions of the flight were compared to the criteria, and it was confirmed that they imagery was taken under the specified conditions (**Table 2**).	**Achieved**

*Root Mean Square Error (RMSE). A measure of the difference between locations that are known and locations that have been interpolated or digitized. RMSE is derived by squaring the differences between known and unknown points, adding those together, dividing that by the number of test points, and then taking the square root of that result. Following guidance from the National Standard for Spatial Data Accuracy (NSSDA), the spatial accuracy will be calculated as the 95% confidence level using the circular map accuracy standard (Accuracy = 1.7308 * RMSE). See http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3 for methods.

2: Ground Truth Survey

Data Quality Objective	Criteria	Protocol	Assessment of Criteria	Data Quality Objective Status
Spatial Accuracy	Field GPS units should have a reported accuracy less than or equal to 3 meters using WGS84 datum	Check reported accuracy of field GPS units.	The GPS units used by the field teams are listed below. • Drop Camera: Garmin 76 (3 m accuracy with WAAS enabled) • Divers: SIMRAD CX44 NavStation (<1 m accuracy) • Edge Mapping: Trimble Geoxh 6000 GPS. Points with >3 m precision (based on standard deviation of 45-100 observations) were deleted.	**Achieved**
Comparability	Field observations should be collected using a standardized protocol	Check that protocols from the QAPP were used for field observations.	All field teams collected data using a standardized field data sheet. The protocols in the QAPP were used except for the minor non-conformances. **See the PREP Ground Truth Survey Report for details.**	**Achieved**
Completeness	Field observations should be made at planned locations and should ideally represent conditions in eelgrass beds in all four cover classes and in areas where eelgrass does not exist currently but existed in the past. At least 80% of the ground truth stations should be visited.	Check ground truth observation locations against planned locations listed in Section B1. Check eelgrass cover classes at ground truth stations. Check that 80% of ground truth stations were visited.	The coordinates for field observations were compared to the planned coordinates. Ninety percent of the visits were made within 60 meters of the planned station. Field crews observed eelgrass in all five of the eelgrass percent cover classes (dense through not-present) as planned. A total of 90 station visits were planned at 60 stations. 85 of the 90 visits were completed (94% completeness). The breakdown by visit type was: • Drop Camera: 60 of 60 • Divers: 17 of 20 • Edge Mapping: 8 of 10 **See the PREP Ground Truth Survey Report for details.**	**Achieved**

3: Photointerpretation

Data Quality Objective	Criteria	Protocol	Assessment of Criteria	Data Quality Objective Status
Mapping completeness	Eelgrass cover classes (dense, some bottom, half, and patchy) mapped for 100% of study area	Extent of mapped eelgrass will be compared to study area.	All of the eelgrass mapped was within the defined mapping extent (**Figure 3**). Additionally, all of the eelgrass mapped was within one of DES's existing Eelgrass Assessment Zones (**Figure 4**).	**Achieved**
Minimum Mapping Unit	Less than or equal to 200 square meters	The area of the smallest delineated eelgrass beds	The area of the smallest delineated eelgrass bed was calculated to be 9 m^2, which is below the minimum mapping unit. The 20th	**Failed, but Not a valid**

Data Quality Objective	Criteria	Protocol	Assessment of Criteria	Data Quality Objective Status
		will be compared to the criteria.	percentile of all the eelgrass beds mapped was calculated to be 174 m^2, which is also below the minimum mapping unit and accounts for 0.9 acres or 0.05% of the total area. (**Table 3, Figure 5**). Note that ≤ 200 m^2 is not a valid minimum mapping unit. The minimum mapping unit is the minimum size technically possible for delineating an eelgrass bed based upon the image data that the land cover is being derived from. (i.e. no eelgrass beds should be smaller than 200 m^2). **This criterion needs to be reevaluated by PREP for future mapping.**	**metric**
Spatial Accuracy	Less than or equal to 5 meters	The bed edge measured at 10 ground truth locations will be compared to mapped edge.	Eelgrass was not present in the area around stations LH03 and LLB05, therefore edge matching was not possible. For the remaining 8 stations, 5 were within the data quality objective of ≤ 5 meters. Station GB12, GB13, GB14, PH03 and PH04 were within 0.4, .05, 0.6, 2.1 and 4.2 meters, respectively. Station GB15 was within 6.5 meters of the mapped boundary. Although this is outside of the data quality objective it was deemed acceptable because it was relatively close to the criteria. GB16 was within 74.1 meters of the mapped boundary. It is evident from reviewing the aerial imagery that the ground survey team mapped the edge of a low density bed that was not mapped by the photointerpreter. There is a clear break/channel between the eelgrass that was mapped from the aerial imagery and the locations of the points collected for edge matching (**Figure 10**). Therefore, this is not considered an exceedence of the data quality objective. Station PH05 was within 28.4 meters of the mapped boundary. Similar to station GB16, it appears that the ground survey team may have mapped the edge of a low density bed that was not mapped by the photointerpeter. This is not considered an exceedence of the data quality objective. (**Figures 6 - 13**)	**Achieved**
Classification Accuracy	Greater than or equal to 85% overall accuracy from an error matrix	Eelgrass cover class assessed by ground truth teams at 60 locations will be compared to mapped cover class. Locations will include areas without eelgrass.	Analysis of the eelgrass cover class assessed by ground truth teams versus the mapped cover class shows an overall accuracy of 61%. It should be noted that although the overall accuracy of density class fails to meet the data quality objective, many of the inaccuracies stem from minor differences in the eelgrass percent cover classification. For example, at site GB20, the ground survey crew classified the eelgrass as "Half" and the photointerpreter classified the eelgrass as "Patchy". This indicates that the error stems from subtle differences in interpretation of density class by different individuals. Moreover, the photointerpreter classified the average percent cover over larger areas, while the ground survey team looked at the area within an 8 meter radius. If the ground truth	**Failed for Density** **Achieved for Presence/Absence**

Data Quality Objective	Criteria	Protocol	Assessment of Criteria	Data Quality Objective Status
			points are used to assess the accuracy of identifying just the presence versus absence of eelgrass, the overall accuracy is 94%. (**Table 4** and **Figures 14** - **24**)	

Figure 1: Aerial Imagery Extent

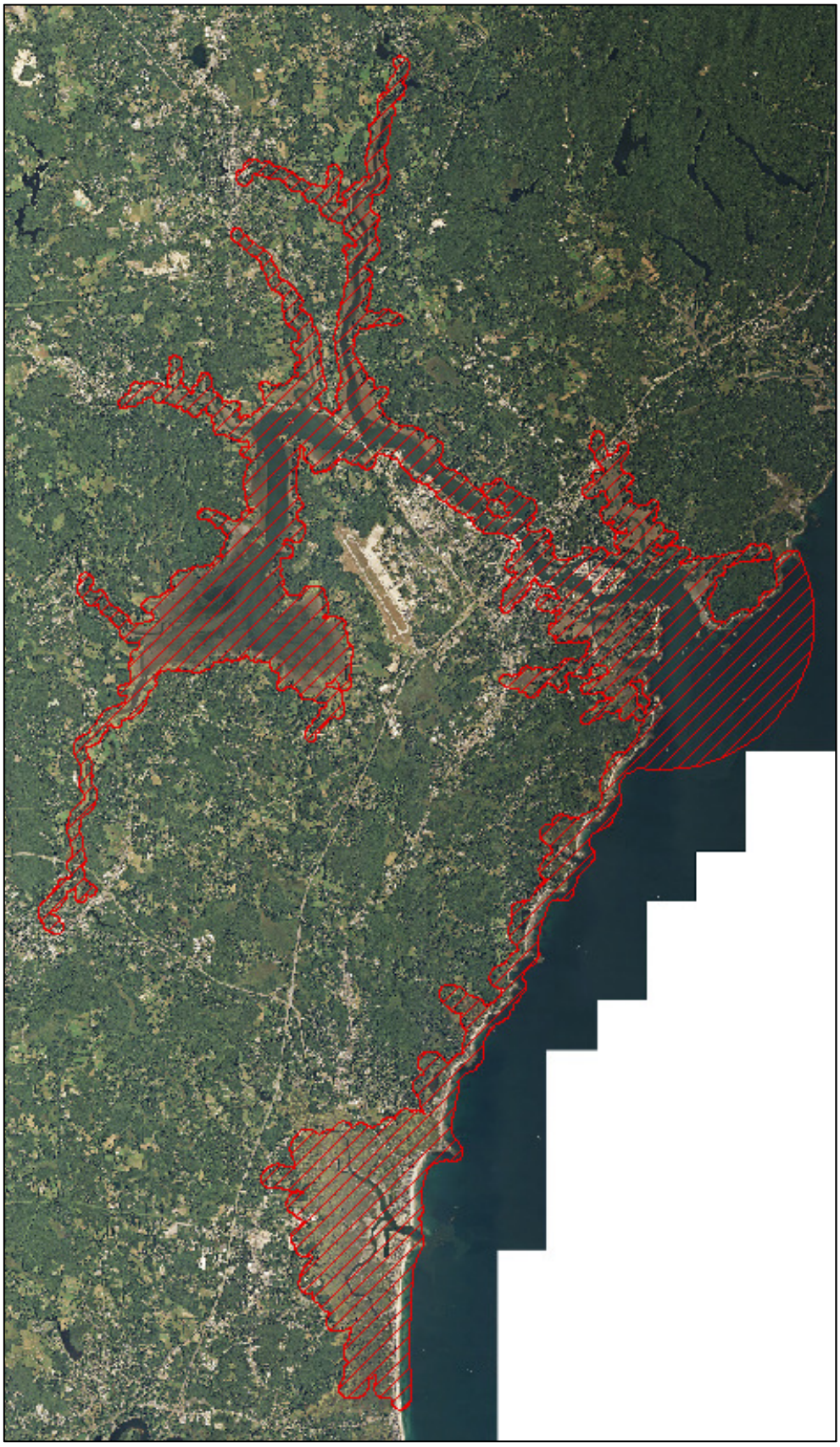
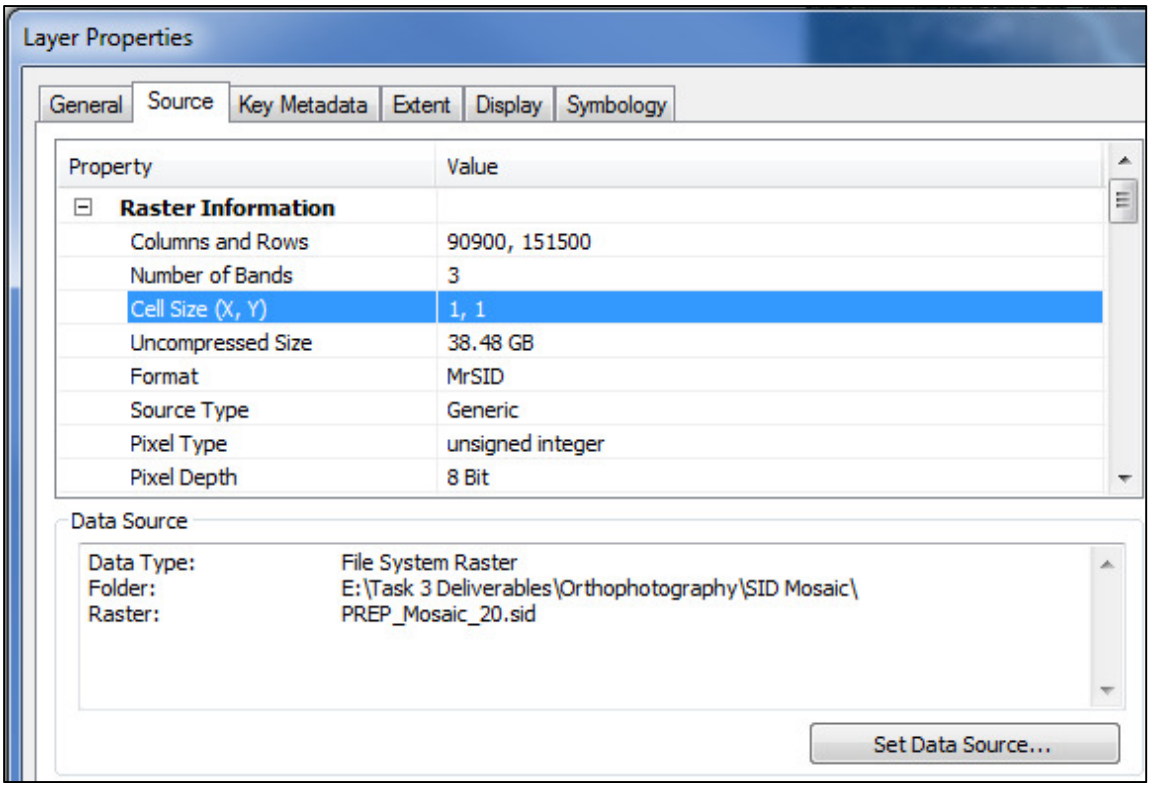
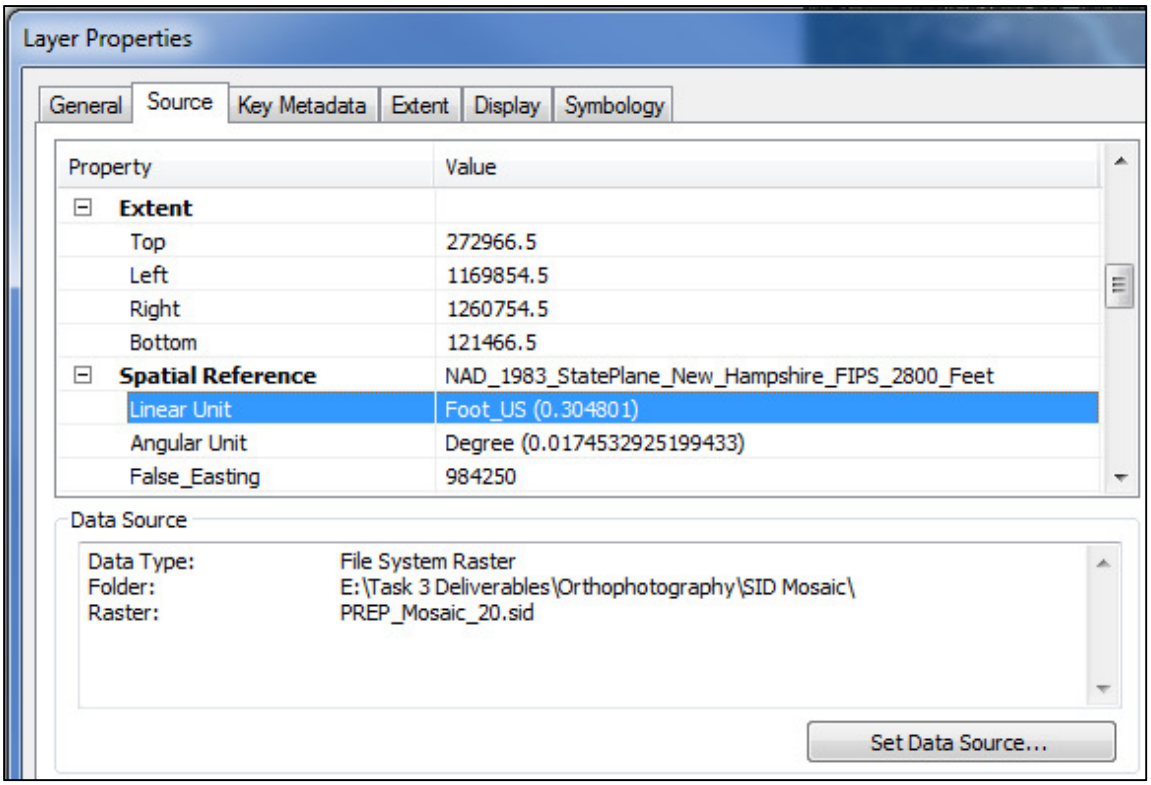


