5.9.2. Separated Actions

Alternative 7bT (Town of Palm Beach portion of alternative)

Alternative 7bT presents a sand placement of 166,500 cubic yards along R-129-210 and R-134+135 and two T-heads located between R-132+556 and R-133+269. Model results for Alternative 7bT are shown in Figure 5-57 through Figure 5-60. The sedimentation areas greater than 0.2 feet are adjacent to the Town of Palm Beach's project area and do not extend into the County.

At the end of the 3 year simulation period, there was an estimated coverage of 4.62 acres of hardbottom and an exposure of 0.53 acres attributed to the alternative as depicted in Figure 5-59. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -4.09 acres.

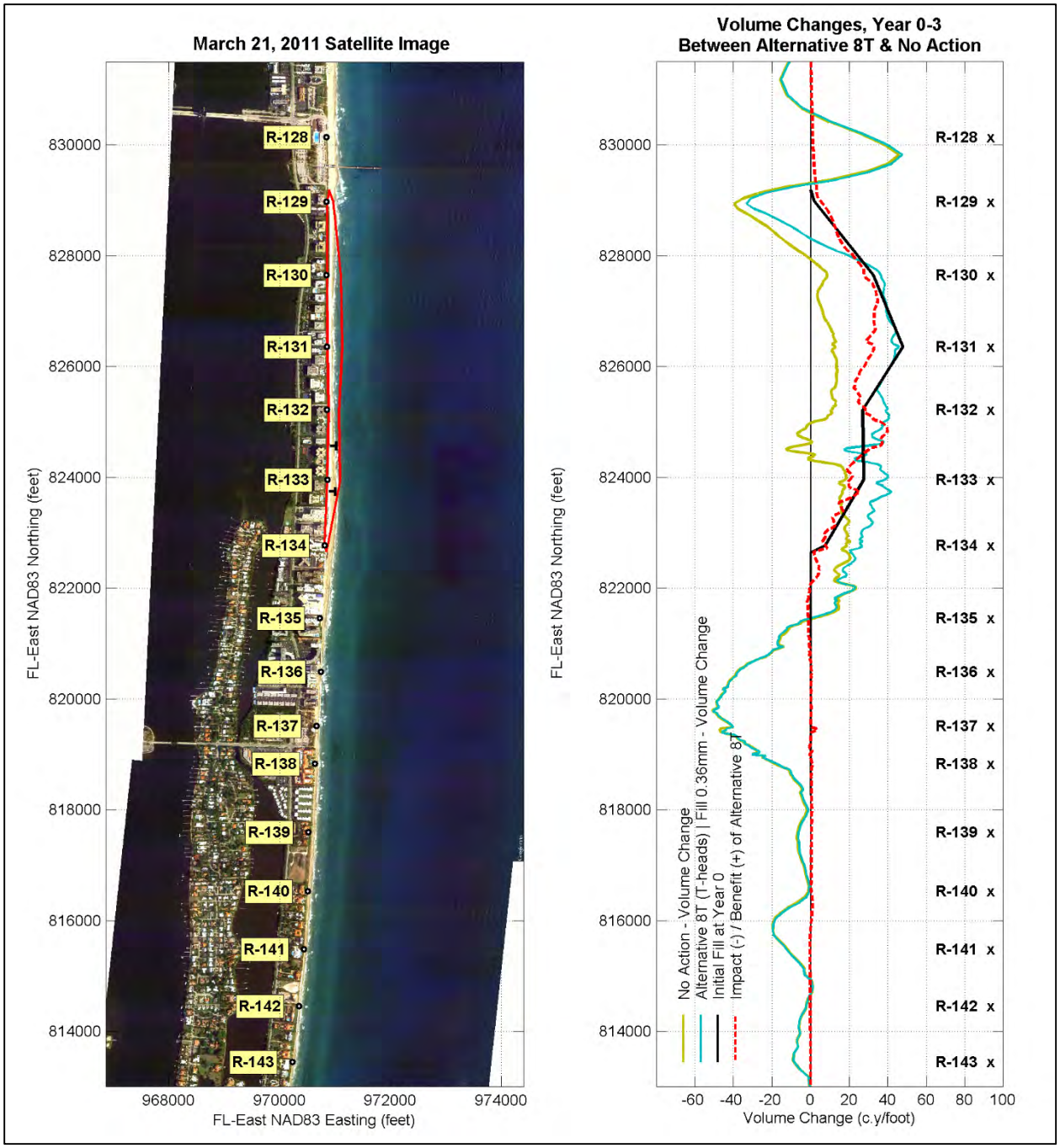

Figure 5-57. Volume changes, Alternative 7bT.

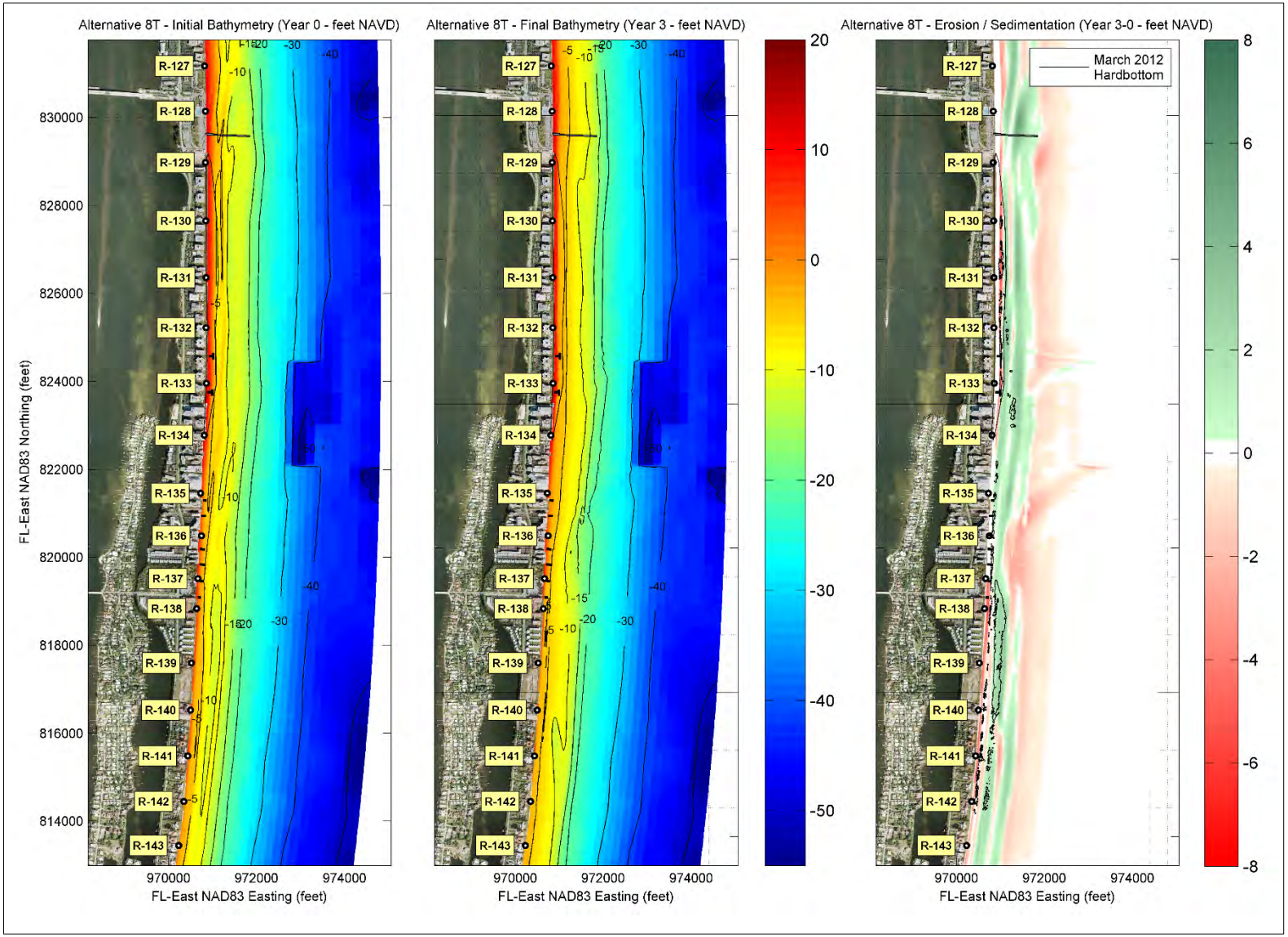

Figure 5-58. Erosion/Sedimentation after 3 years of simulation, Alternative 7bT.

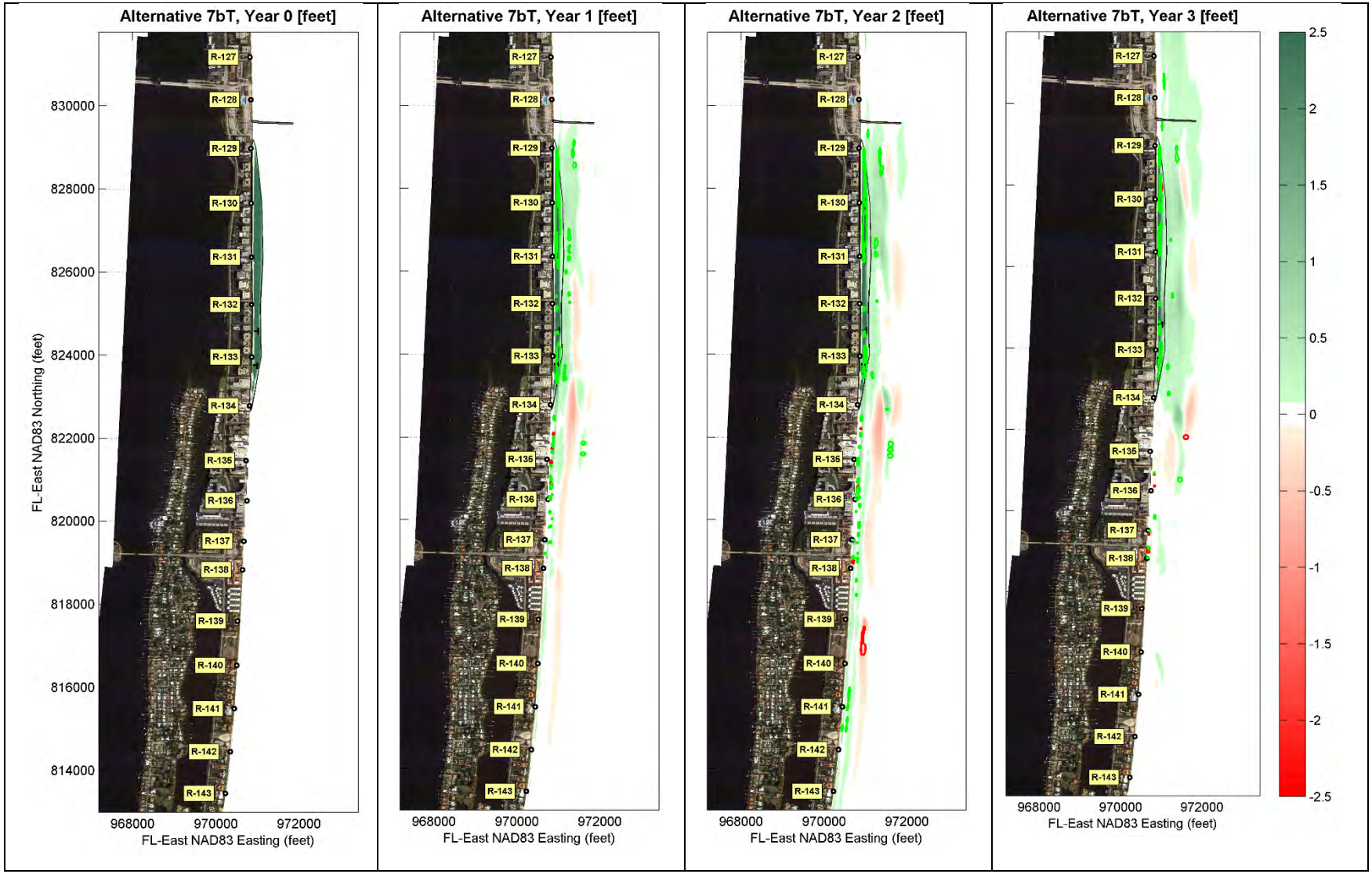

Figure 5-59. Temporal evolution of erosion (red) / sedimentation (green) for Alternative 7bT, compared to No Action scenario.

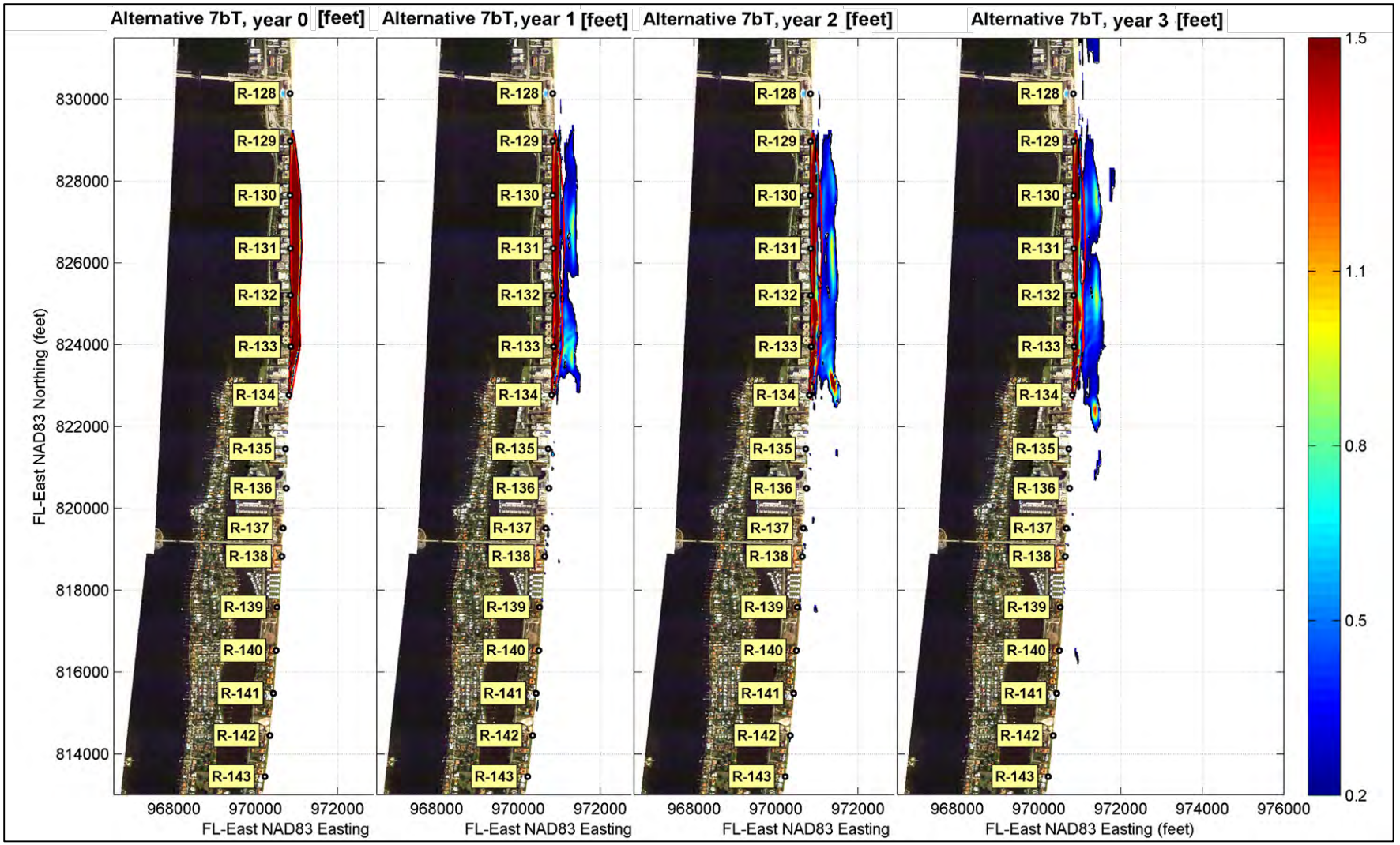

Figure 5-60. Sediment accumulation greater than 0.2 ft for Alternative 7bT.

6.0 DOWNDRIFT IMPACT ANALYSIS

Downdrift impacts were evaluated by analyzing the volumetric changes within the area extending 4,000 feet south from the south end of the fill templates of each alternative and offshore to the closure depth (-21.5 feet, NAVD88). Erosion and accretion volumes within the defined area were estimated to determine the net volume change (accretion minus erosion). The net changes are presented in Table 6-1. Negative values represent net erosion/loss of sand downdrift and positive values represent net accretion/gain of sand when compared to the No Action Alternative.

Alternative 2, Alternative 5, and Alternative 7a, which are the alternatives with the groins between R-135+160 and R-137+422, resulted in net erosion downdrift for all the sediment grain size combinations simulated.

Alternative 3, Alternative 4, Alternative 6, and Alternative 7b resulted in net accretion downdrift. Alternative 4 and Alternative 6 presented higher accretion once larger fill volume was placed in the County portion of the project.

Regarding Town of Palm Beach only alternatives, Alternative 2T, Alternative 7aT, and Alternative 7bT resulted in net accretion downdrift for all the sediment grain size combinations simulated, while Alternative 6T resulted in net erosion.

The County only alternatives presented similar trends of the combined action alternatives, with Alternative 2C resulting in net erosion, and Alternative 3C and Alternative 6C resulting in net accretion downdrift.