Figure 2: Pixel Size of Imagery





* Linear Units are expressed in the units of measure defined in the coverage, with the equivalent meters per unit shown in brackets.

Table 1: Horizontal Positional Accuracy (excerpt of Worksheet from National Standard for Spatial Data Accuracy (NSSDA) Report for PREP Orthophotography, submitted by KAPPA Mapping, Inc.) Units in Feet

A	B	C	D	E	F	G	H	I	J	K
Point number	Point description	x (independent)	x (test)	diff in x	(diff in x)^2	y (independent)	y (test)	diff in y	(diff in y)^2	(diff in x)^2 + (diff in y)^2
1	ME Corner Box	1236632.52	1236632.97	-0.45	0.2025	227524.47	227524.63	-0.16	0.0256	0.22810
2	ME SidewalkCorner	1212865.83	1212865.01	0.82	0.6724	268380.07	268379.66	0.41	0.1681	0.84050
3	ME Parkinglot	1222666.58	1222666.08	0.5	0.25	232379.03	232379.53	-0.5	0.25	0.50000
4	ME RoadLine	1255056.44	1255056.64	-0.2	0.04	229625.82	229626.42	-0.6	0.36	0.40000
5	ME Roadcorner	1252971.53	1252971.86	-0.33	0.1089	262101.66	262103.18	-1.52	2.3104	2.41930
6	ME Corner	1229361.58	1229361.07	0.51	0.2601	247817.24	247816.73	0.51	0.2601	0.52020
7	ME Sidewalk	1242451.98	1242452.41	-0.43	0.1849	214673.4	214673.55	-0.15	0.0225	0.20740
8	ME Wall	1223436.54	1223435.94	0.6	0.36	219936.08	219935.69	0.39	0.1521	0.51210
9	ME PaintIntersection	1249940.02	1249939.91	0.11	0.0121	238324.73	238323.98	0.75	0.5625	0.57460
10	ME BallField	1212489.68	1212490.34	-0.66	0.4356	246157.54	246157.21	0.33	0.1089	0.54450
11	NELidar Dock	1197828.65	1197829.47	-0.82	0.6724	179372.38	179372.65	-0.27	0.0729	0.74530
12	NELidar Fence	1178769.69	1178770.76	-1.07	1.1449	139777.66	139778.2	-0.54	0.2916	1.43650
13	NELidarManhole	1218566.18	1218565.97	0.21	0.0441	195855.07	195854.94	0.13	0.0169	0.06100
14	NELidarDEM_Ballfield	1208364.33	1208365.04	-0.71	0.5041	193737.83	193737.12	0.71	0.5041	1.00820
15	NHLidarDEM	1189742.75	1189743.35	-0.6	0.36	244472.21	244472.51	-0.3	0.09	0.45000
16	NHLidarDEM Water	1218684.01	1218684.77	-0.76	0.5776	167521.25	167520.11	1.14	1.2996	1.87720
17	NHDEM Building	1180176.83	1180176.65	0.18	0.0324	210061.22	210061.04	0.18	0.0324	0.06480
18	NHLidarDEM_Culvert	1211297.1	1211295.94	1.16	1.3456	141111.5	141111.79	-0.29	0.0841	1.42970
19	NHLidarDEMParkingCorner	1177739.06	1177738.13	0.93	0.8649	262902.27	262902.31	-0.04	0.0016	0.86650
20	NHLidarDEMIntersection	1176712.36	1176713.11	-0.75	0.5625	183757.76	183758.5	-0.74	0.5476	1.11010
									sum	15.79600
									average	0.78980
									RMSE	0.88871
									NSSDA	1.53817

Table 2: Environmental & Timing Conditions of Aerial Imagery (excerpt of Task Checklist form Task 1 QC Summary Report submitted by KAPPA Mapping, Inc.)

Environmental Conditions:	Completed	Pass or Fail	Comments
Fly July 1 to September 30, 2013 (August 1 to August 31 is ideal)	Yes	Pass	Flown 8/24/13
Early morning (7:00 am – 10:00 am)	Yes	Pass	Time range: 8:19 AM EDT to 10:17 EDT. Based on tides and sun angles, the flight window on 8/24/13 was 8:22 to 10:41 AM EDT.
Low spring tide (+/-2 hours of low tide at Adams Point in Great Bay)	Yes	Pass	Low tide at Adams Point on 8/24/13 was at 10:05 am EDT.
Low sun angle (>30 degrees ideal, >50 degrees unacceptable.)	Yes	Pass	Sun angle range: 25 to 44
Low cloud cover (>10% cover is unacceptable)	Yes	Pass	<1%, A little haze
Calm winds (<10 mph)	Yes	Pass	5 knots (5.8 mph)
No preceding rain events	Yes	Pass	The last significant rainfall recorded in Greenland NH before the flight was 1.72 inches on 8/9/13.
Low turbidity / good water clarity	Yes	Pass	The Project Manager consulted with monitoring staff at the UNH Jackson Laboratory who reported that water clarity was good.