Table 6-1. Downdrift net volume changes.

Downdrift Net Volume Changes After 3 years [c.y.]	
Alternative 2	-6,764
Alternative 2T	1,115
Alternative 2C	-6,775
Alternative 3	8,924
Alternative 3C	9,052
Alternative 4	16,284
Alternative 5	-6,673
Alternative 6	17,393
Alternative 6T	-1,598
Alternative 6C	17,770
Alternative 7a	-3,649
Alternative 7aT	16,545
Alternative 7b	919
Alternative 7bT	1,178

7.0 SUMMARY AND CONCLUSIONS

A numerical modeling study utilizing Delft3D model was conducted to simulate the proposed Project alternatives and to evaluate the potential hardbottom impact. Seven “combined” alternatives, seven “separated” alternatives, and one “No Action” Alternative were modeled for a total of thirteen simulations (Table 5-1).

The Delft3D morphological model from previous studies of Southern Palm Beach Island was recalibrated (updated) based on more recent erosion patterns and available data. The performance and impact of each alternative over a 3 year project life was then assessed using the updated calibrated model. The performance and impacts were assessed in terms of volume changes and erosion/sedimentation patterns at 1 year increments during simulation period. The following are the primary findings of the study:

- Greater fill volumes result in increased sedimentation areas and net hardbottom coverage as the fill is redistributed cross shore and transported alongshore. Hardbottom coverage and exposure discussed in this report were quantified based on sediment thickness mapping developed as part of the model calibration.

Impacts to hardbottom attributable to the project alternatives were assessed based the areas of sediment accumulation greater than 0.2 feet and are presented in Chapter 4, Section 4.4 of main text.

- Groins retain a portion of the sand that otherwise would be transported downdrift to adjacent beaches. The model indicated that groins within the County for Alternative 2 (and Alternative 2C) resulted in greater sedimentation offshore of the groin field as compared to Alternative 3C with the same fill volume, but less downdrift sedimentation. This is attributed to a greater volume retained within the groins field being redistributed cross shore as opposed to alongshore in the absence of the groins. The net hardbottom coverage was less for Alternative 2 (and Alternative 2C) as compared to Alternative 3C.

- For Alternative 6C, the fill placed south of R-134+135 within the County spreads north resulting in increased sedimentation within the Town of Palm Beach.

- For Alternative 7aT, the fill placed north of R-134+135 within the Town of Palm Beach is transported south resulting in increased sedimentation within the County.

- Alternative 2 resulted in the least area of sedimentation and net hardbottom coverage as compared to the other combined alternatives.

Regarding the downdrift impact analysis, it could be observed:

- In general alternatives with more sand placed in the County portion of the template presented higher positive (net accretion/gain of sand) downdrift impacts. Although it should be noted that the same alternatives presented more net change in hardbottom.

- In general alternatives simulated with groins on the template presented negative (net erosion/loss of sand) downdrift impact.

- County only alternatives presented similar results as the correspondent combined action alternatives.

The results of this numerical modeling study should be used in conjunction with other coastal engineering assessments and prudent engineering judgment.

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SUB-APPENDIX G-3 – ATTACHMENT A

DELFT3D ADDITIONAL SCENARIOS

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SUB-APPENDIX G-3 – ATTACHMENT A
DELFT3D ADDITIONAL SCENARIOS

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1.0 INTRODUCTION

Under direction of the U.S. Army Corps of Engineers (USACE), CB&I Coastal Planning & Engineering, Inc. (CB&I) assisted in the development of the Southern Palm Beach Island Comprehensive Shoreline Stabilization Project Environmental Impact Statement (EIS). The USACE determined that additional work was required to consider a range of sediment grain sizes in evaluating the Town of Palm Beach's request for maintaining flexibility with respect to potential sand sources for the Town of Palm Beach's portion of the project area.

One factor contributing to the redistribution of sediments placed within the coastal system is grain size. An additional Delft3D numerical modeling study was conducted to assess the potential impacts to hardbottom as a result of the proposed alternatives considering a range of sediment grain sizes from potential sand sources identified by the Town of Palm Beach. The additional modeling builds upon the previous study presented in Sub-Appendix G-3 that considered a single sediment grain size (0.36 mm) for the proposed alternatives.

The Florida Department of Environmental Protection (FDEP) Palm Beach Island Beach Management Agreement (BMA) identifies compliance specifications for beach fill material that "take into account the variability of sediment on the native or existing beach" (FDEP, 2013). The agreement specifies that sediments with mean grain sizes ranging from 0.25 mm to 0.60 mm are acceptable beach fill material. The study presented herein evaluated the proposed alternatives to consider fill material with mean grain sizes of 0.25 mm and 0.60 mm placed within the Town of Palm Beach's portion of the project. As such, seven "combined" and the four Town of Palm Beach's "separated" scenarios were modeled for the proposed alternatives. Each scenario considered to the two grain sizes resulting in a total of twenty-two (22) modeled simulations.

2.0 MODEL SETUP

The model setup developed for the previous study presented in Sub-Appendix G-3 was utilized by including a layered bed stratigraphy methodology. The methodology accounted for the grain sizes and sediment distributions of the fill material for the proposed alternatives with respect to the natural beach sediments.

The layered bed stratigraphy methodology accounts for the percentages of various grain sizes, sediment depths, and mixing of sediments within each grid cell during the model simulation. With this methodology a user-defined number of bed composition bookkeeping layers can be included to keep track of the sediment deposits, which in this case were native sediment (grain size of 0.36 mm) and fill sediment (0.25 mm or 0.60 mm). The layers comprise the sediment package, which was based on the 2012 sediment thickness mapping described in Sub-Appendix G-3 and schematized in Figure 2-1 – A.

Eight layers were defined for the sediment package as schematized in Figure 2-1 – B. The discretization was more detailed near the surface of the sediment package because the transport occurs from top to bottom of the package. The vertical discretization was set as shown in Table 2-1. The layers follow the shape of the primary thickness contour, but when they cross the hard bottom their thickness is limited by the elevation of hard bottoms (Figure 2-1 - B). More information regarding bed layered stratigraphy can be found at Deltares (2011).

Table 2-1. Vertical discretization of layers in sediment package used in Delft3D model simulations.

Layer	Thickness [m]	Accumulated Thickness [m]
1 (Top of Sediment Package)	0.1	0.1
2	0.2	0.3
3	0.2	0.5
4	0.5	1.0
5	1.0	2.0
6	1.0	3.0
7	1.0	4.0
8 (Bottom of Package)	6.0	10.0

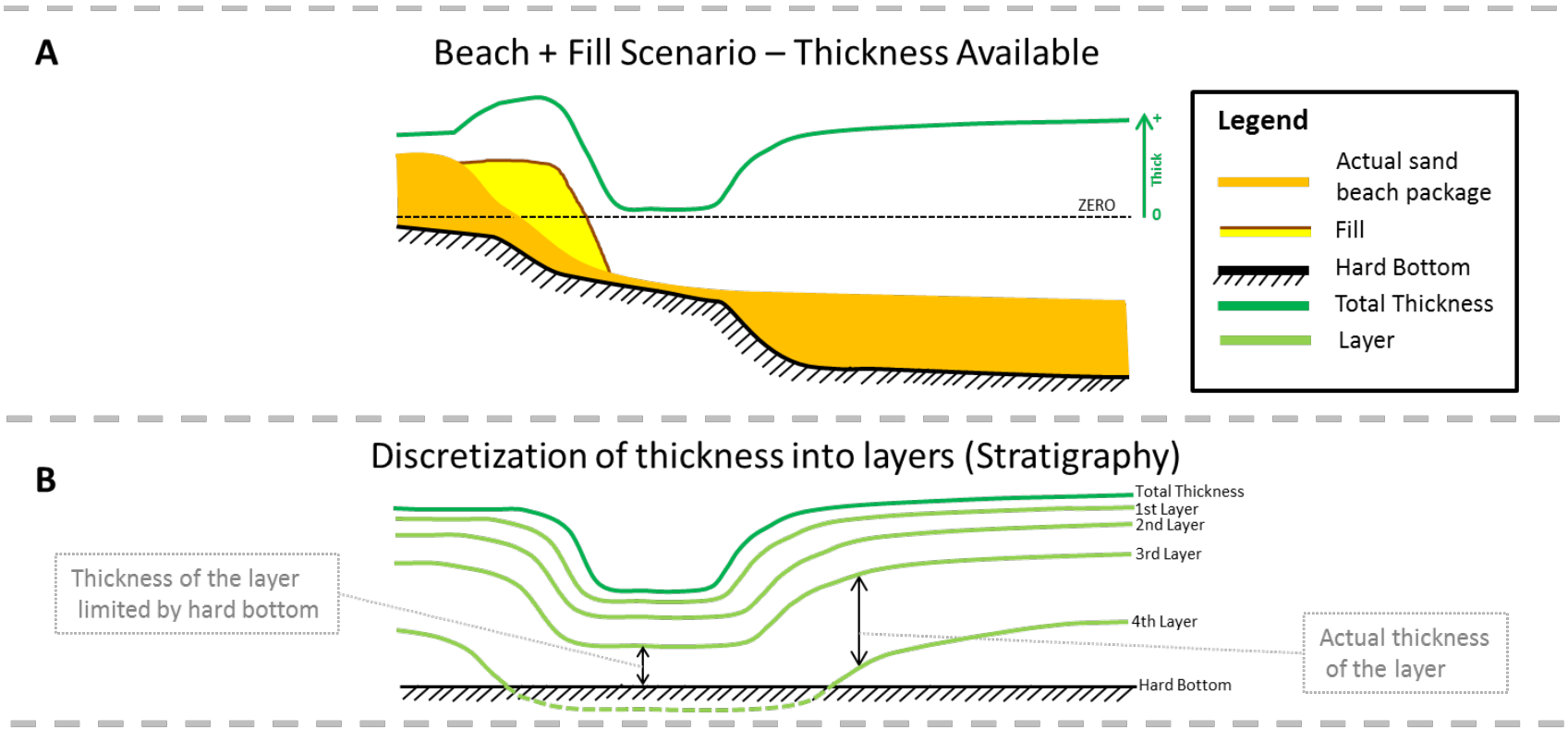

Figure 2-1. Schematization of the numerical and structural schemes representing the layered bed stratigraphy.

3.0 MODEL RESULTS

Model calibration setup described in Sub-Appendix G-3 was used to assess the performance of the additional alternatives, and the same analysis is presented for the two sediment grain sizes (0.25 mm and 0.60 mm) of the beach fill material.

The seven "combined" alternatives were considered as well as the four "separated" alternatives associated with the Town of Palm Beach (T) fill templates. The summary of the nine alternatives simulated are presented in Table 3-1. Each alternative was simulated for the Town of Palm Beach's fill templates with the two fill grain sizes totaling eighteen model simulations. In the combined alternatives, a fill grain size of 0.36 mm was used in the County portion of the template. The existing conditions beneath and outside the fill templates were modeled with a sediment grain size of 0.36 mm. More information about the templates, volumes, dimensions, and volumetric fill densities (cy/ft) of the alternatives can be found in Sub-Appendix G-3.

The No Action Alternative (Alternative 1) was not modeled for the additional study as the grain size of the existing beach remained unchanged at 0.36 mm as modeled for the previous study.

Table 3-1. Summary of Alternatives Simulated in the Additional Modeling Effort.

Alternative	Total Design Fill Volumes (cubic yards)	Shoreline Protection Structures
2	117,300	7 groins between R-135+160 and R-137+422
2T	53,800	Alternative 2 Town of Palm Beach only (no groins)
3	117,300	No structures
4	225,900	No structures
5	164,400	7 groins between R-135+160 and R-137+422
6	273,000	No structures
6T	100,900	Alternative 6 Town of Palm Beach only (no structures)
7a	401,600	7 groins between R-135+160 and R-137+422 and 2 T-head groins between R-132+556 and R-133+269
7aT	338,100	Alternative 7a Town of Palm Beach only (2 T-head groins between R-132+556 and R-133+269)
7b	230,000	7 groins between R-135+160 and R-137+422; 2 T-head groins between R-132+550 and R-133+270
7bT	166,500	Alternative 7b Town of Palm Beach only (2 T-head groins between R-132+550 and R-133+270)

3.1. SEDIMENT GRAIN SIZE 0.25 mm

Results of the alternatives simulated with a fill grain size of 0.25 mm within the Town of Palm Beach's portion of the project area are presented in this section. Figure 3-1 shows the annual rate of sediment transport of each alternative simulated for these simulations.

The simulations with fill grain size of 0.25 mm suggests that the alternative with finer grain size sediments tend to be experience greater southerly transport and offshore spreading when compared to the scenario simulated with a uniform fill grain size of 0.36 mm.

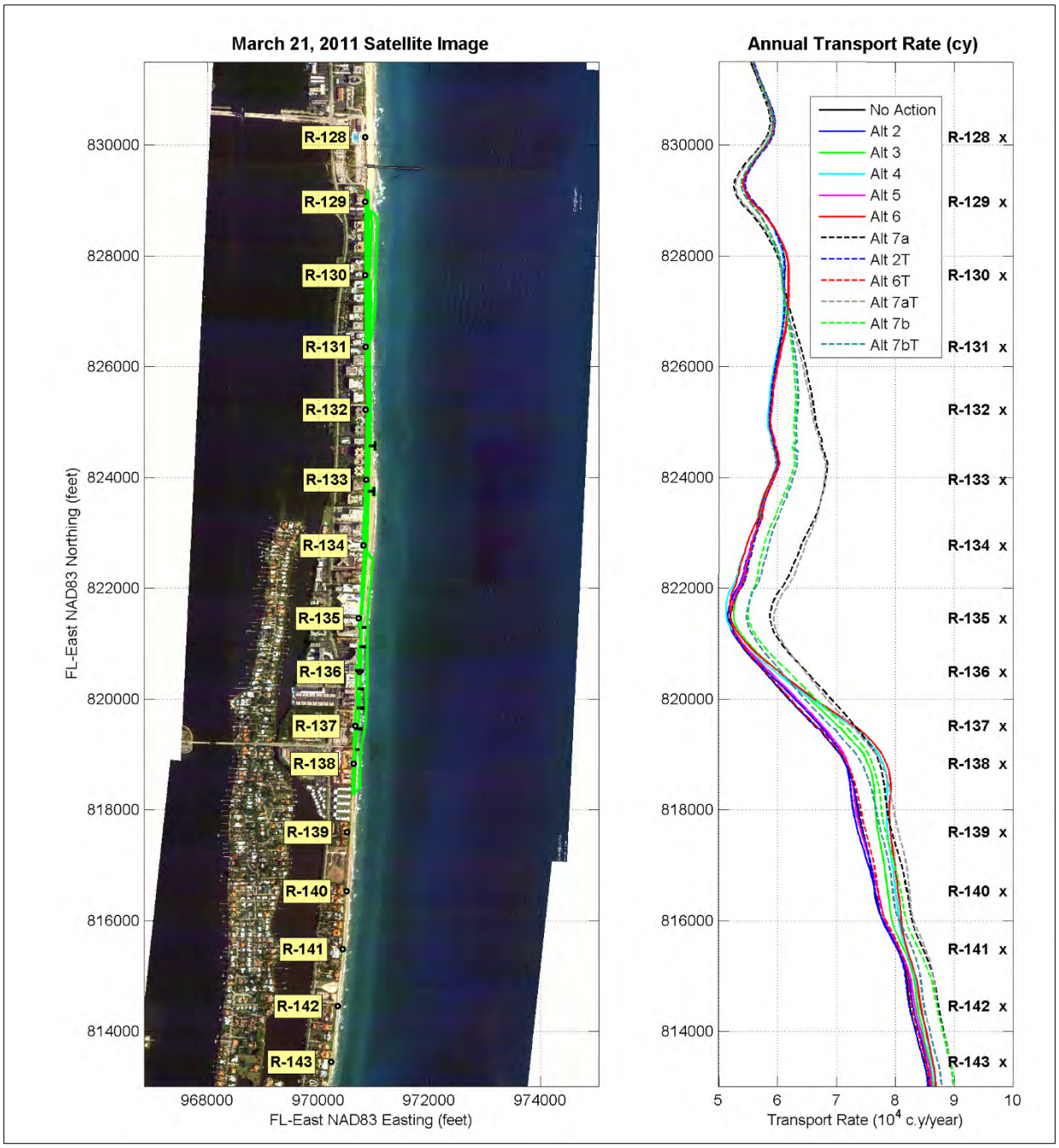

Figure 3-1. Annual transport rate (cy) for the alternatives simulated with fill grain size of 0.25 mm.

3.1.1. Alternative 2 - The Applicants' Preferred Alternative (Proposed Action): Beach and Dune Fill with Shoreline Protection Structures Project

Combined Action

Model results for Alternative 2 simulated with fill grain size of 0.25 mm in Town of Palm Beach's portion of the template are presented in Figure 3-2 through Figure 3-5.

Within the areas of sand movement, hardbottom coverage is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-4). The areas of increased sedimentation/scour and areas of increased coverage/exposure as compared to the No Action Alternative migrate over time as sand is redistributed during the 3 year simulation period. At the end of the 3 years, the model simulation indicated that there was an estimated coverage of 8.69 acres of hardbottom and an exposure of 3.24 acres attributed to the alternative. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -5.45 acres. The net change is 0.67 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

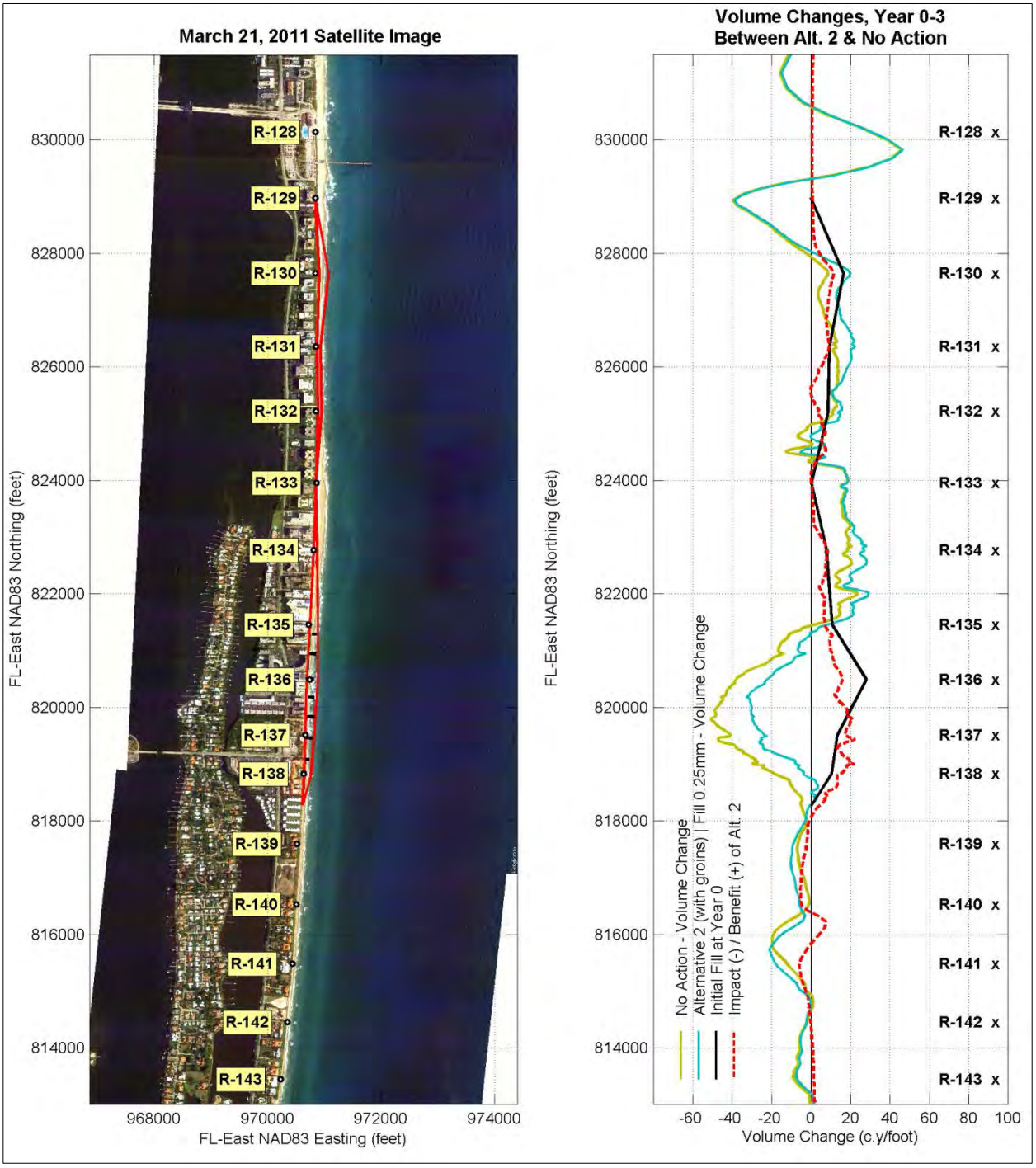

Figure 3-2. Volume changes for Alternative 2 – fill grain size 0.25 mm.

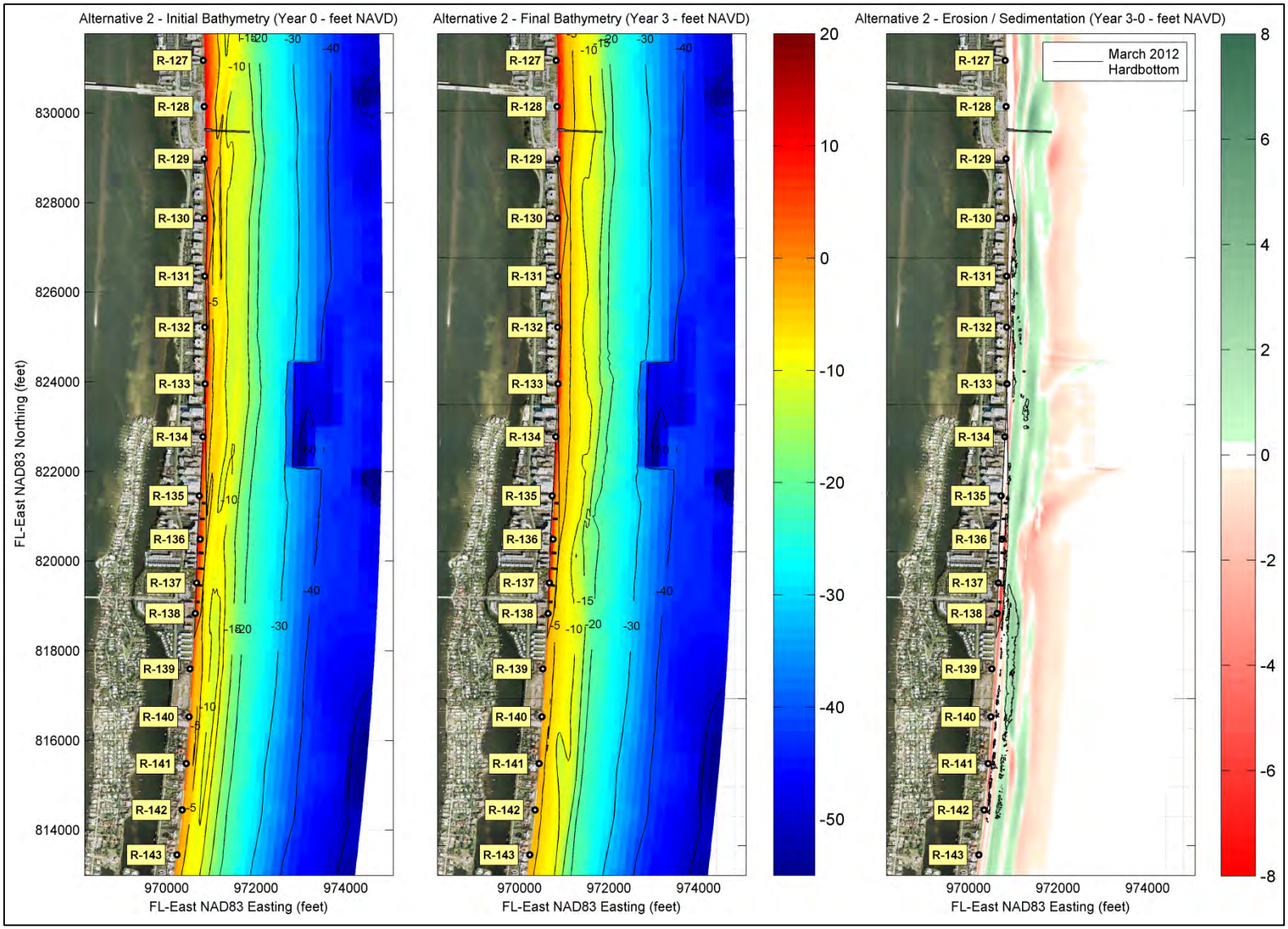

Figure 3-3. Erosion/sedimentation after 3 years of simulation, Alternative 2 - fill grain size 0.25 mm.

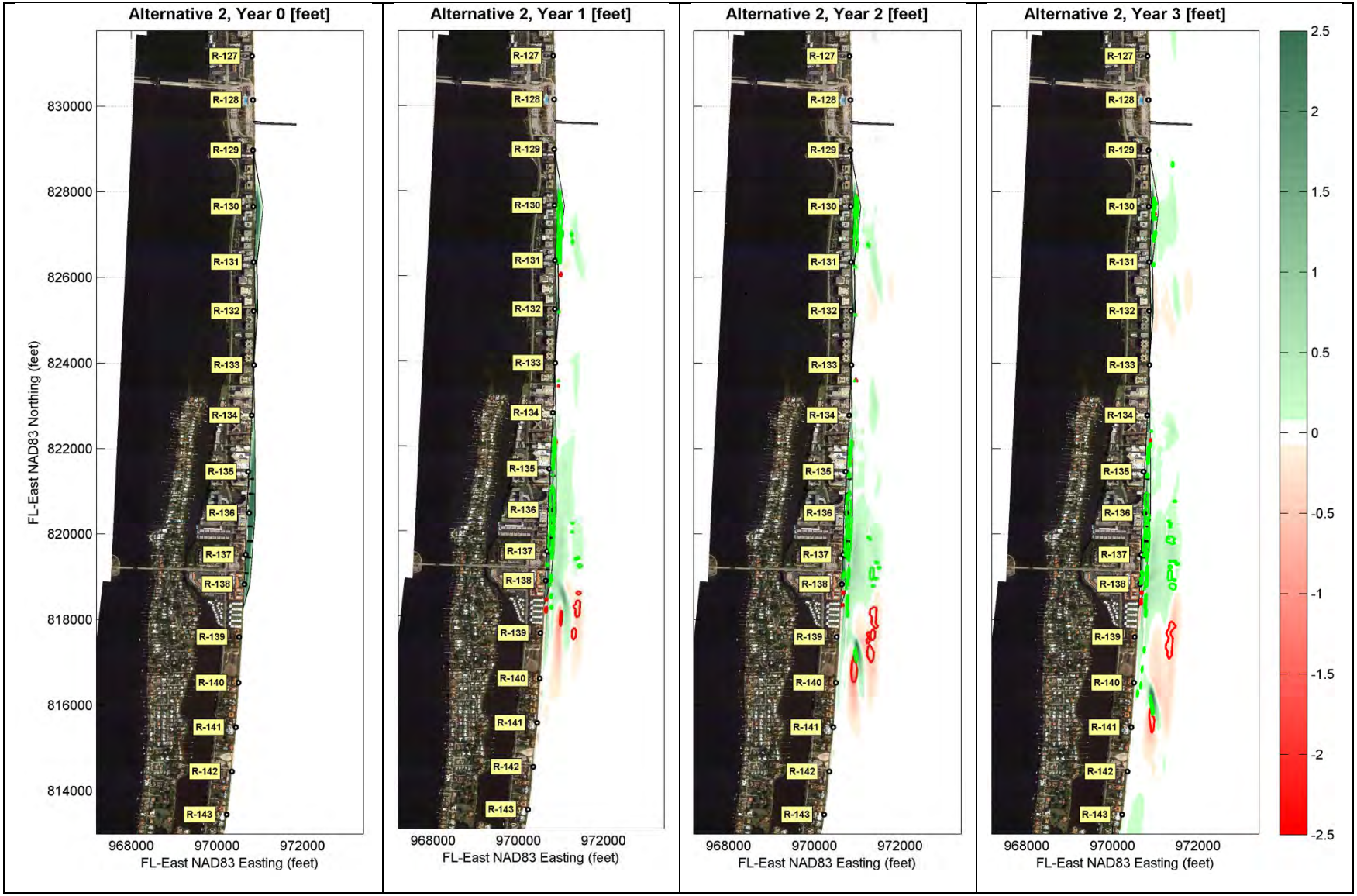

Figure 3-4. Temporal evolution of beach nourishment for Alternative 2, compared to No Action scenario – fill grain size 0.25 mm.

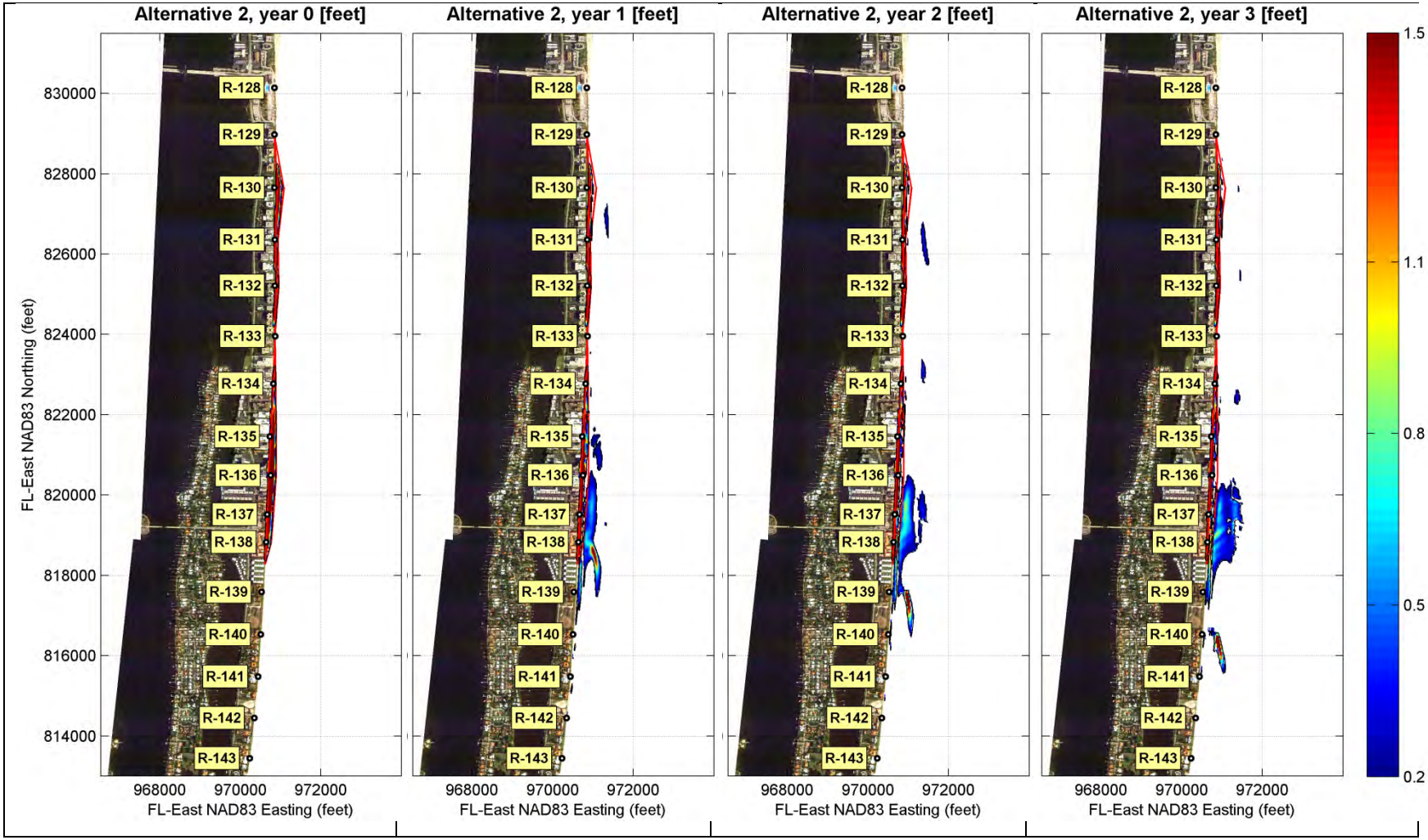

Figure 3-5. Sediment accumulation greater than 0.2 ft for Alternative 2 - fill grain size 0.25 mm.