Figure 3: Extent of Mapped Eelgrass

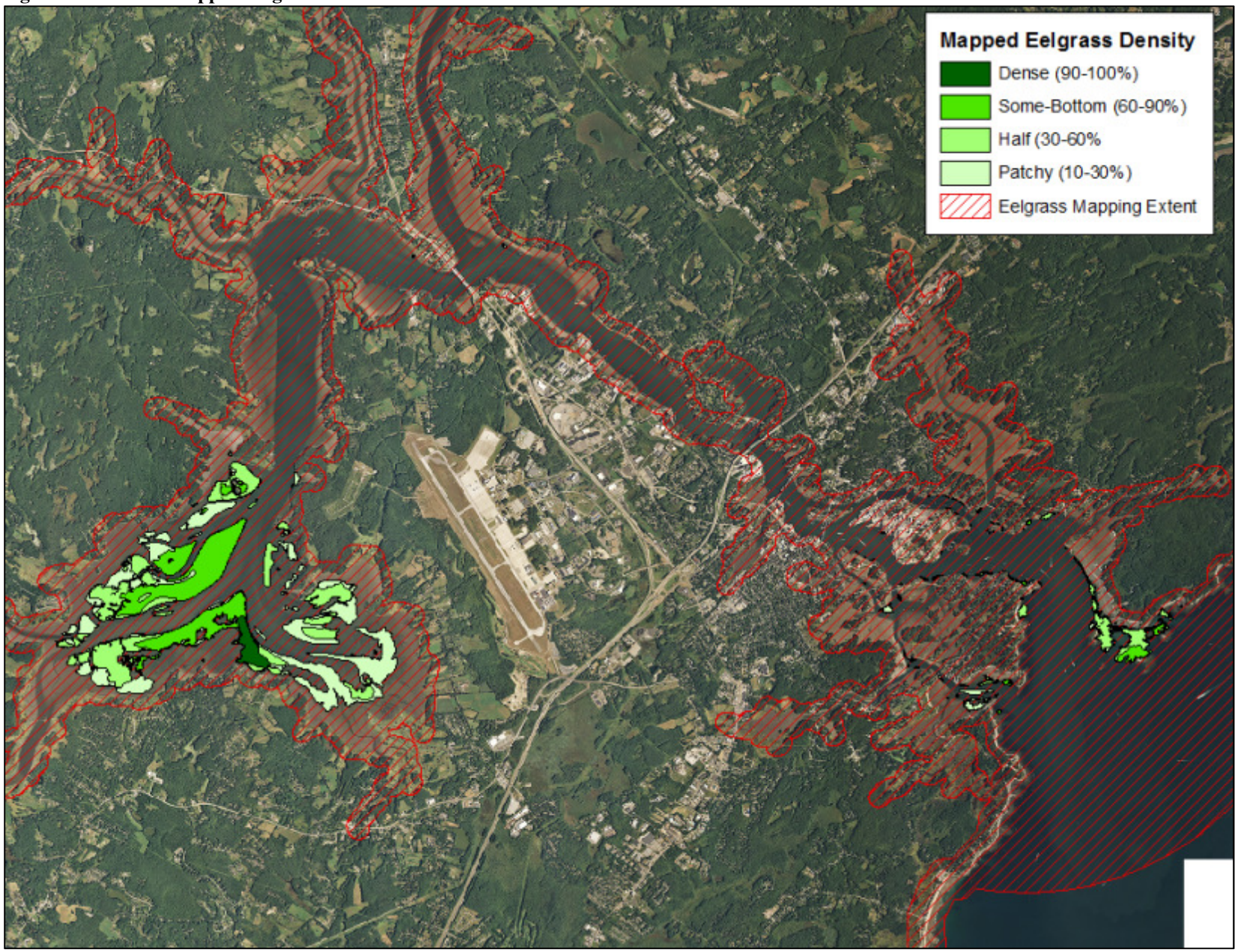


Figure 4: Extent of Mapped Eelgrass

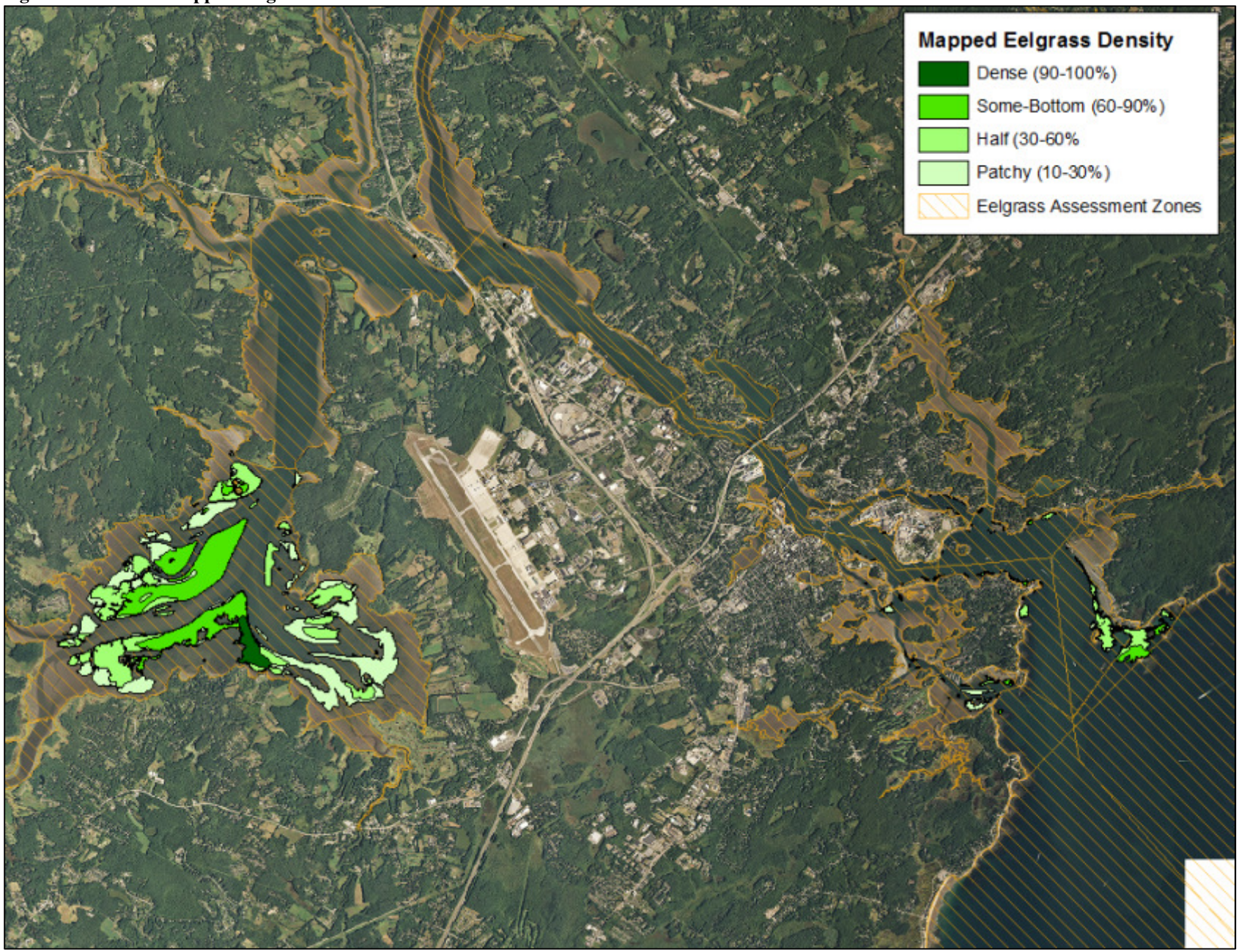


Table 3: Mapping Unit Observations

Observation		QC Criteria ($\leq$ 200 m^2)
Total number of eelgrass beds/densities mapped	240	N/A
Total number of eelgrass beds/densities mapped $\leq$ 200 m^2	50	
Percent of eelgrass beds/densities mapped $\leq$ 200 m^2	21%	
Smallest eelgrass bed/density mapped	9 m^2	Failed
Average area of eelgrass bed/density mapped	28,633 m^2	N/A
Largest eelgrass bed/density mapped	912,575 m^2	
20th Percentile of eelgrass beds/densities mapped	174 m^2	Failed