Separated Action – Alternative 2T (Town of Palm Beach portion of alternative)

Alternative 2T represents the same conditions as Alternative 2 but with fill placement limited to the Town of Palm Beach portion only. The results for the simulation with fill grain size of 0.25 mm are presented in Figure 3-6 through Figure 3-9.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-8). At the end of the 3 year simulation period, there was an estimated coverage of 1.38 acres of hardbottom and an exposure of 0.28 acres attributed to the alternative as depicted in Figure 3-8. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -1.11 acres. The net change is 0.07 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

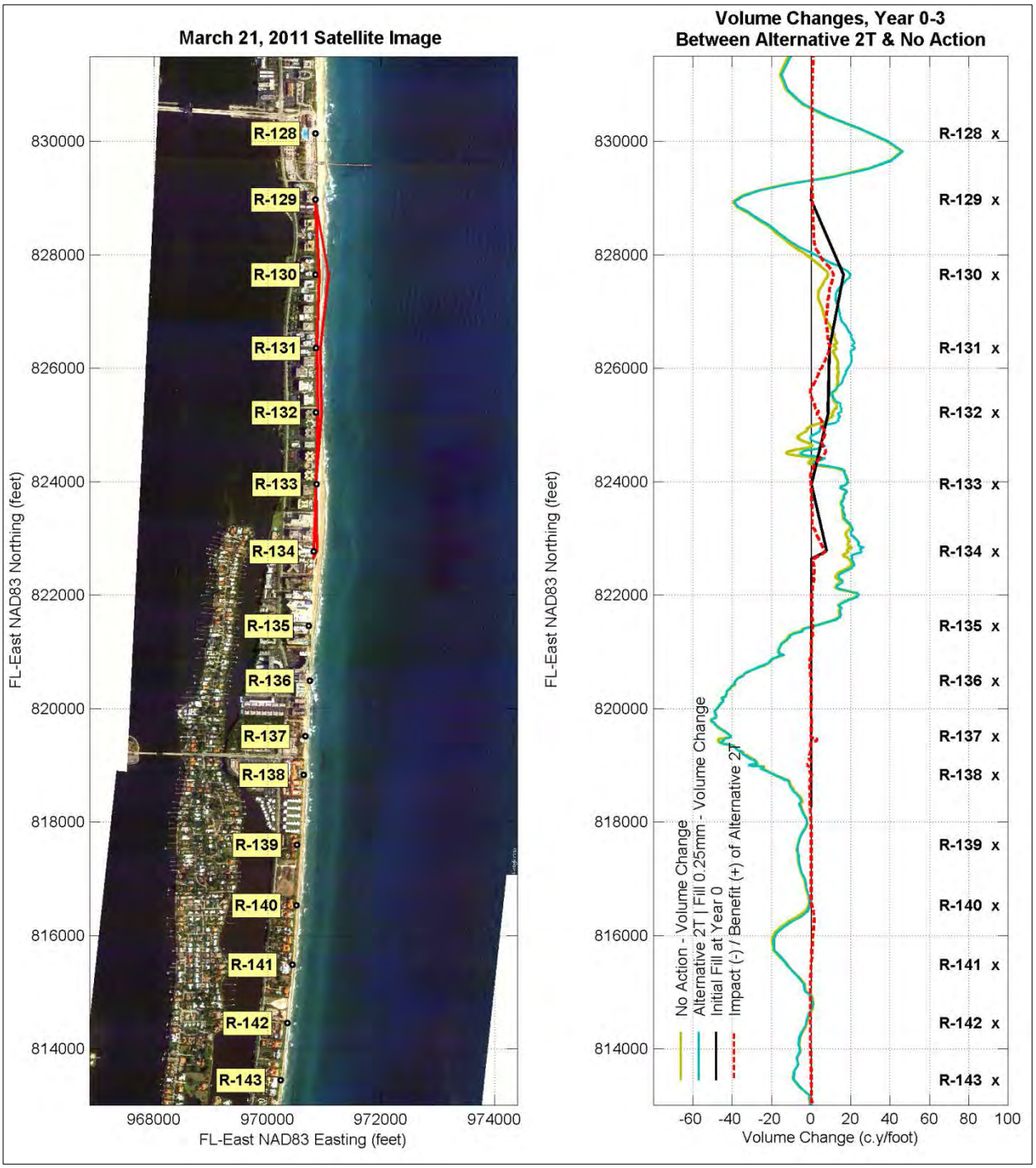

Figure 3-6. Volume changes to Alternative 2T - fill grain size 0.25 mm.

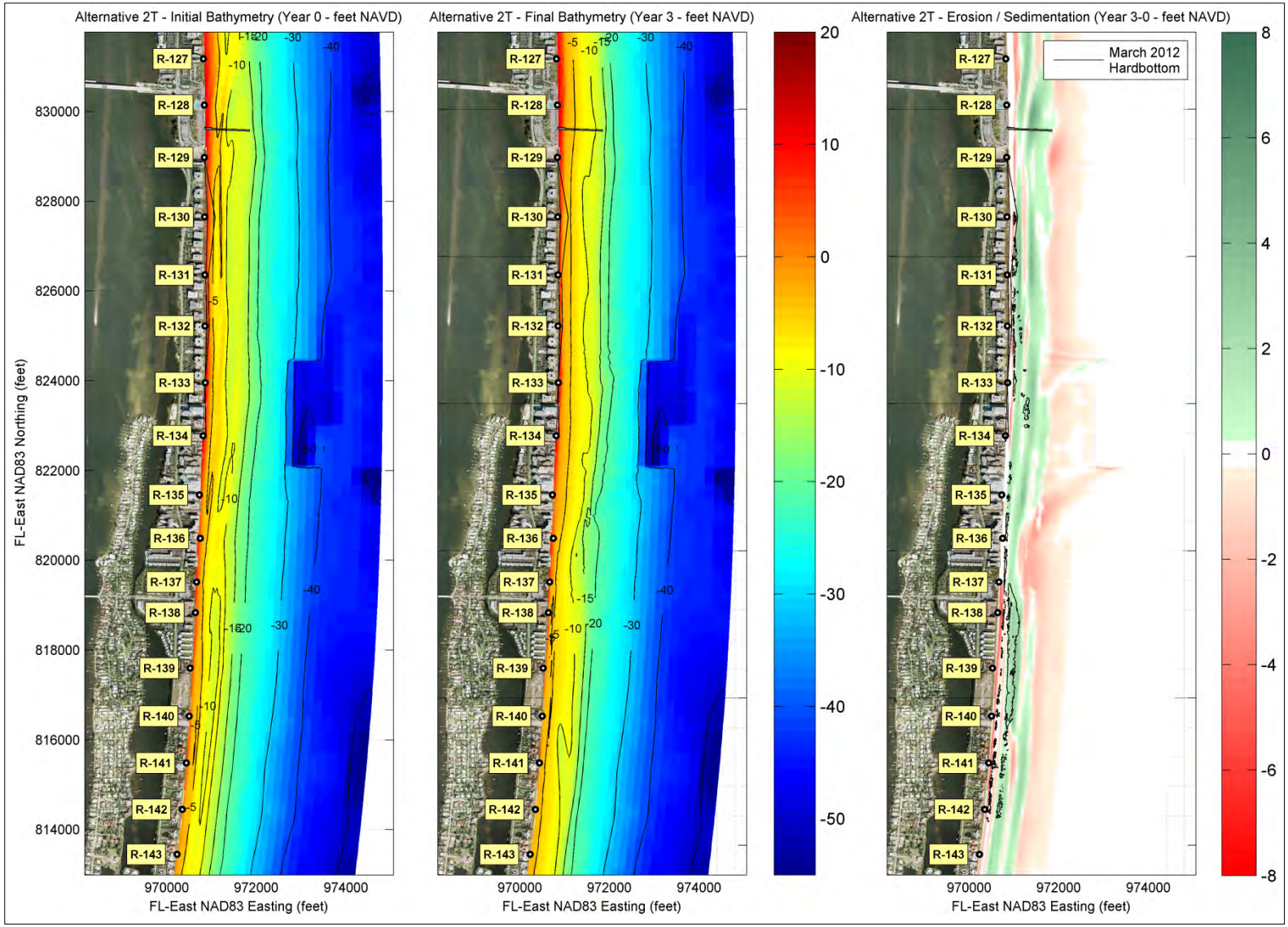

Figure 3-7. Erosion/sedimentation after 3 years of simulation, Alternative 2T - fill grain size 0.25 mm.

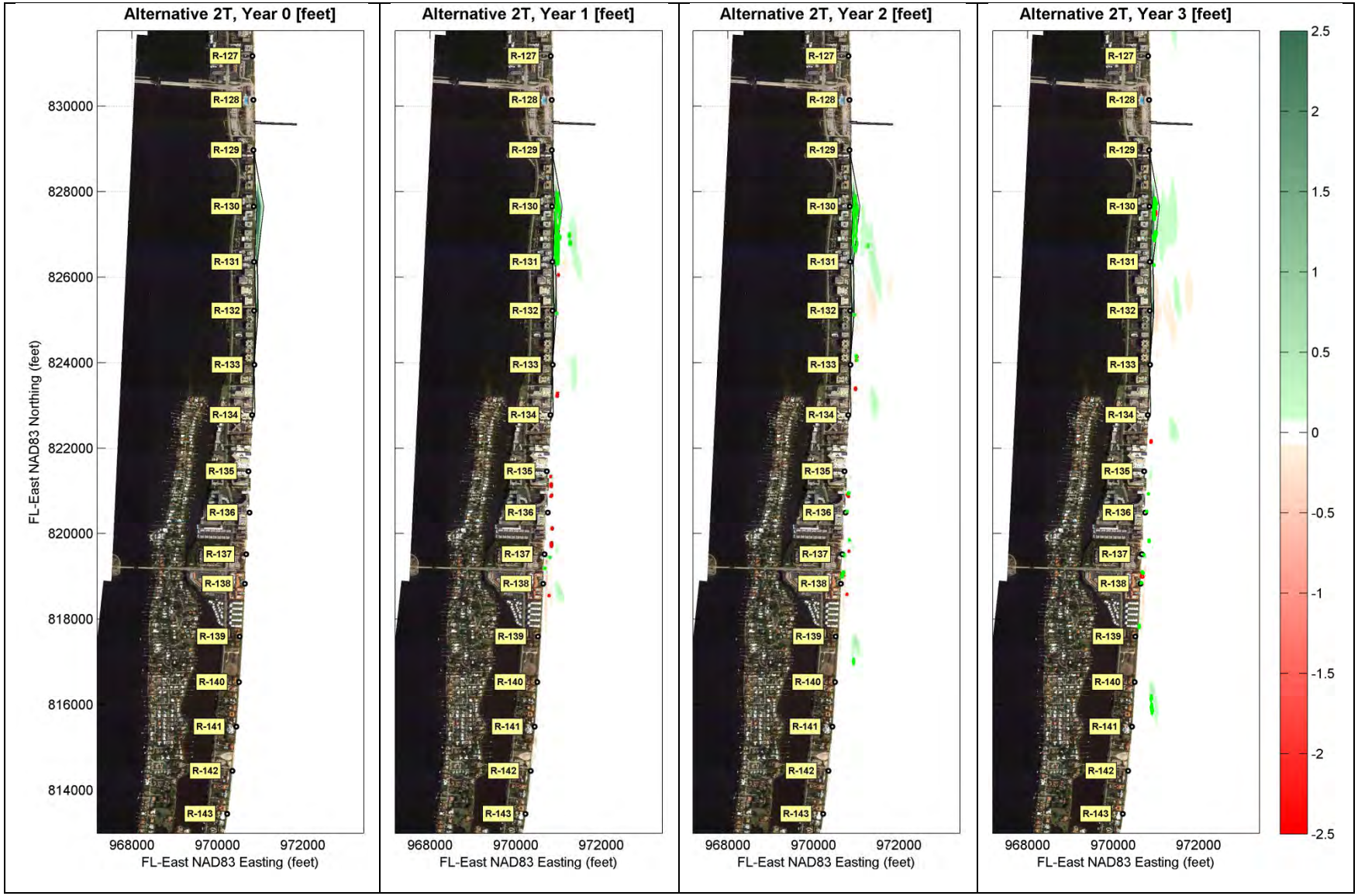

Figure 3-8. Temporal evolution of beach nourishment for Alternative 2T, compared to No Action scenario – fill grain size 0.25 mm.

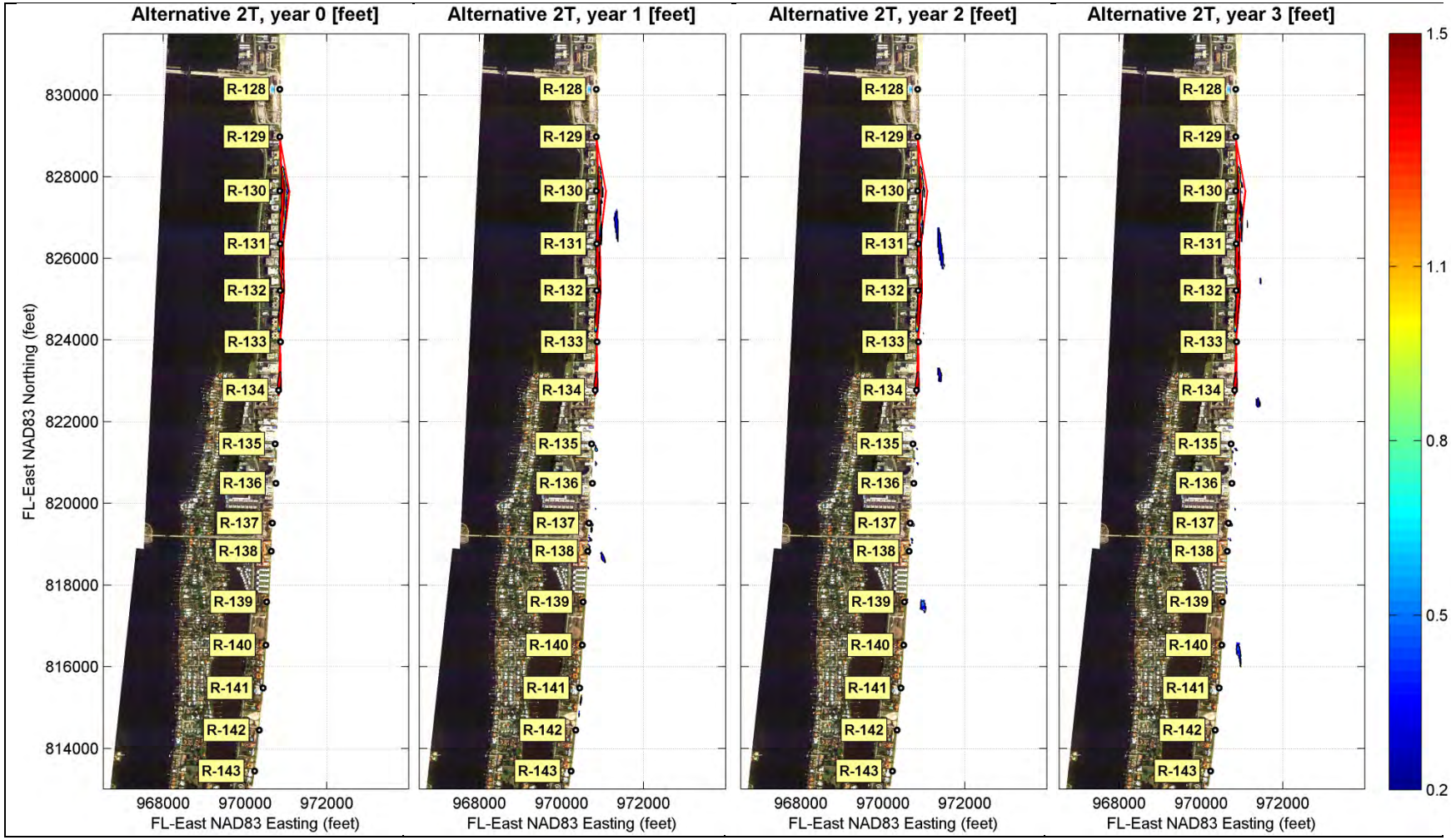

Figure 3-9. Sediment accumulation greater than 0.2 ft for Alternative 2T - fill grain size 0.25 mm.

3.1.2. Alternative 3 - The Applicants' Preferred Project without Shoreline Protection Structures

Model results for Alternative 3 fill grain size of 0.25 mm in Town of Palm Beach's portion of the template are presented in Figure 3-10 through Figure 3-13.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-12). At the end of the 3 year simulation period, there was an estimated coverage of 7.89 acres of hardbottom and an exposure of 0.64 acres attributed to the alternative as depicted in Figure 3-12. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -7.25 acres. The net change is 0.04 acres less (less coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

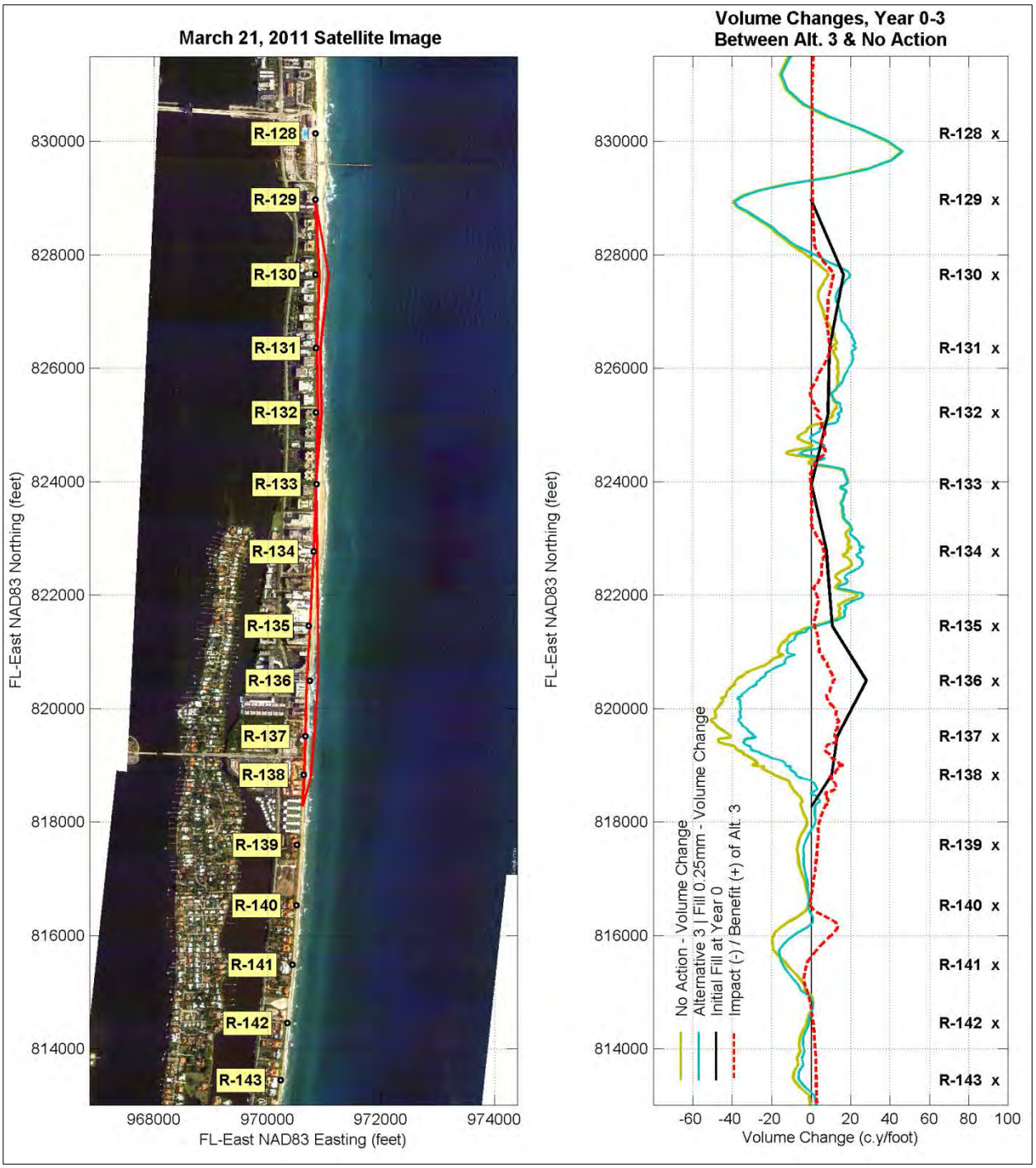

Figure 3-10. Volume changes to Alternative 3 - fill grain size 0.25 mm.