Figure 5: Example of Eelgrass Beds Mapped with Areas $\leq$ 200 m^2

Figure 6: Edge Mapping at Station GB12

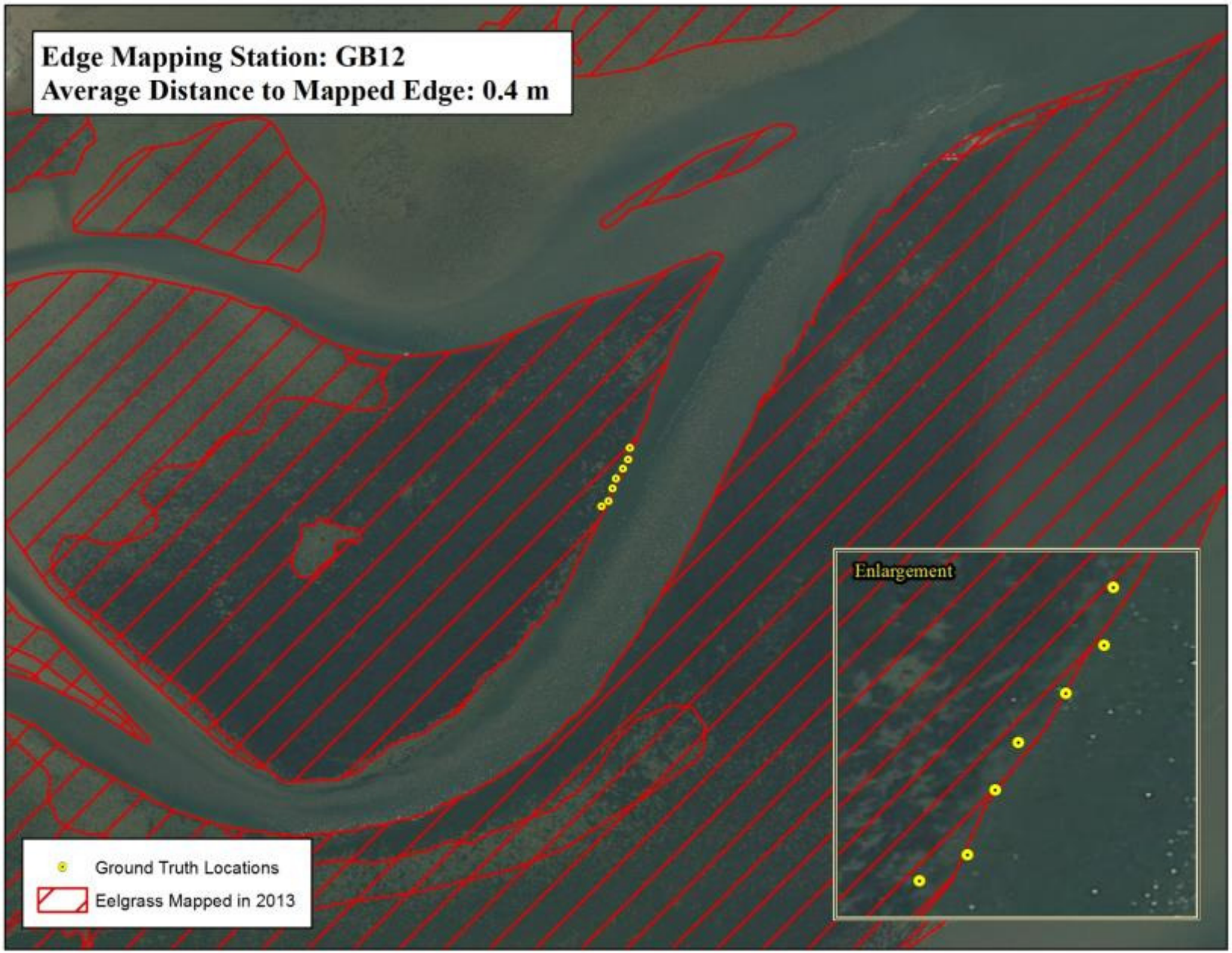


Figure 7: Edge Mapping at Station GB13

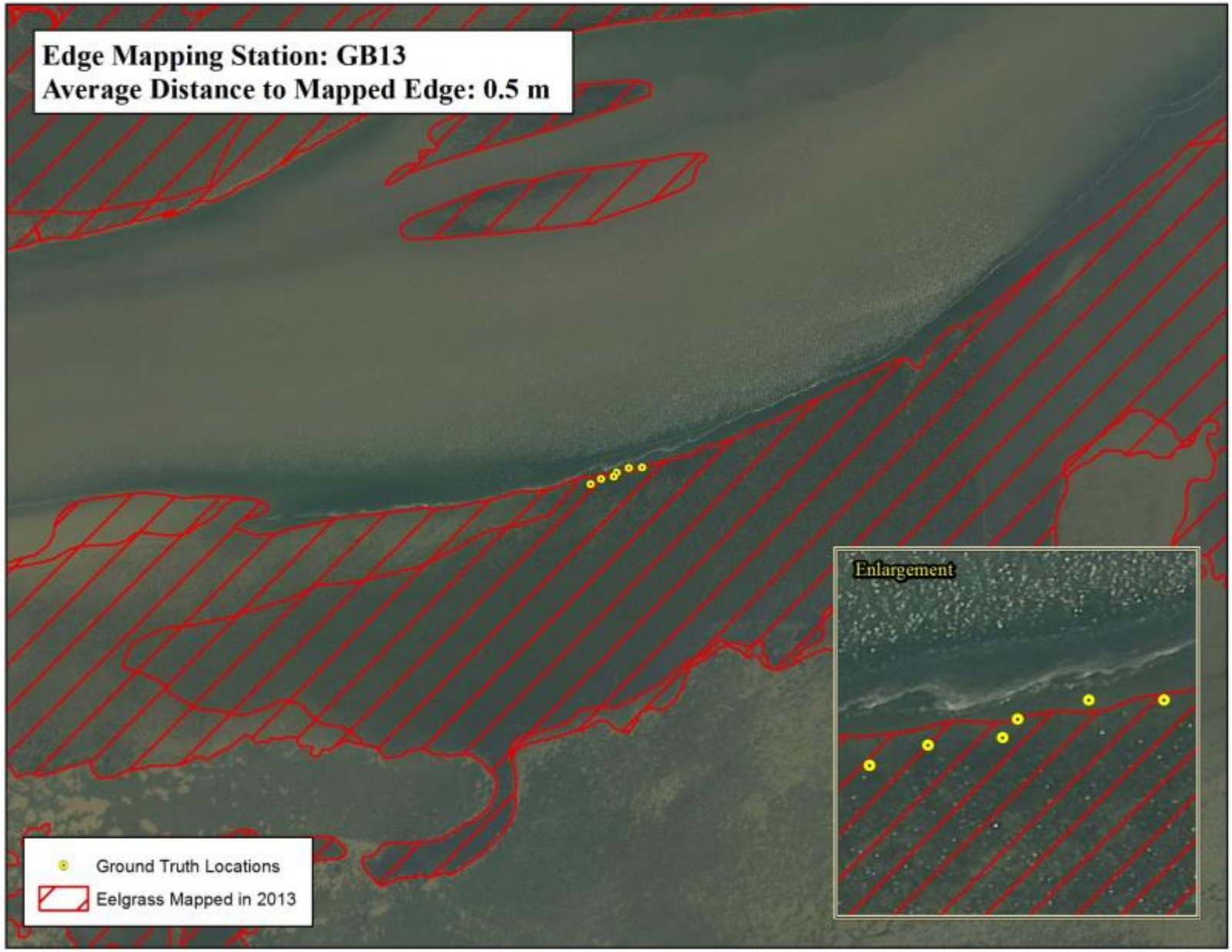


Figure 8: Edge Mapping at Station GB14

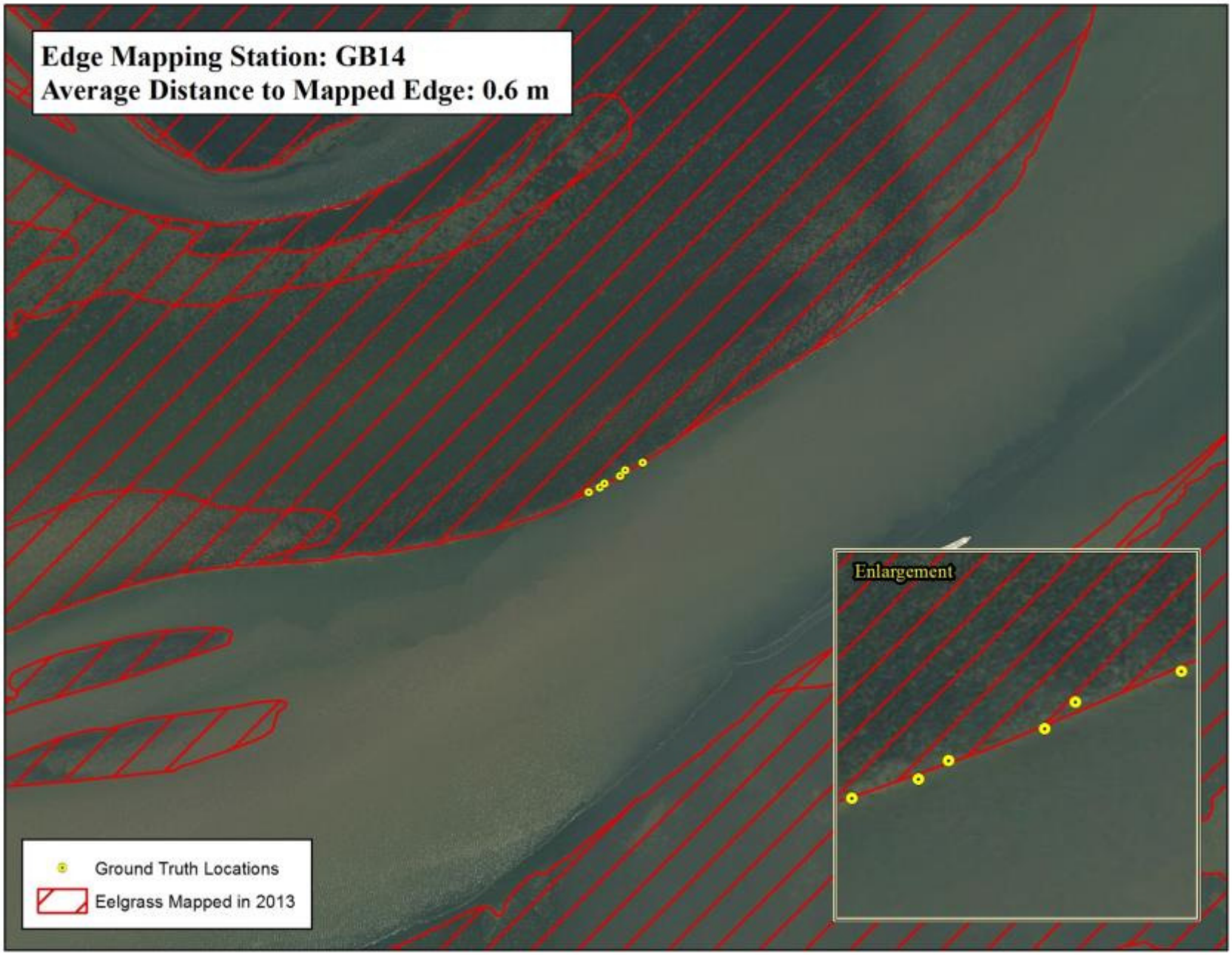


Figure 9: Edge Mapping at Station GB15

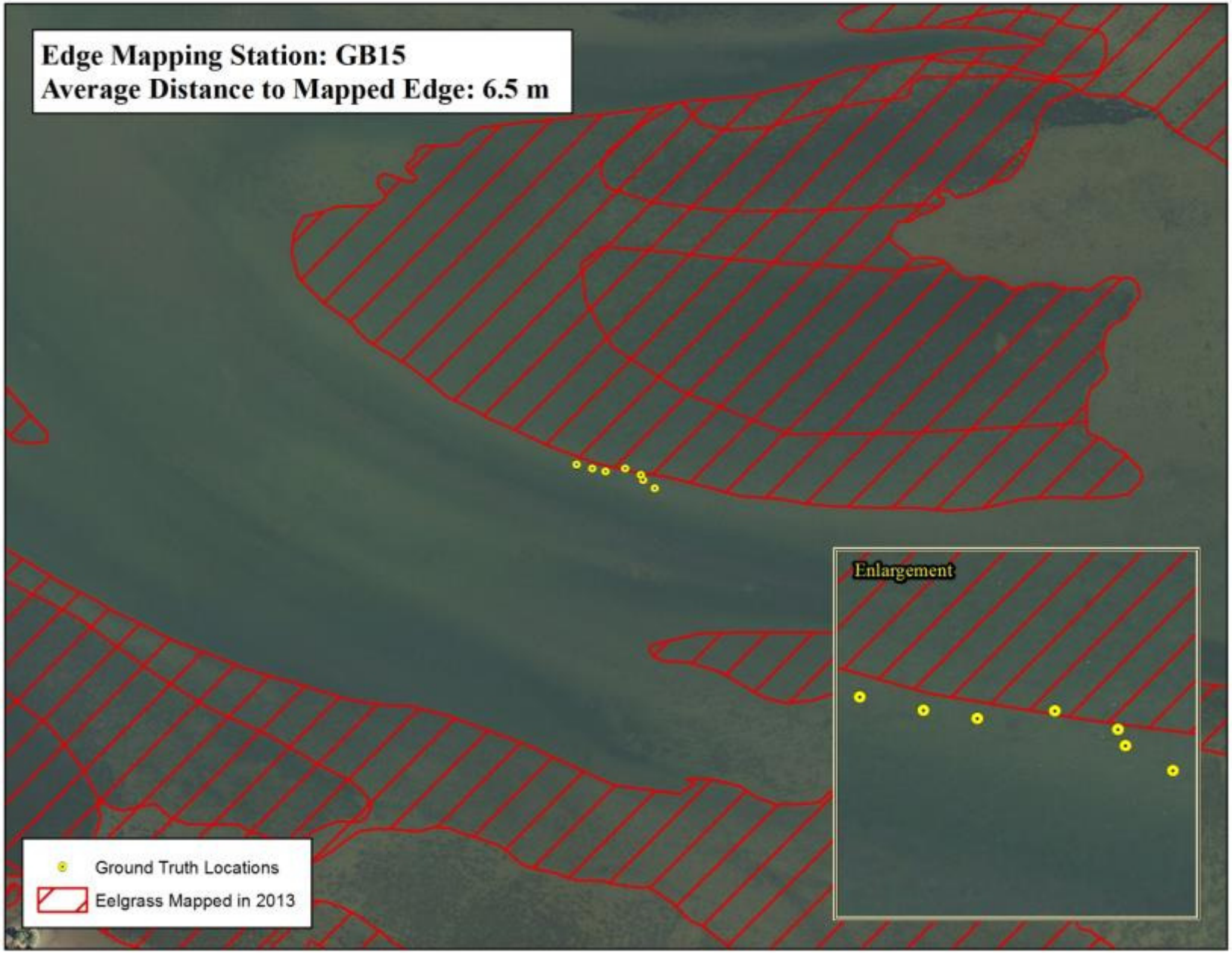


Figure 10: Edge Mapping at Station GB16

Figure 11: Edge Mapping at Station PH03

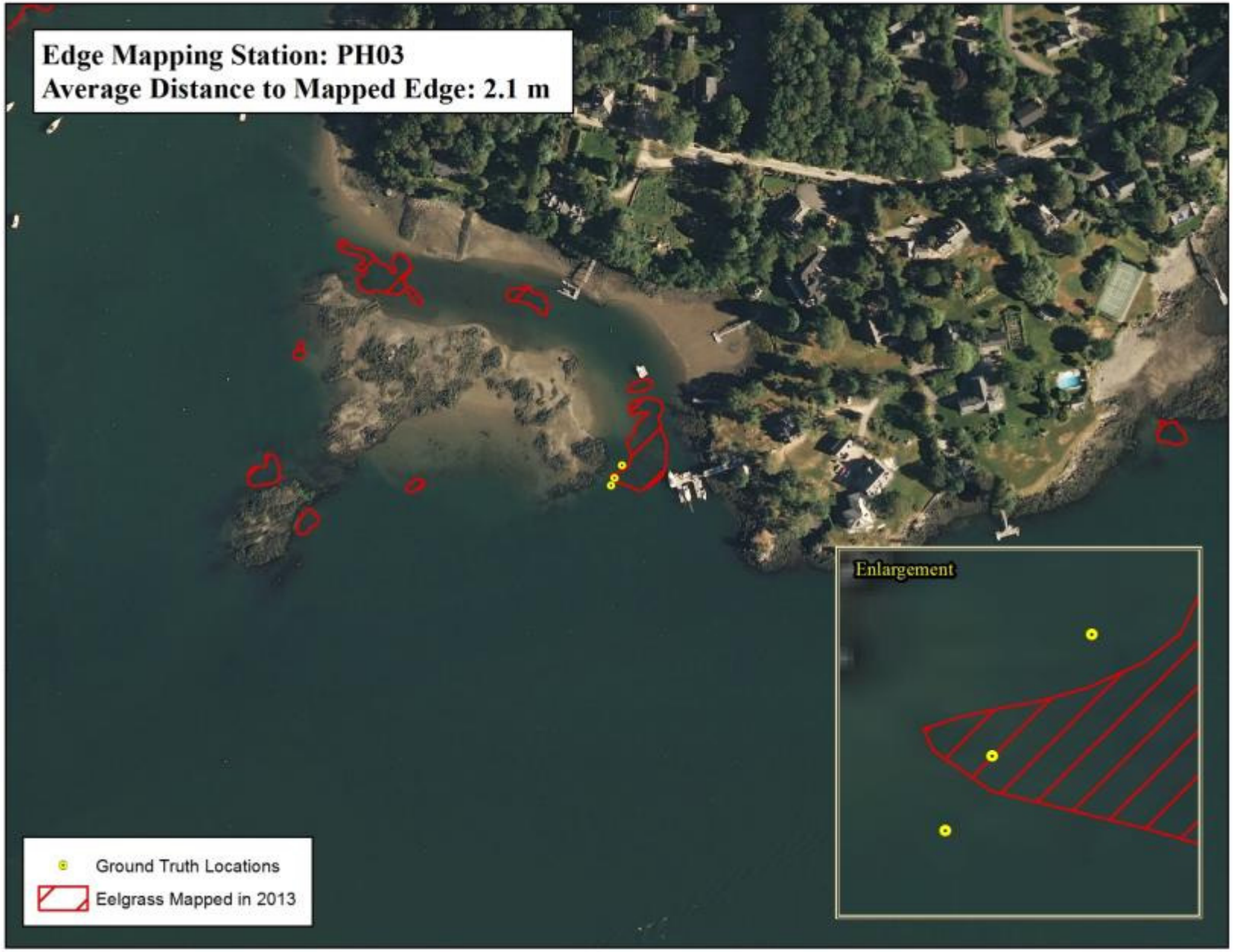


Figure 12: Edge Mapping at Station PH04

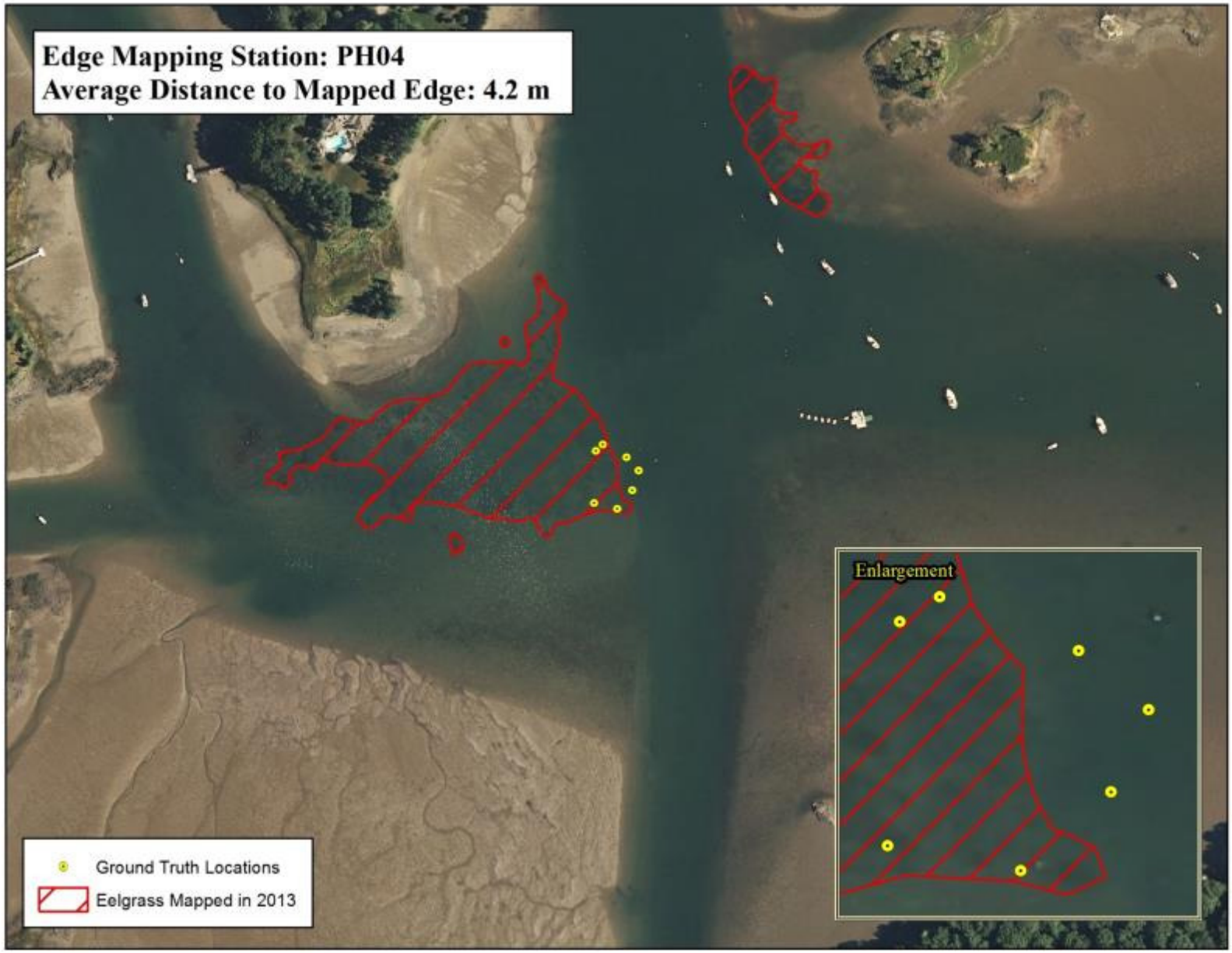


Figure 13: Edge Mapping at Station PH05

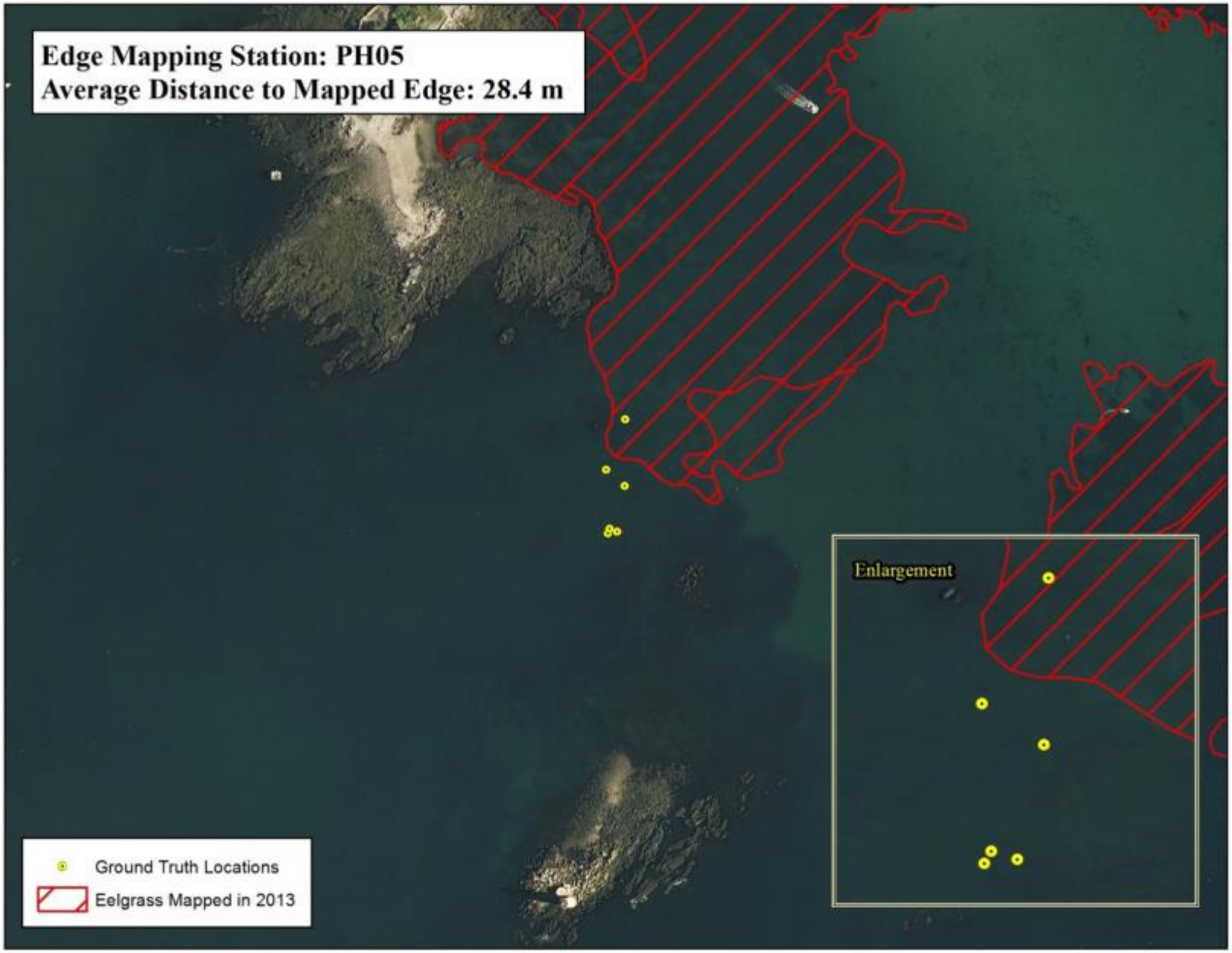


Table 4: Eelgrass Cover Class Assessment

Station ID	Ground Truth Survey Team	Ground Truth Density	Mapped Density	Ground Truth vs. Mapping	Density Comment	Presence vs. Non-Presence
BLM01	JEL	NP	NP	Match		Match
GB01	JEL	H	P	Non-Match	Possible Density Interpretation Error	Match
GB02	EPA	H	H	Match		Match
GB03	JEL	H	P	Non-Match	Possible Density Interpretation Error	Match
GB04	EPA	H	P	Non-Match	Possible Density Interpretation Error	Match
GB05	JEL	SB	SB	Match		Match
GB06	EPA	H	H	Match		Match
GB06	JEL	P	H	Non-Match	Possible Density Interpretation Error	Match
GB07	JEL	SB	SB	Match		Match
GB08	EPA	P	P	Match		Match
GB09	JEL	NP	NP	Match		Match
GB10	JEL	H	H	Match		Match
GB11	JEL	P	H	Non-Match	Possible Density Interpretation Error	Match
GB12	JEL	NP	NP	Match		Match
GB13	JEL	H	SB	Non-Match	Possible Density Interpretation Error	Match
GB14	JEL	NP	NP	Match		Match
GB15	JEL	P	P	Match		Match
GB16	JEL	NP	NP	Match		Match
GB17	JEL	NP	NP	Match		Match
GB18	JEL	P	H	Non-Match	Possible Density Interpretation Error	Match
GB19	JEL	P	H	Non-Match	Possible Density Interpretation Error	Match
GB20	JEL	H	P	Non-Match	Possible Density Interpretation Error	Match
GB21	JEL	P	P	Match		Match
GB22	JEL	NP	NP	Match		Match
GB23	JEL	H	SB	Non-Match	Possible Density Interpretation Error	Match
GB24	JEL	P	SB	Non-Match	True Density Error	Match
GB25	JEL	H	D	Non-Match	True Density Error	Match
GB26	JEL	H	H	Match		Match
GB27	JEL	H	SB	Non-Match	Possible Density Interpretation Error	Match
GB28	JEL	P	P	Match		Match
GI01	JEL	H	SB	Non-Match	Possible Density Interpretation Error	Match
GI02	JEL	SB	H	Non-Match	Possible Density Interpretation Error	Match
GI03	JEL	SB	H	Non-Match	Possible Density Interpretation Error	Match
LH01	JEL	NP	NP	Match		Match
LH02	EPA	P	NP	Non-Match	Possible Density Interpretation Error	Non-Match
LH03	JEL	NP	NP	Match		Match
LH04	JEL	H	P	Non-Match	Possible Density Interpretation Error	Match
LLB01	JEL	NP	NP	Match		Match