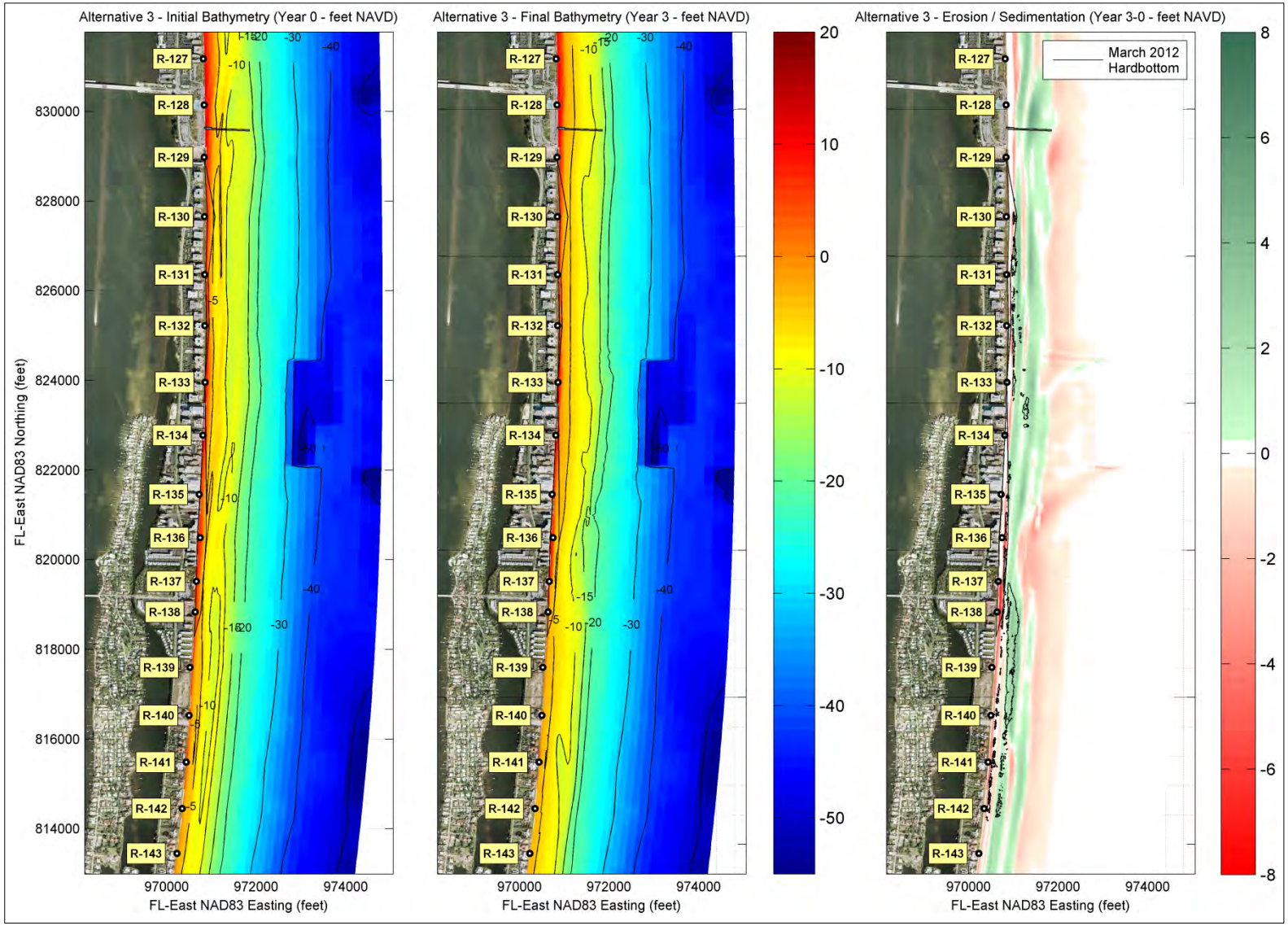

Figure 3-11. Erosion/sedimentation after 3 years of simulation, Alternative 3 - fill grain size 0.25 mm.

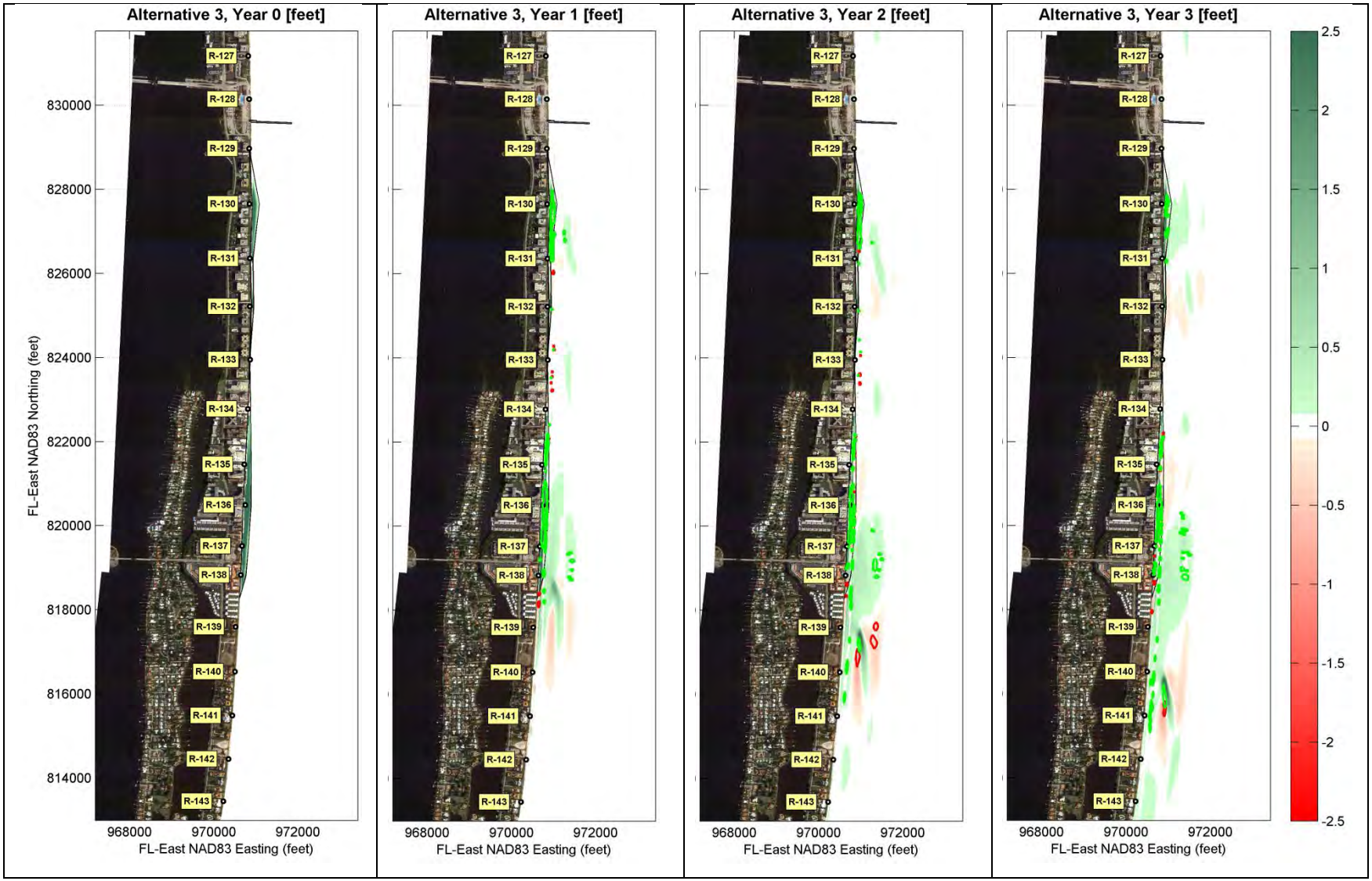

Figure 3-12. Temporal evolution of erosion (red) / sedimentation (green) for Alternative 3, compared to No Action scenario - Fill grain size 0.25 mm.

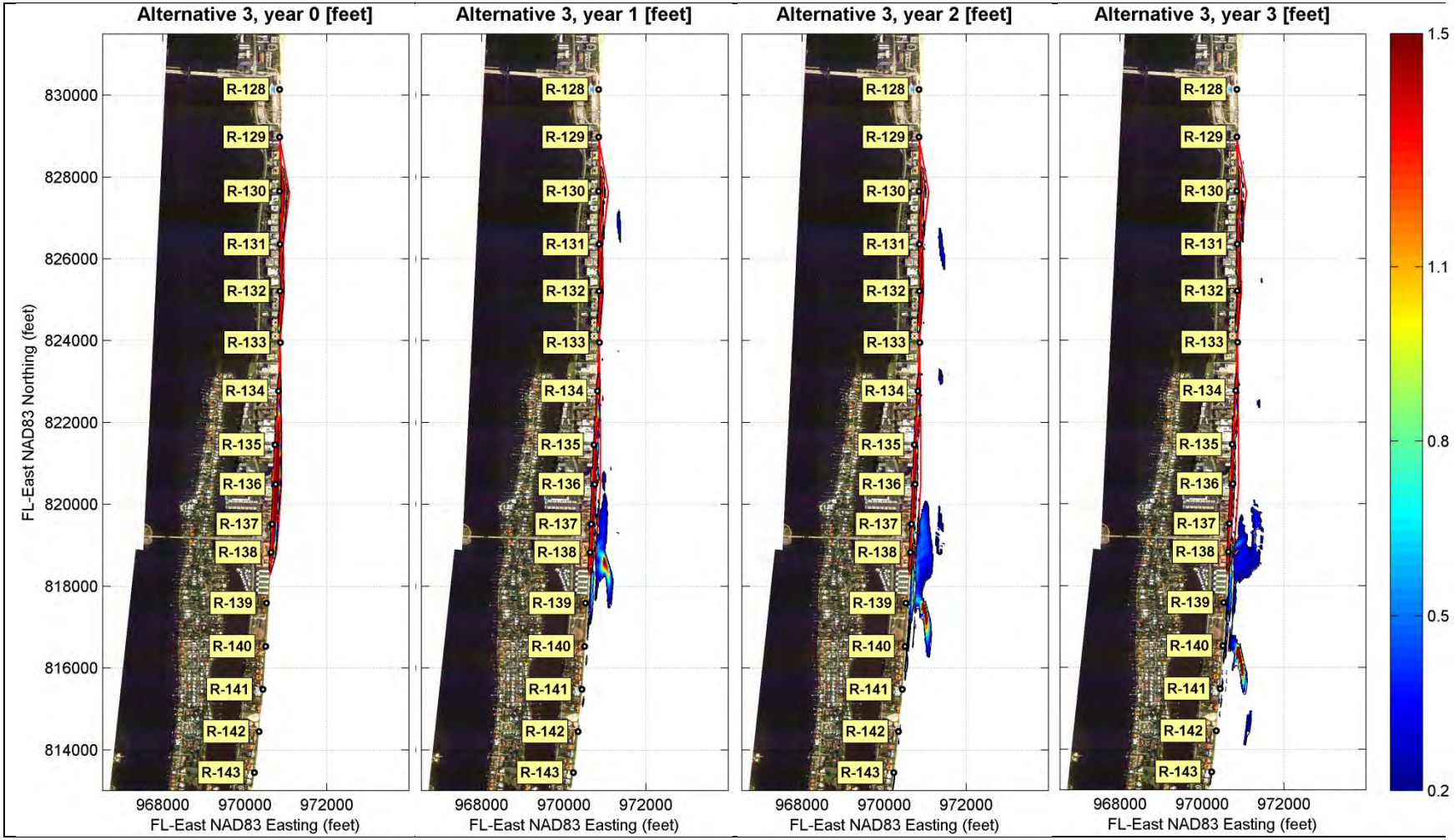

Figure 3-13. Sediment accumulation greater than 0.2 ft for Alternative 3 - fill grain size 0.25 mm.

3.1.3. Alternative 4 - The Town of Palm Beach Preferred Project and County Increased Sand Volume Project without Shoreline Protection Structures

Model results for Alternative 4 simulated with fill grain size of 0.25 mm in the Town of Palm Beach's portion of the template are shown in Figure 3-14 through Figure 3-17.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-16). At the end of the 3 year simulation period, there was an estimated coverage of 12.04 acres of hardbottom and an exposure of 0.53 acres attributed to the alternative as depicted in Figure 3-16. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -11.51 acres. The net change is 0.03 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

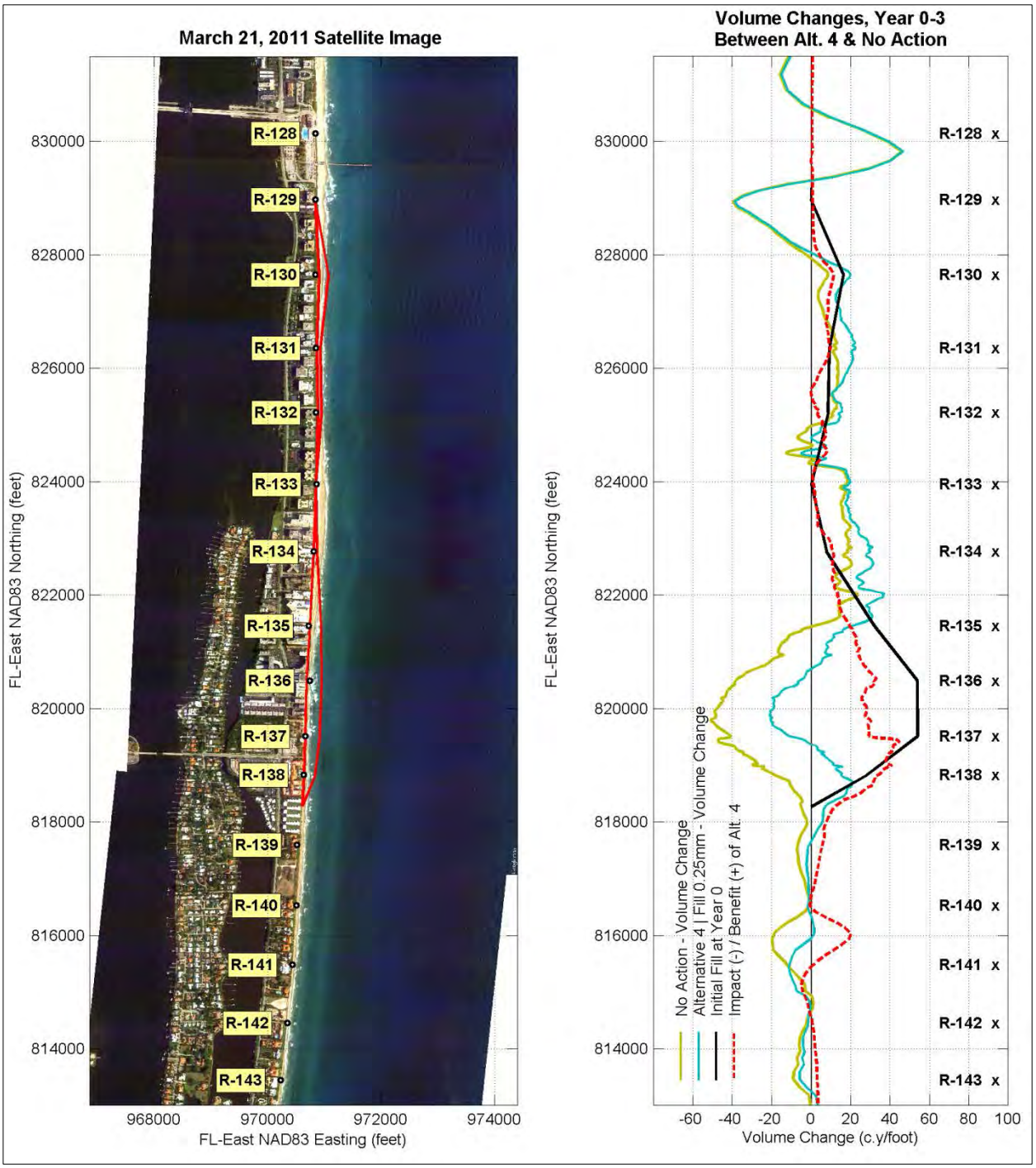

Figure 3-14. Volume changes to Alternative 4 - fill grain size 0.25 mm.

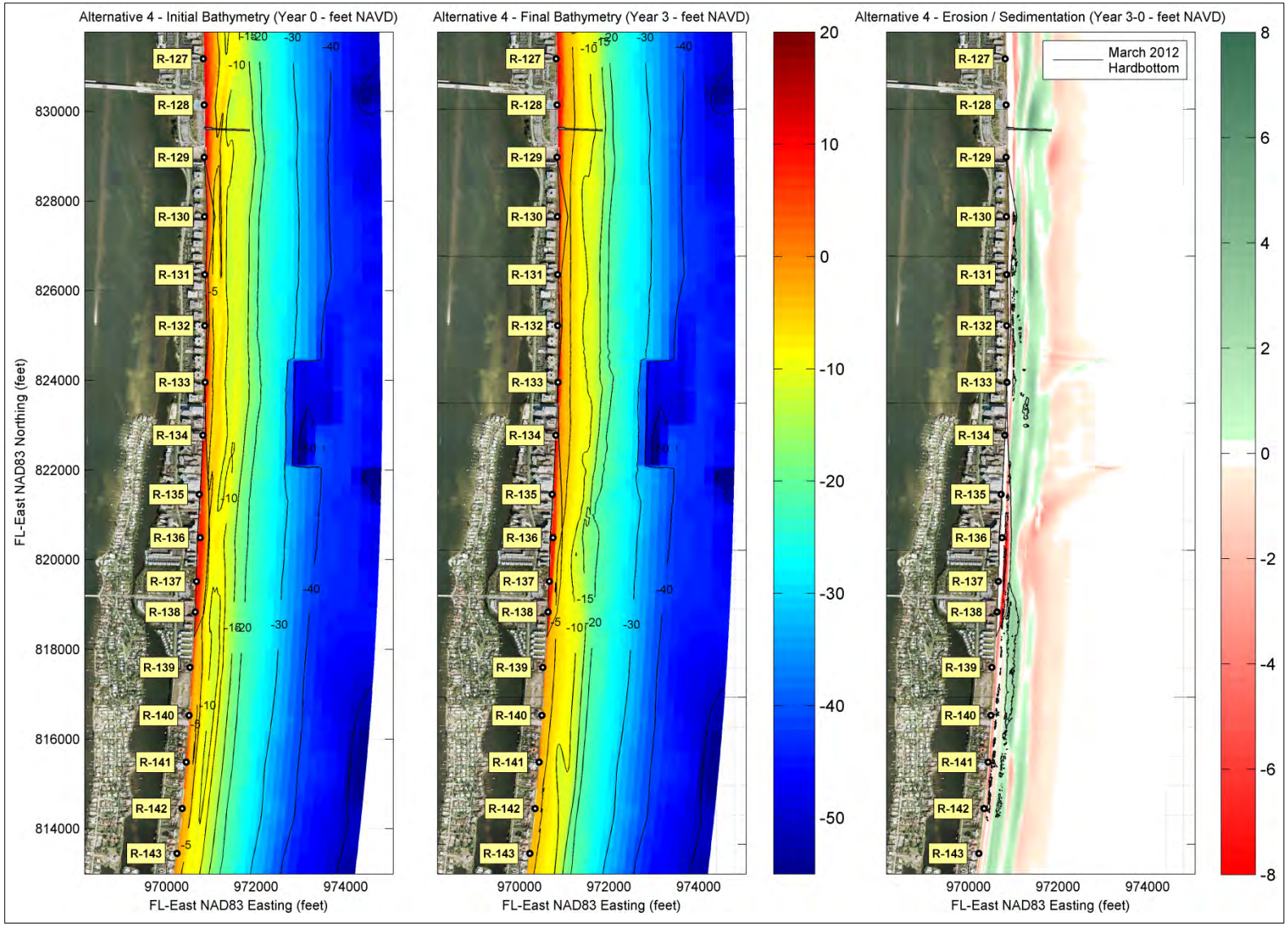

Figure 3-15. Erosion/sedimentation after 3 years of simulation, Alternative 4 - fill grain size 0.25 mm.

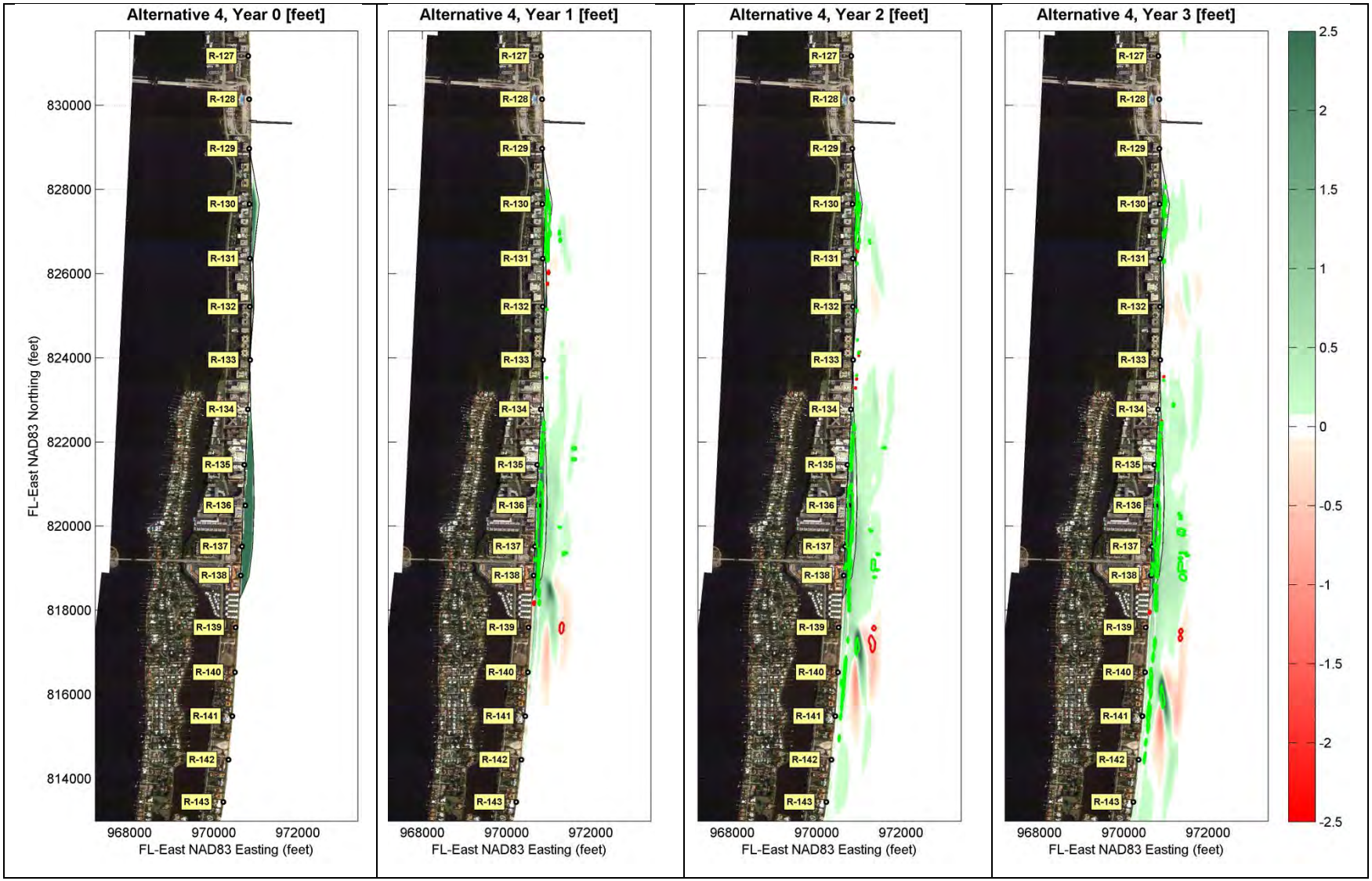

Figure 3-16. Temporal evolution of erosion (red) / sedimentation (green) for Alternative 4 - fill grain size 0.25 mm.

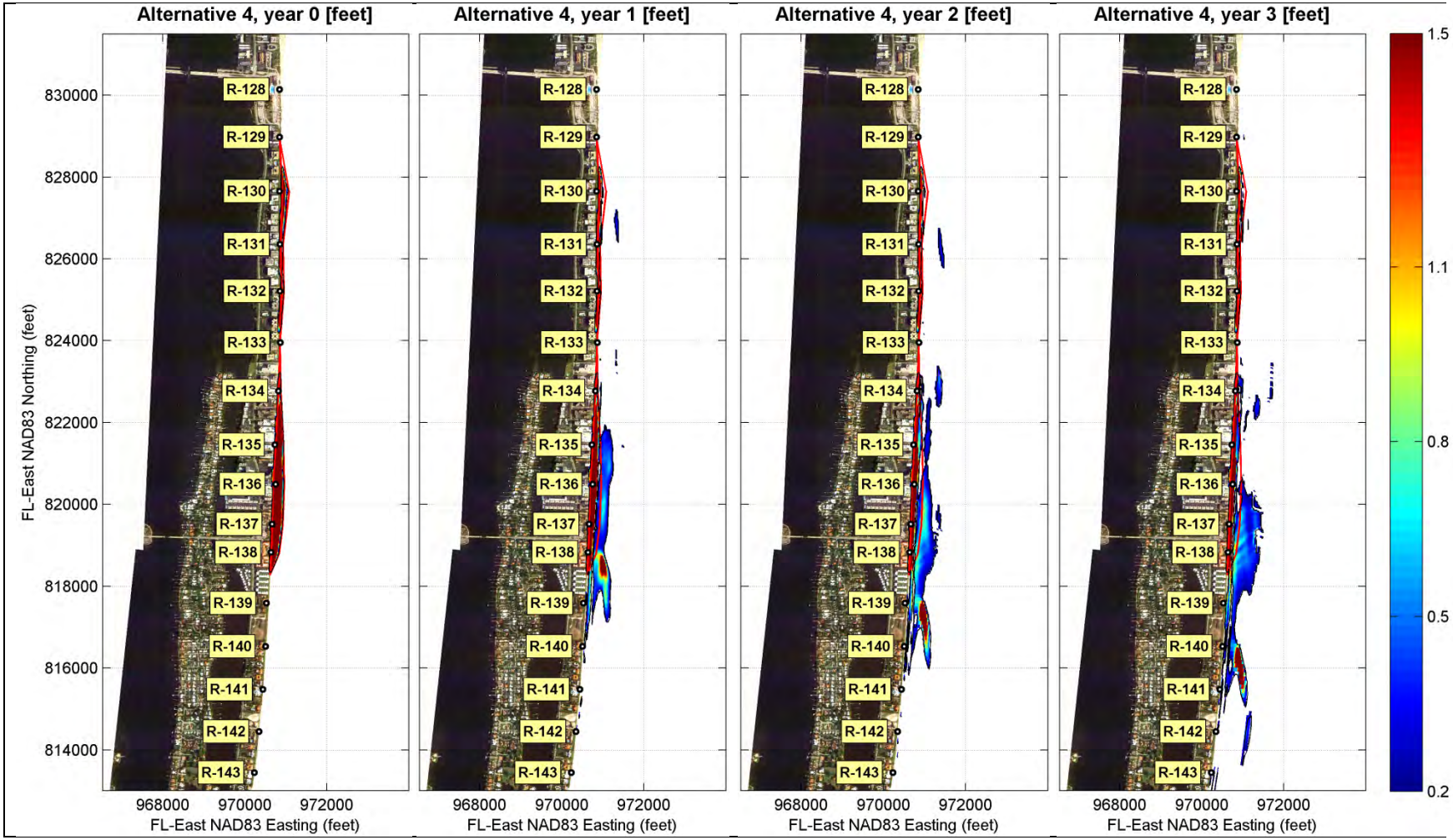

Figure 3-17. Sediment accumulation greater than 0.2 ft for Alternative 4 - fill grain size 0.25 mm.

3.1.4. Alternative 5 - The Town of Palm Beach Increased Sand Volume Project and County Preferred Project

Model results given in Alternative 5 with fill grain size of 0.25 mm in the Town of Palm Beach's portion of the template appear in Figure 3-18 through Figure 3-21.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-20). At the end of the 3 year simulation period, there was an estimated coverage of 10.65 acres of hardbottom and an exposure of 2.89 acres attributed to the alternative as depicted in Figure 3-20. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -7.75 acres. The net change is 1.11 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

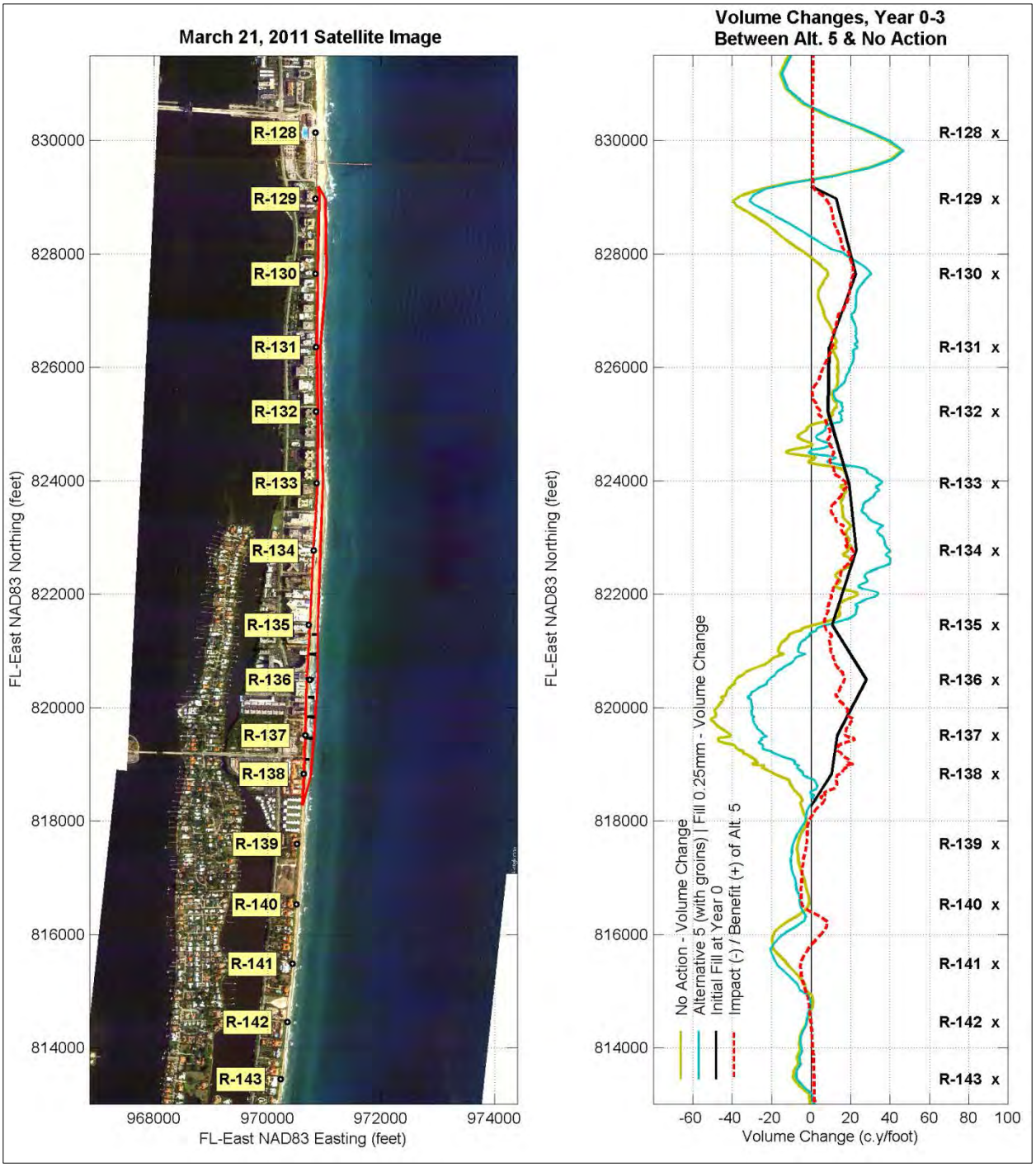

Figure 3-18. Volume changes, Alternative 5 - fill grain size 0.25 mm.