Station ID	Ground Truth Survey Team	Ground Truth Density	Mapped Density	Ground Truth vs. Mapping	Density Comment	Presence vs. Non-Presence
LLB02	JEL	NP	NP	Match		Match
LLB03	JEL	NP	NP	Match		Match
LLB04	JEL	NP	NP	Match		Match
LLB05	JEL	NP	NP	Match		Match
LLB06	JEL	NP	NP	Match		Match
LLB07	JEL	NP	NP	Match		Match
LLB08	JEL	NP	NP	Match		Match
LMP01	JEL	NP	NP	Match		Match
OYS01	JEL	NP	NP	Match		Match
PH01	JEL	SB	H	Non-Match	Possible Density Interpretation Error	Match
PH02	EPA	P	SB	Non-Match	True Density Error	Match
PH03	JEL	P	NP	Non-Match	Possible Density Interpretation Error	Non-Match
PH04	JEL	P	P	Match		Match
PH05	JEL	NP	NP	Match		Match
PH05	NAI	P	NP	Non-Match	Possible Density Interpretation Error	Non-Match
PH06	JEL	P	H	Non-Match	Possible Density Interpretation Error	Match
PH07	JEL	H	NP	Non-Match	True Density Error	Non-Match
PH08	JEL	NP	NP	Match		Match
PH09	JEL	NP	NP	Match		Match
SQM01	JEL	NP	NP	Match		Match
ULB01	JEL	NP	NP	Match		Match
ULB02	JEL	NP	NP	Match		Match
UPR01	JEL	NP	NP	Match		Match
UPR02	JEL	NP	NP	Match		Match

Figure 14(a): Classification Accuracy Error Matrix for Eelgrass Percent Cover Classes

Classified Data \ Reference Data	NP	P	H	SB	D	Grand Total
NP	27	0	0	0	0	27
P	3	5	5	2	0	15
H	1	5	4	4	1	15
SB	0	0	3	2	0	5
D	0	0	0	0	0	0
Grand Total	31	10	12	8	1	62

Density	Producer's Accuracy	User's Accuracy	Overall Accuracy
NP	87%	100%	61%
P	50%	33%	
H	33%	27%	
SB	25%	40%	
D	0%	n/a	

Figure 14(b) Classification Accuracy Error Matrix for Eelgrass Presence/Absence

Classified Data \ Reference Data	Not Present	Present	Total
Not Present	27	0	27
Present	4	31	35
Total	31	31	62

Density	Producer's Accuracy	User's Accuracy	Overall Accuracy
Not Present	87%	100%	94%
Present	100%	89%	