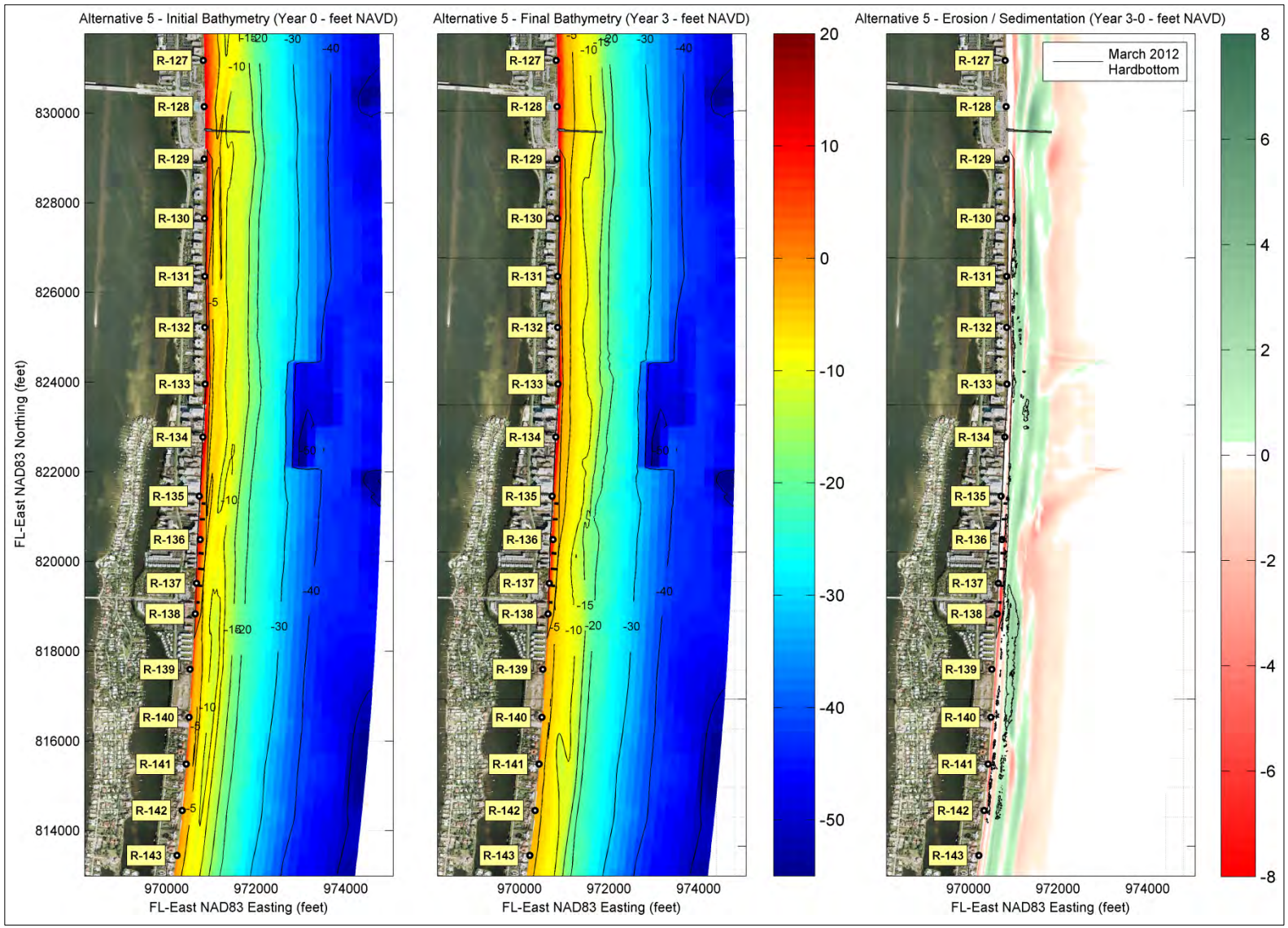

Figure 3-19. Erosion/Sedimentation after 3 years of simulation, Alternative 5 - Fill grain size 0.25 mm.

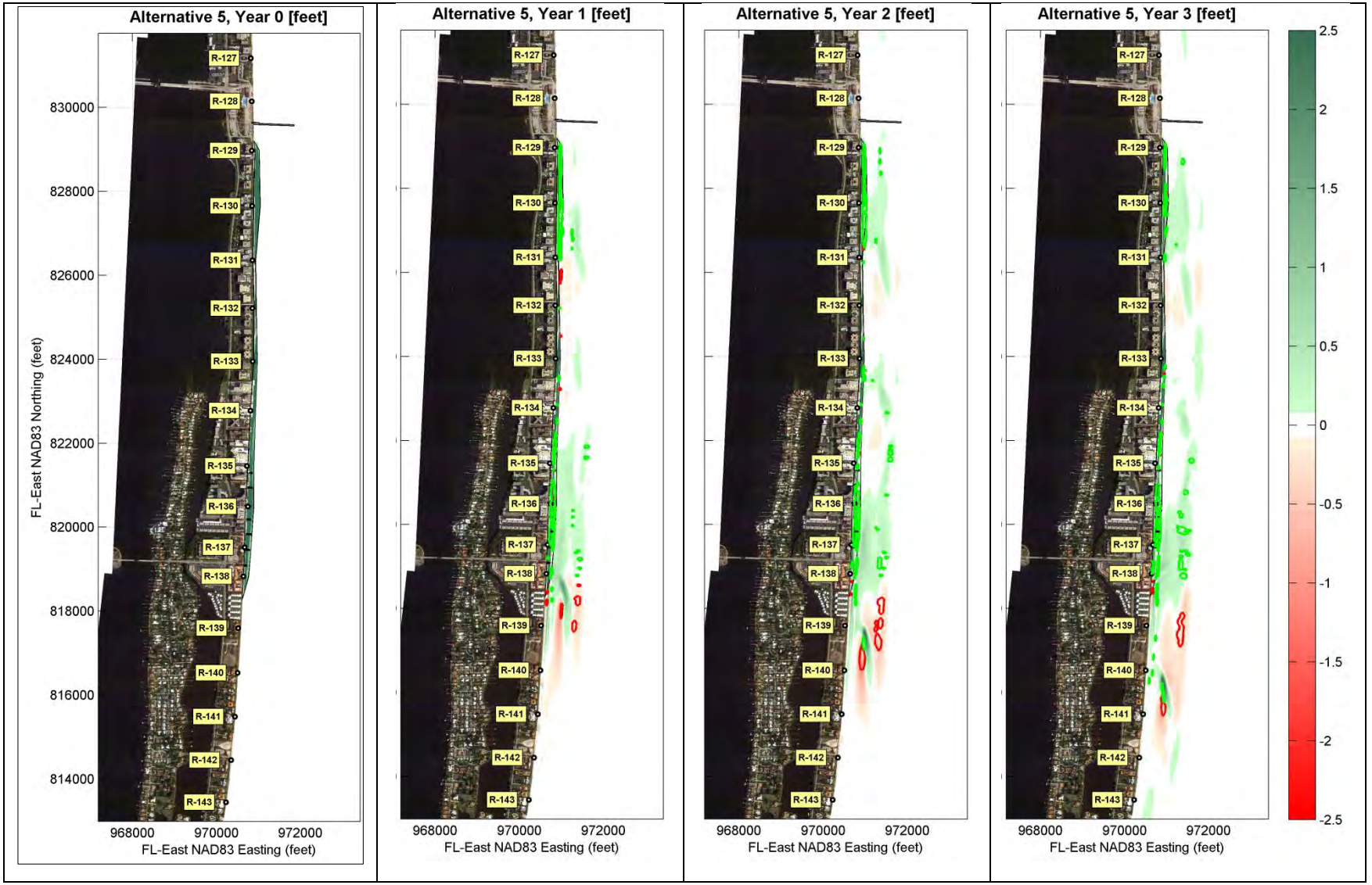

Figure 3-20. Temporal evolution of erosion (red) / sedimentation (green) for Alternative 5 - fill grain size 0.25 mm.

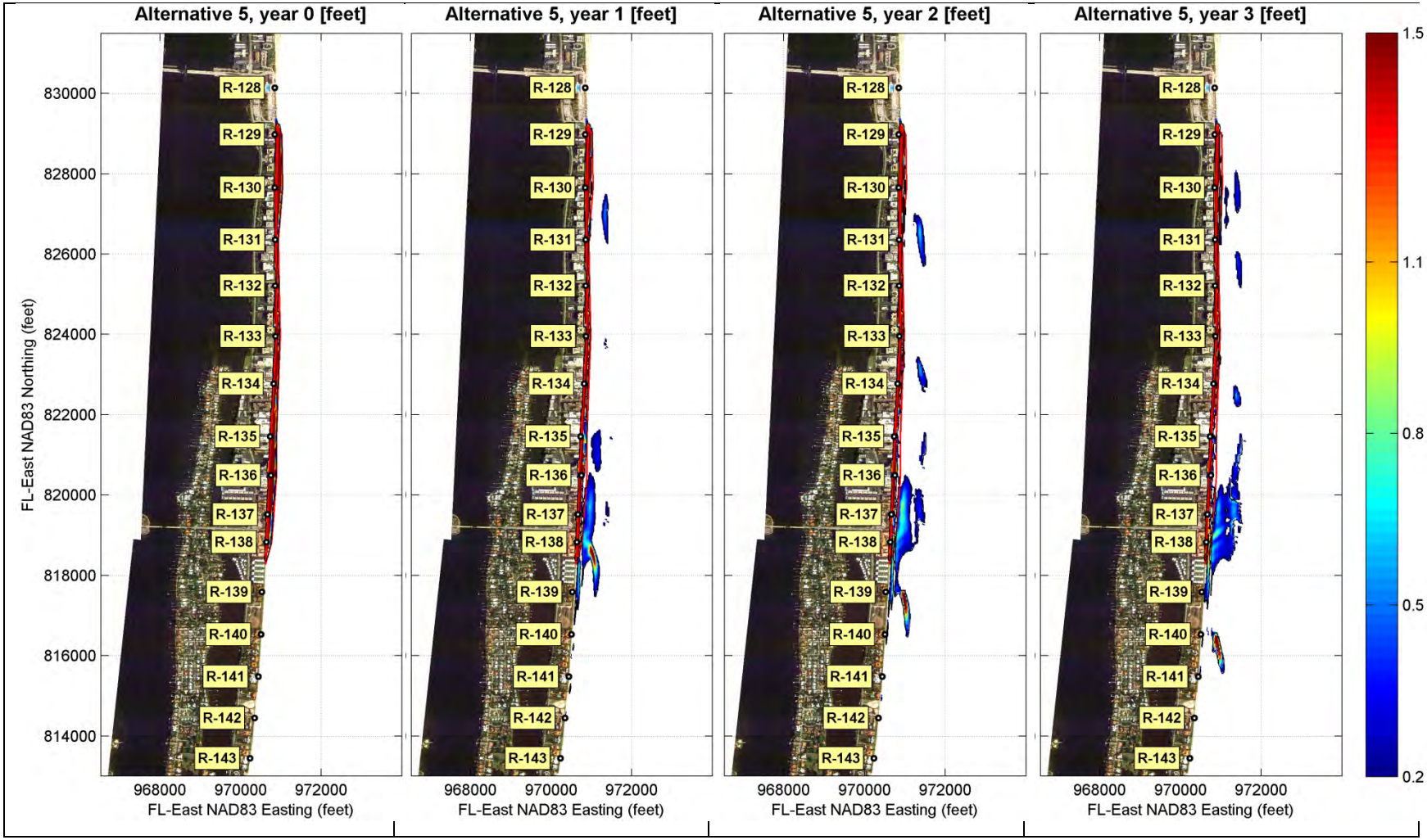

Figure 3-21. Sediment accumulation greater than 0.2 ft for Alternative 5 - fill grain size 0.25 mm.

3.1.5. Alternative 6 - The Town of Palm Beach Increased Sand Volume Project and County Increased Sand Volume without Shoreline Protection Structures Project

Combined Action

Model results given in Alternative 6 simulated with fill sediment grain size of 0.25 mm in the Town of Palm Beach's portion of the template appear in Figure 3-22 through Figure 3-25.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-24). At the end of the 3 year simulation period, there was an estimated coverage of 13.48 acres of hardbottom and an exposure of 0.51 acres attributed to the alternative as depicted in Figure 3-24. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -12.98 acres. The net change is 0.01 acres less (less coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

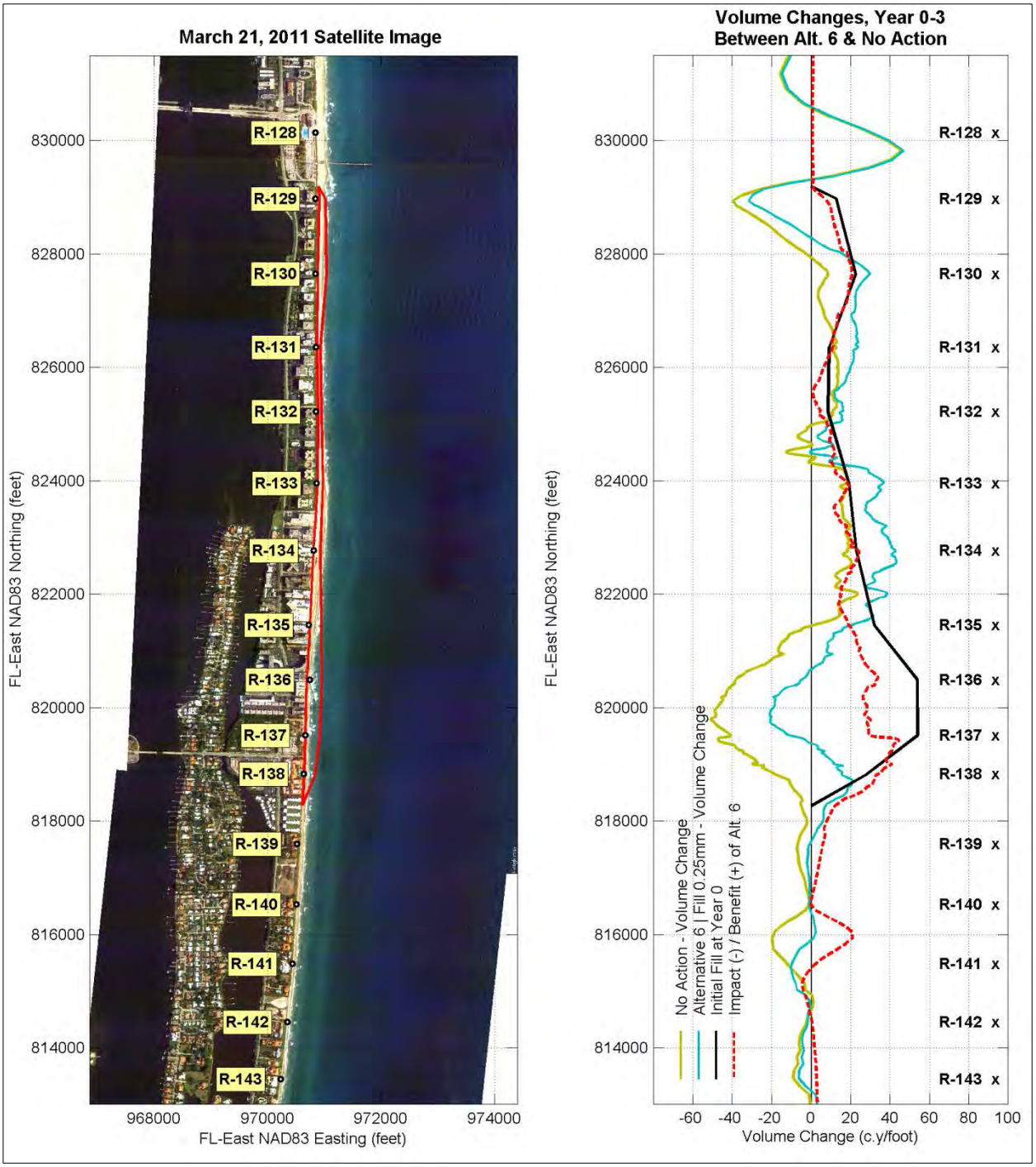

Figure 3-22. Volume changes, Alternative 6 - fill grain size 0.25 mm.

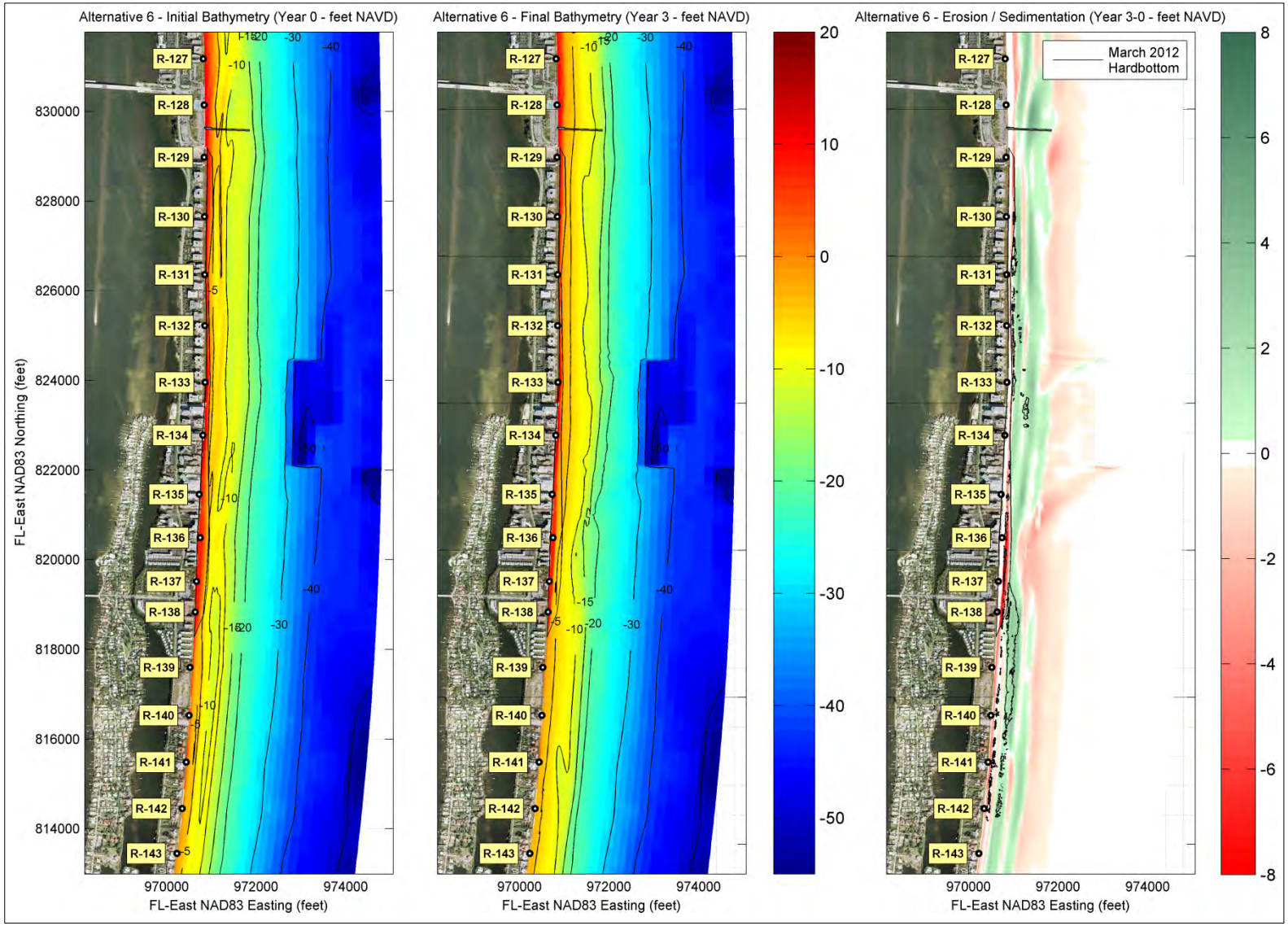

Figure 3-23. Erosion/sedimentation after 3 years of simulation, Alternative 6 - fill grain size 0.25 mm.