Figure 15: Bellamy River Ground Truth Comparison

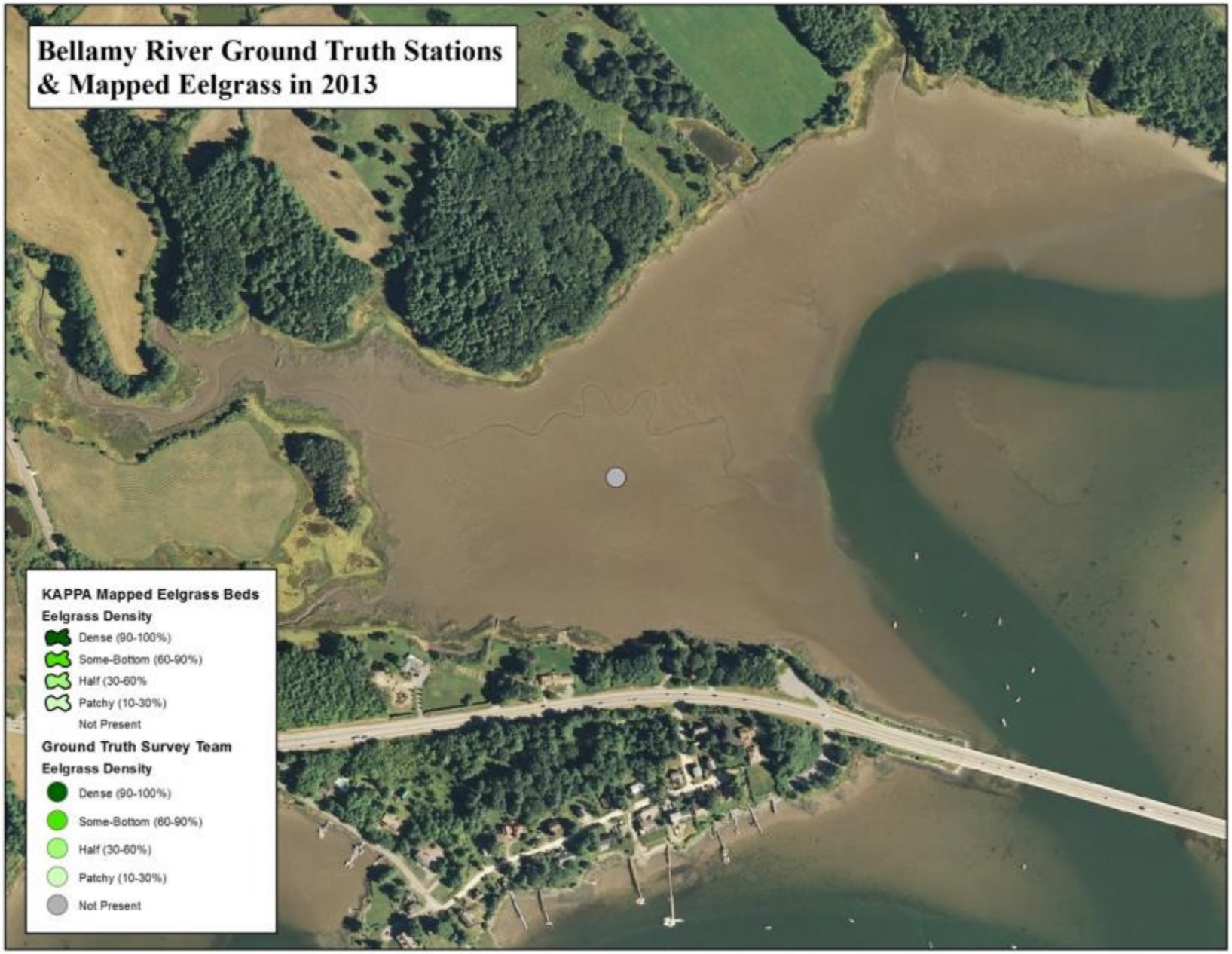


Figure 16: Great Bay Ground Truth Comparison

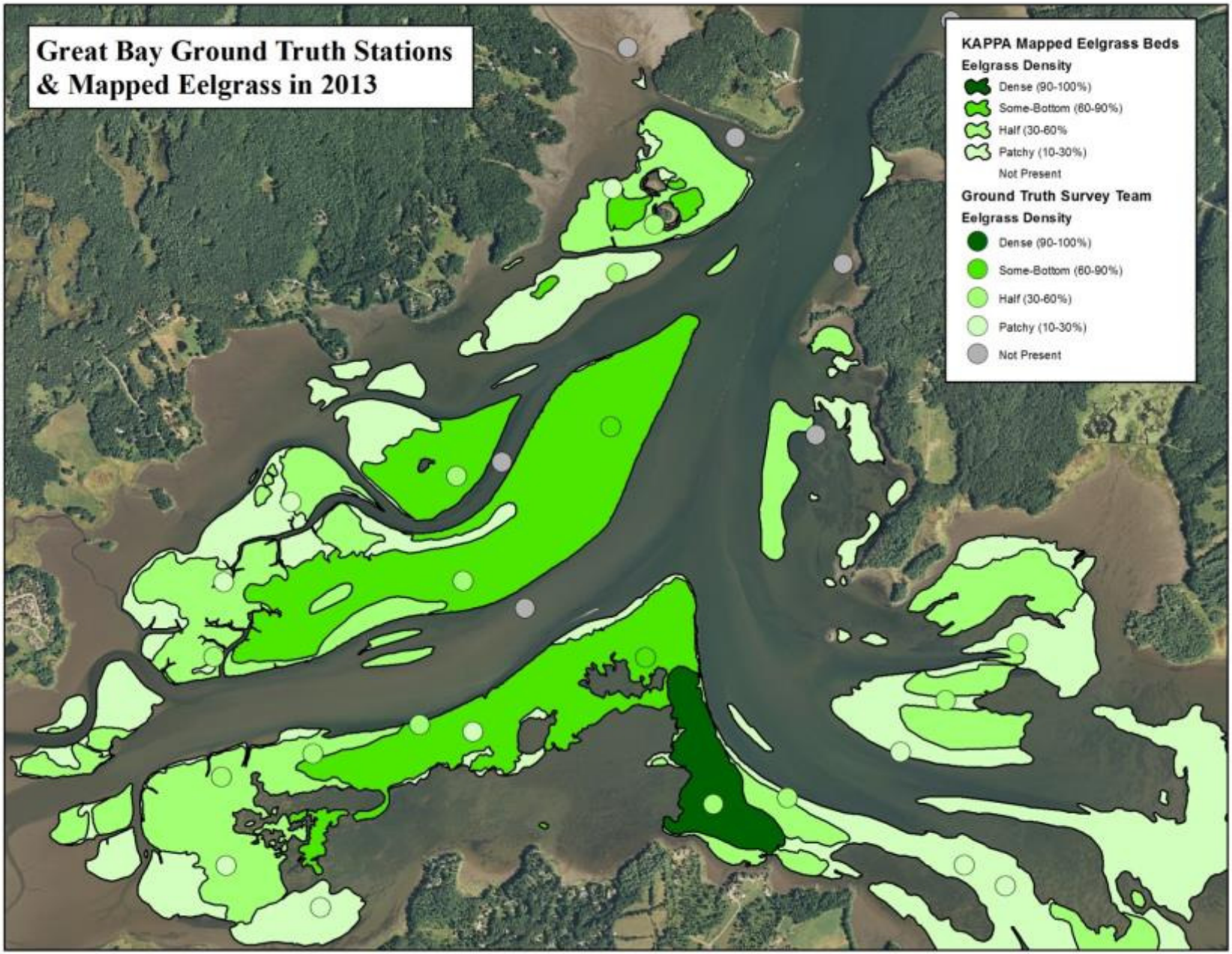


Figure 17: Gerrish Island Ground Truth Comparison

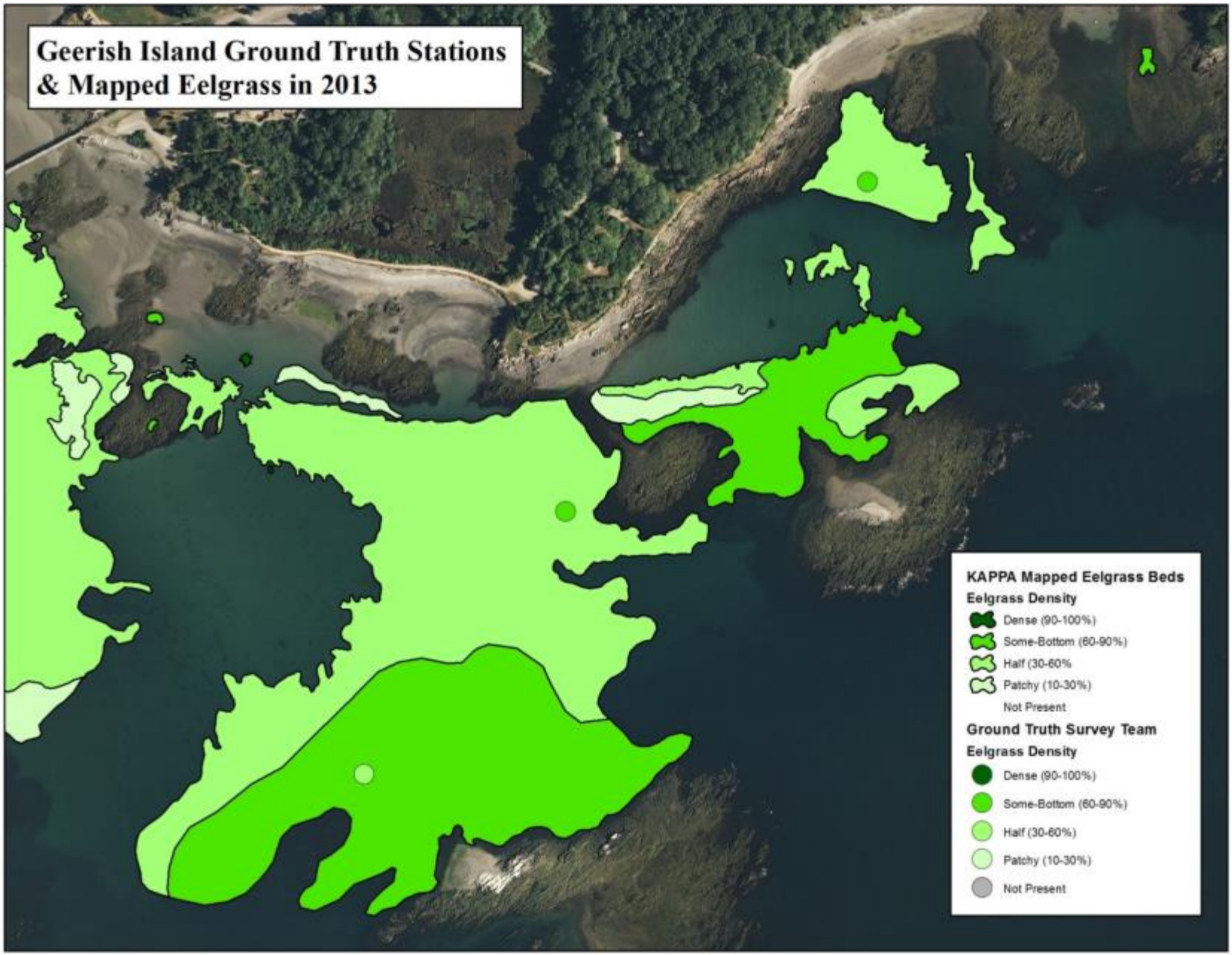


Figure 18: Little Bay Ground Truth Comparison

Figure 19: Little Harbor Ground Truth Comparison

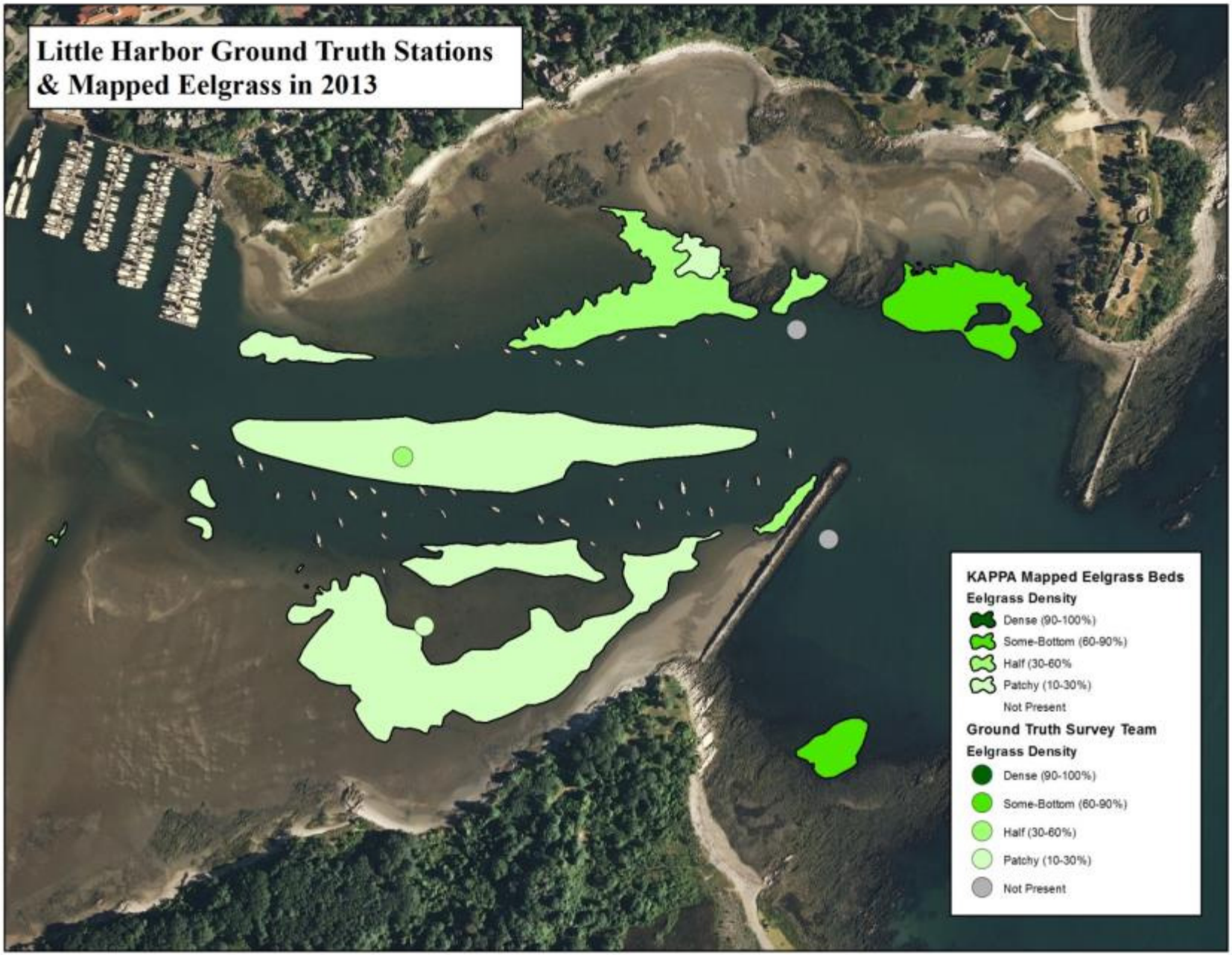


Figure 20: Lamprey River Ground Truth Comparison

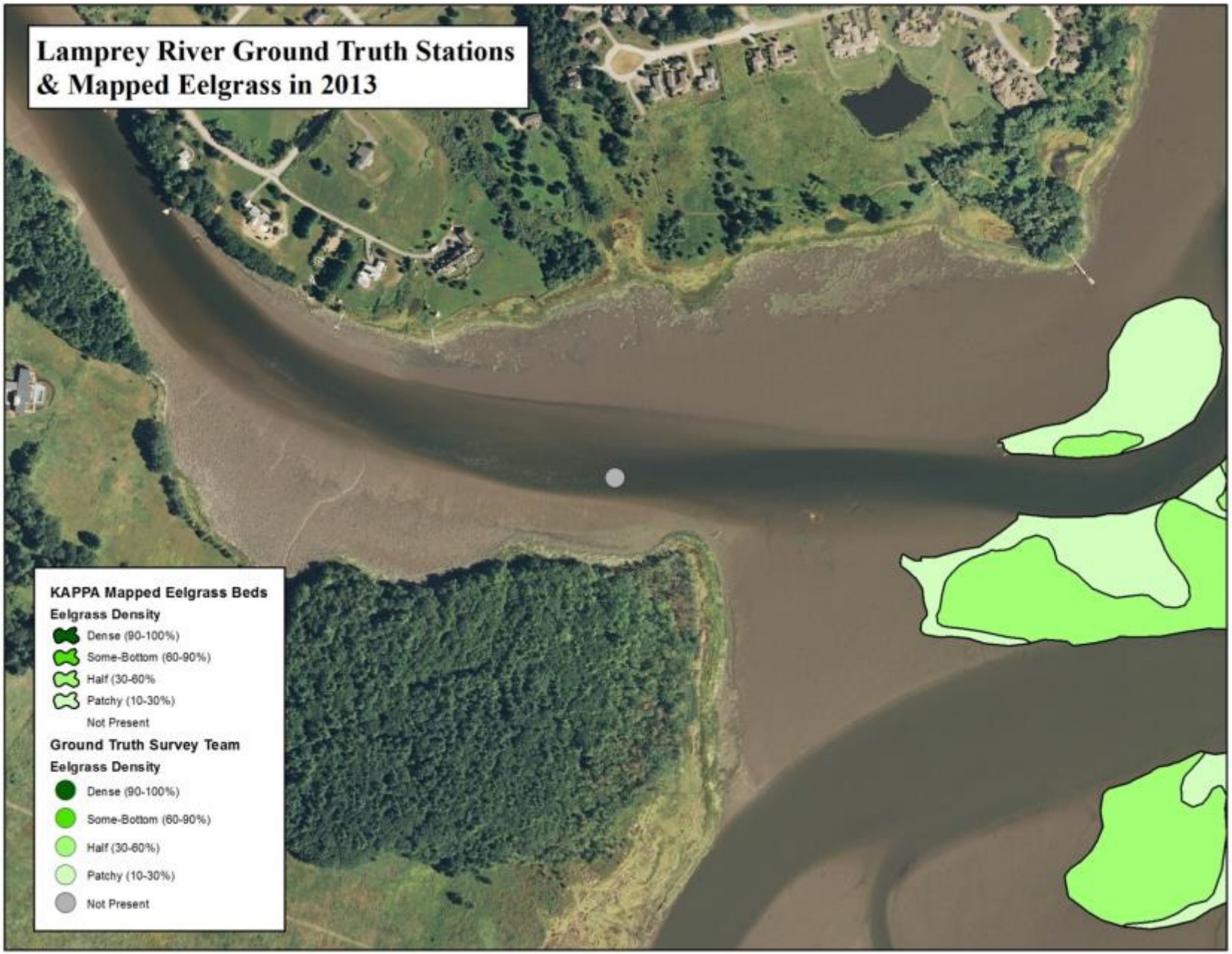


Figure 21: Oyster River Ground Truth Comparison

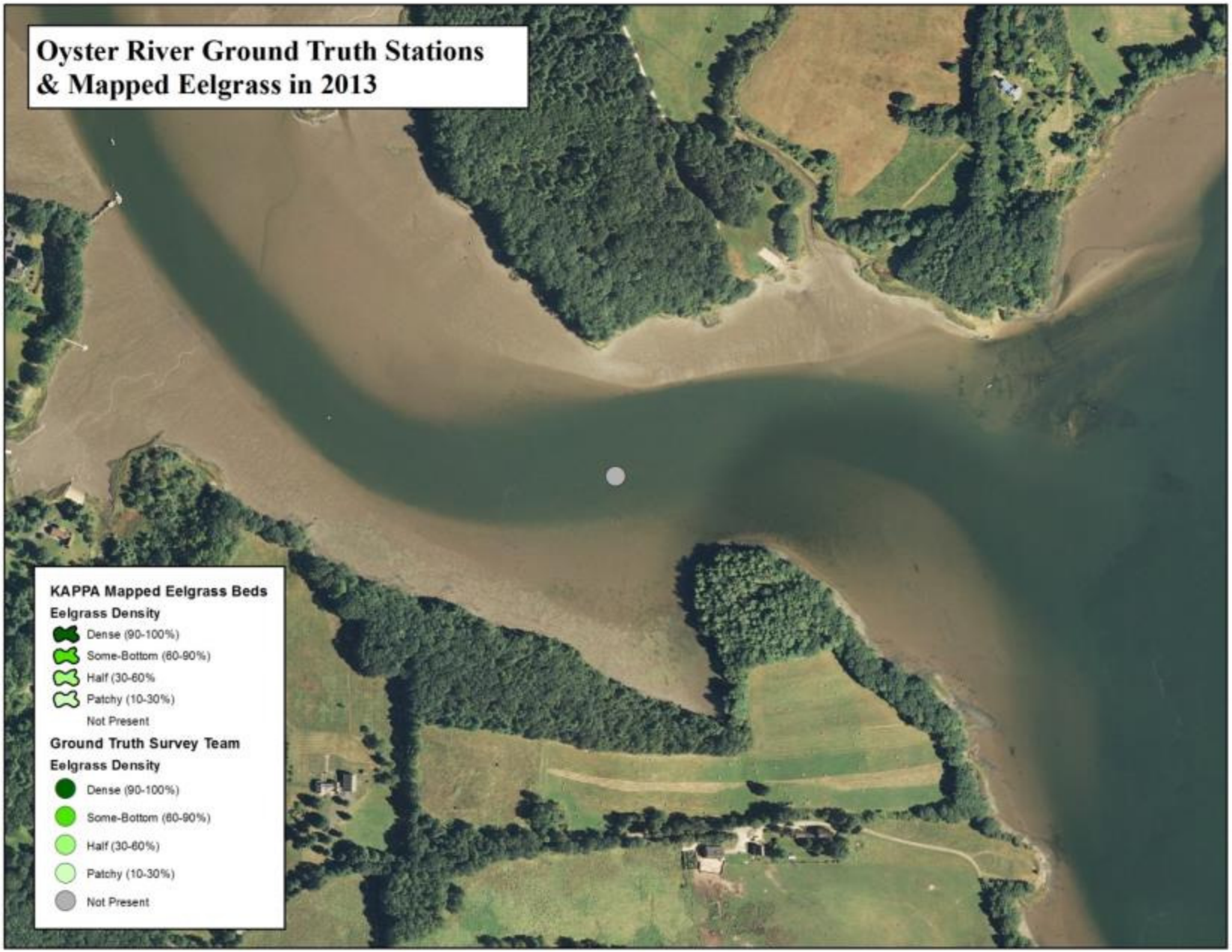


Figure 22: Portsmouth Harbor Ground Truth Comparison

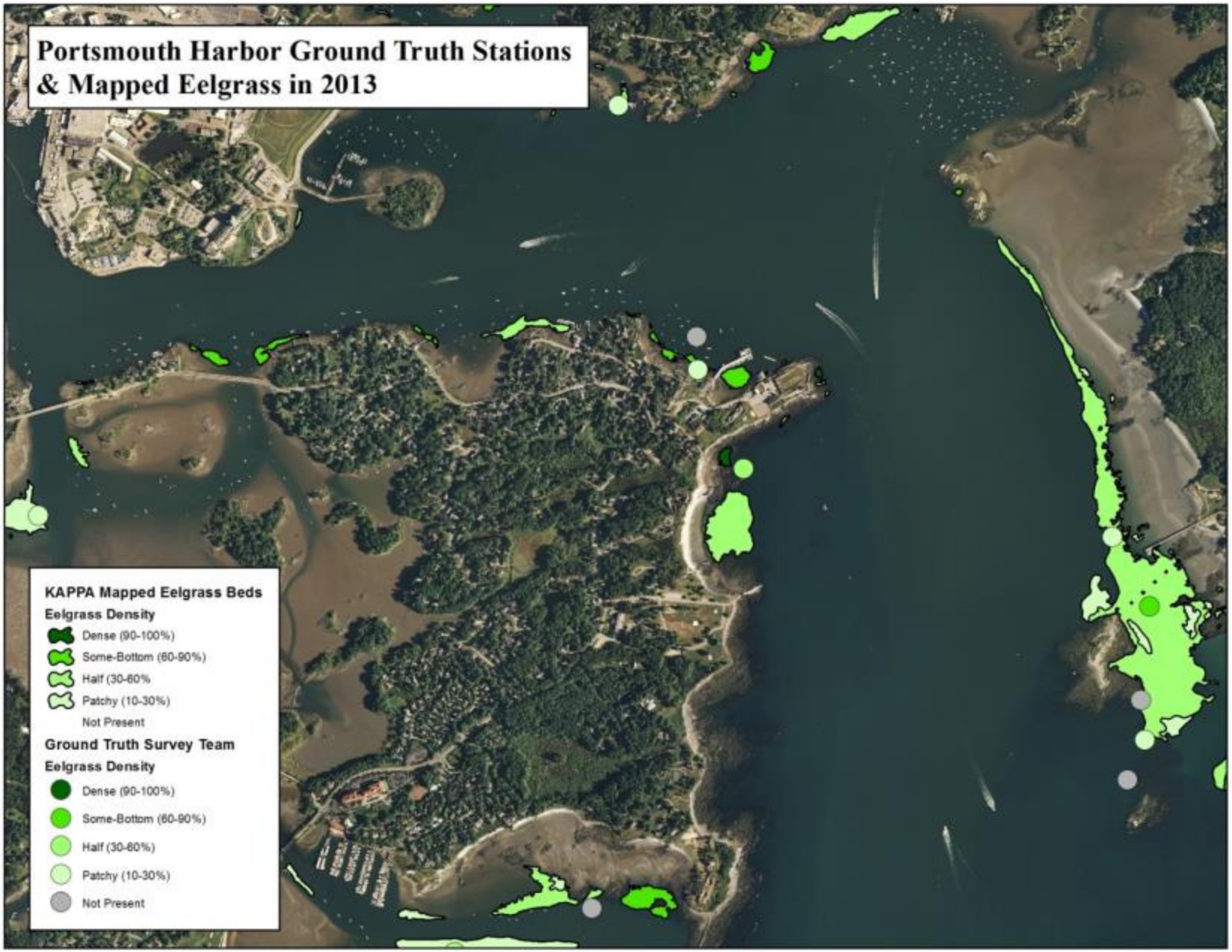


Figure 23: Squamscott River Ground Truth Comparison

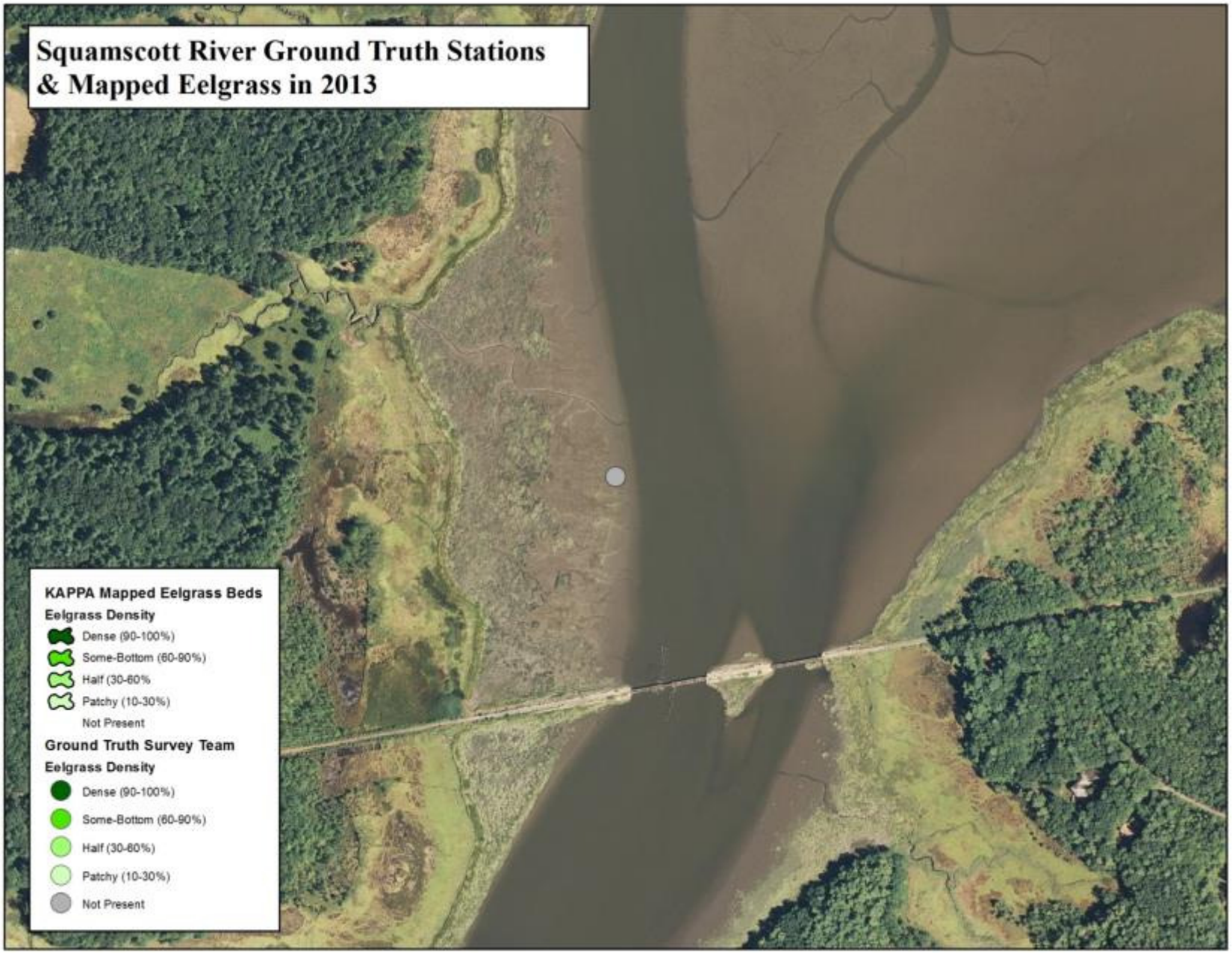


Figure 24: Upper Piscataqua River Ground Truth Comparison