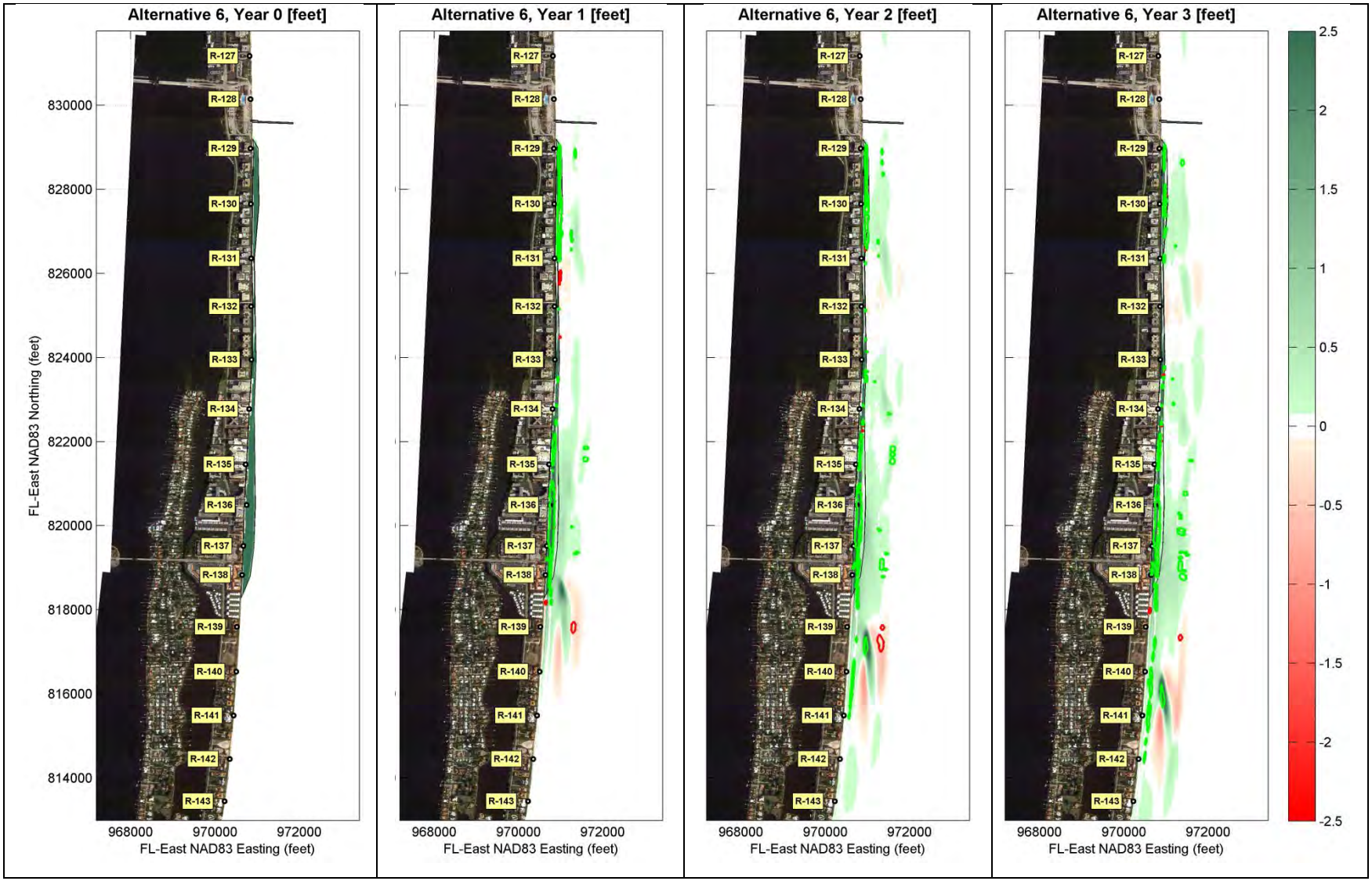

Figure 3-24. Temporal evolution of erosion (red) / sedimentation (green) for Alternative 6, compared to No Action scenario - fill grain size 0.25 mm.

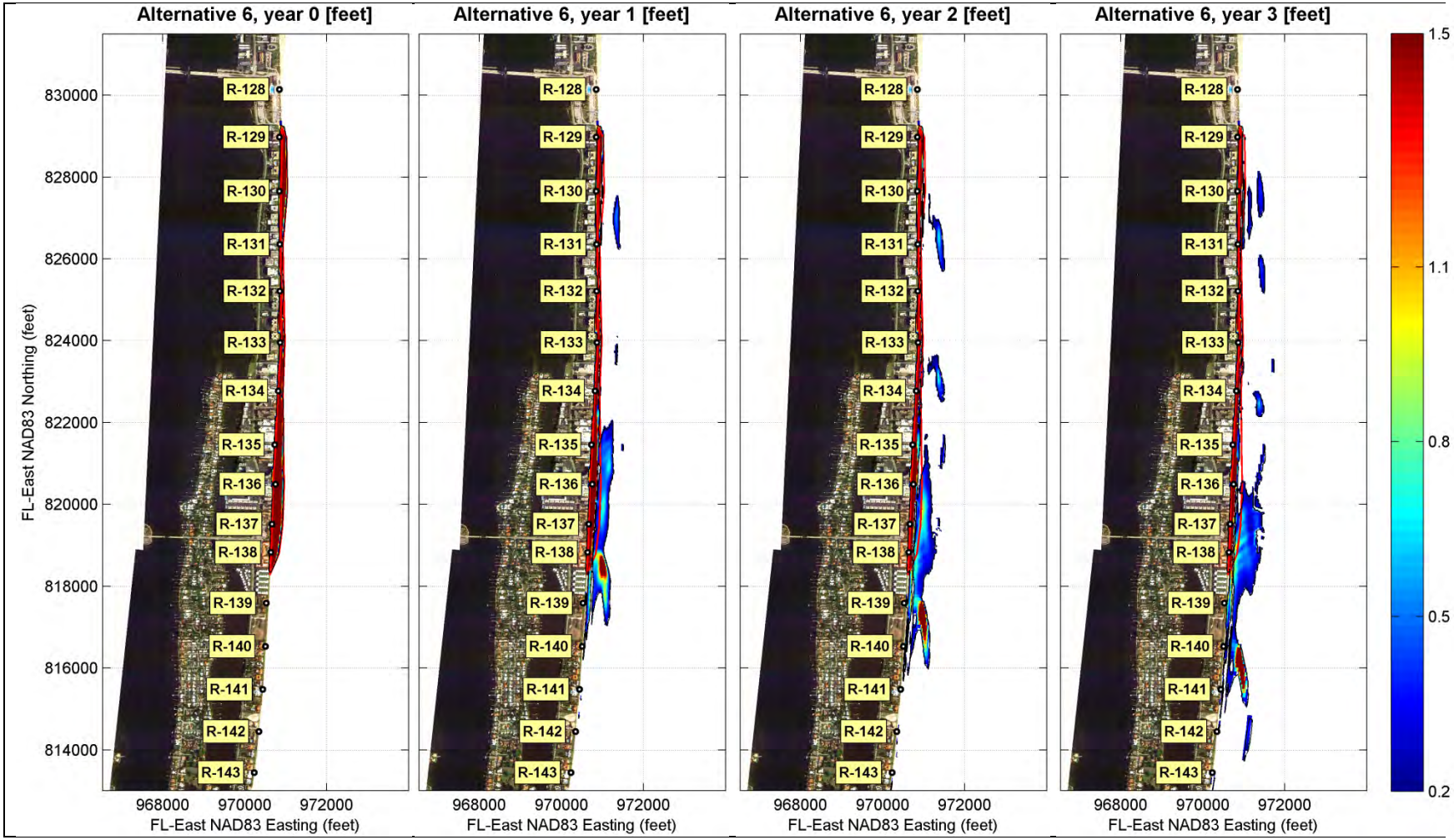

Figure 3-25. Sediment accumulation greater than 0.2 ft for Alternative 6 - fill grain size 0.25 mm.

Separated Action – Alternative 6T (Town of Palm Beach portion of alternative)

Model results for Alternative 6T grain size 0.25 mm are shown in Figure 3-26 through Figure 3-29.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-28). At the end of the 3 year simulation period, there was an estimated coverage of 2.80 acres of hardbottom and an exposure of 0.18 acres attributed to the alternative as depicted in Figure 3-28. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -2.63 acres. The net change is 0.42 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

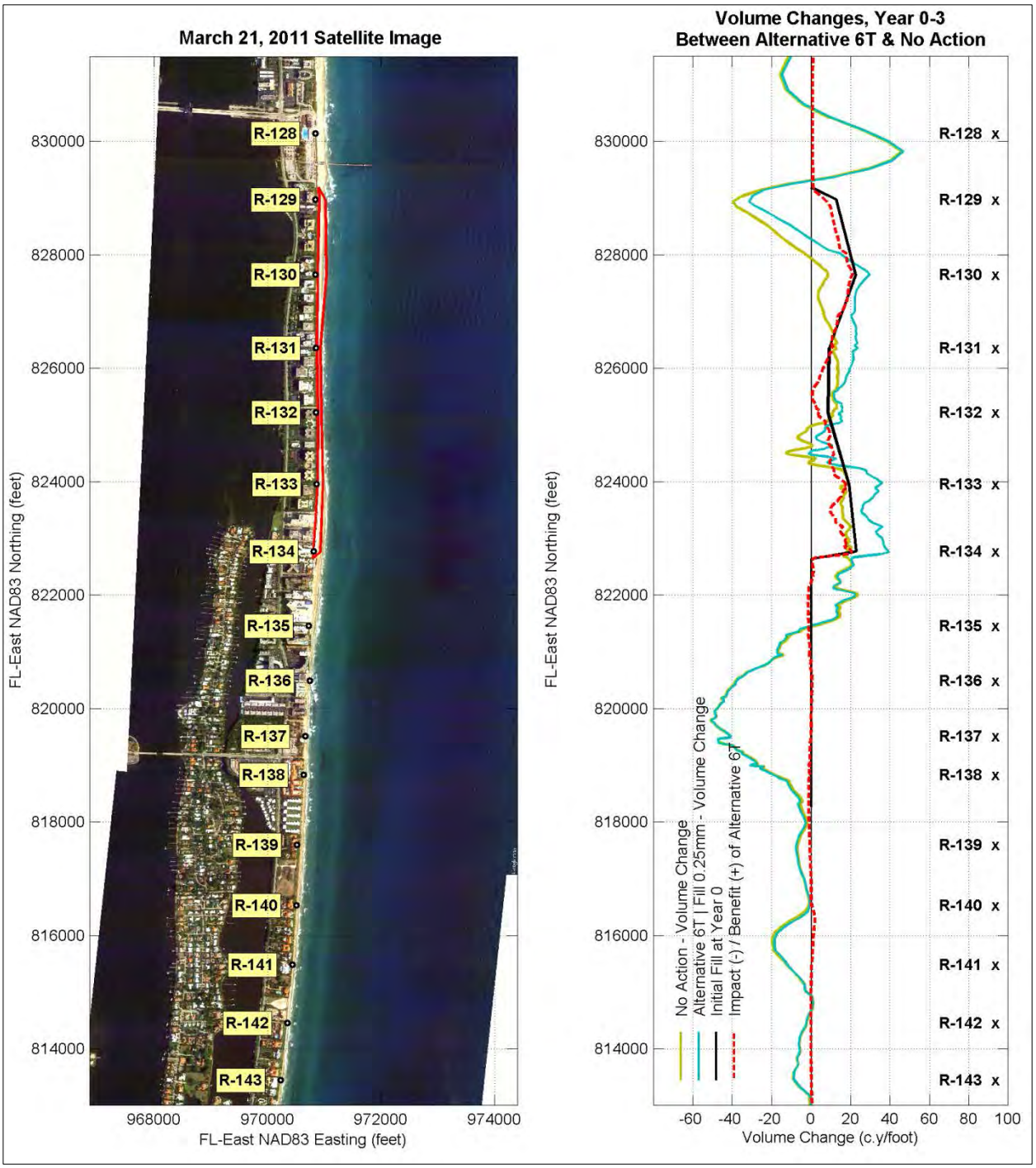

Figure 3-26. Volume Changes, Alternative 6T - fill grain size 0.25 mm.

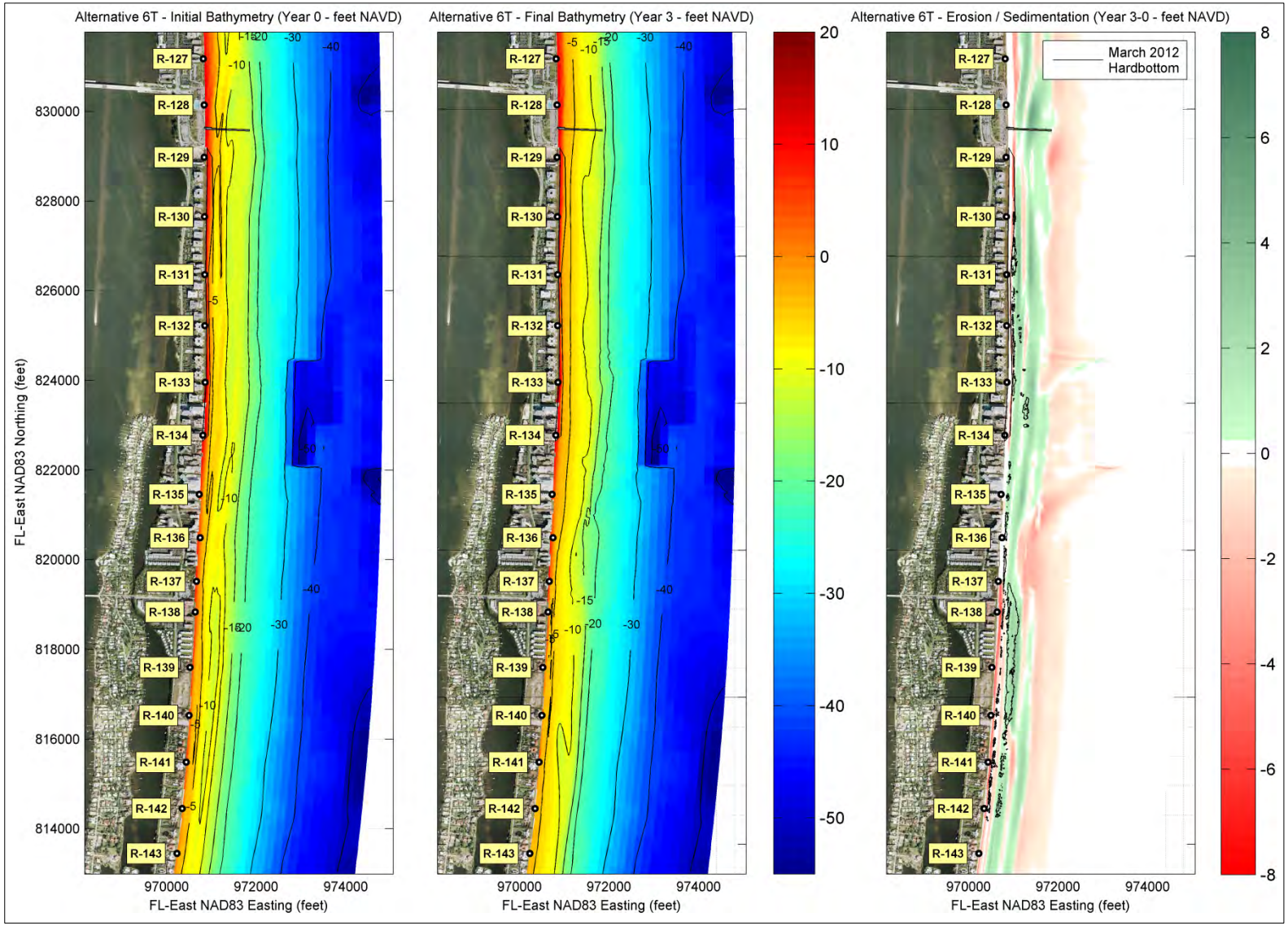

Figure 3-27. Erosion/sedimentation after 3 years of simulation, Alternative 6T - fill grain size 0.25 mm.

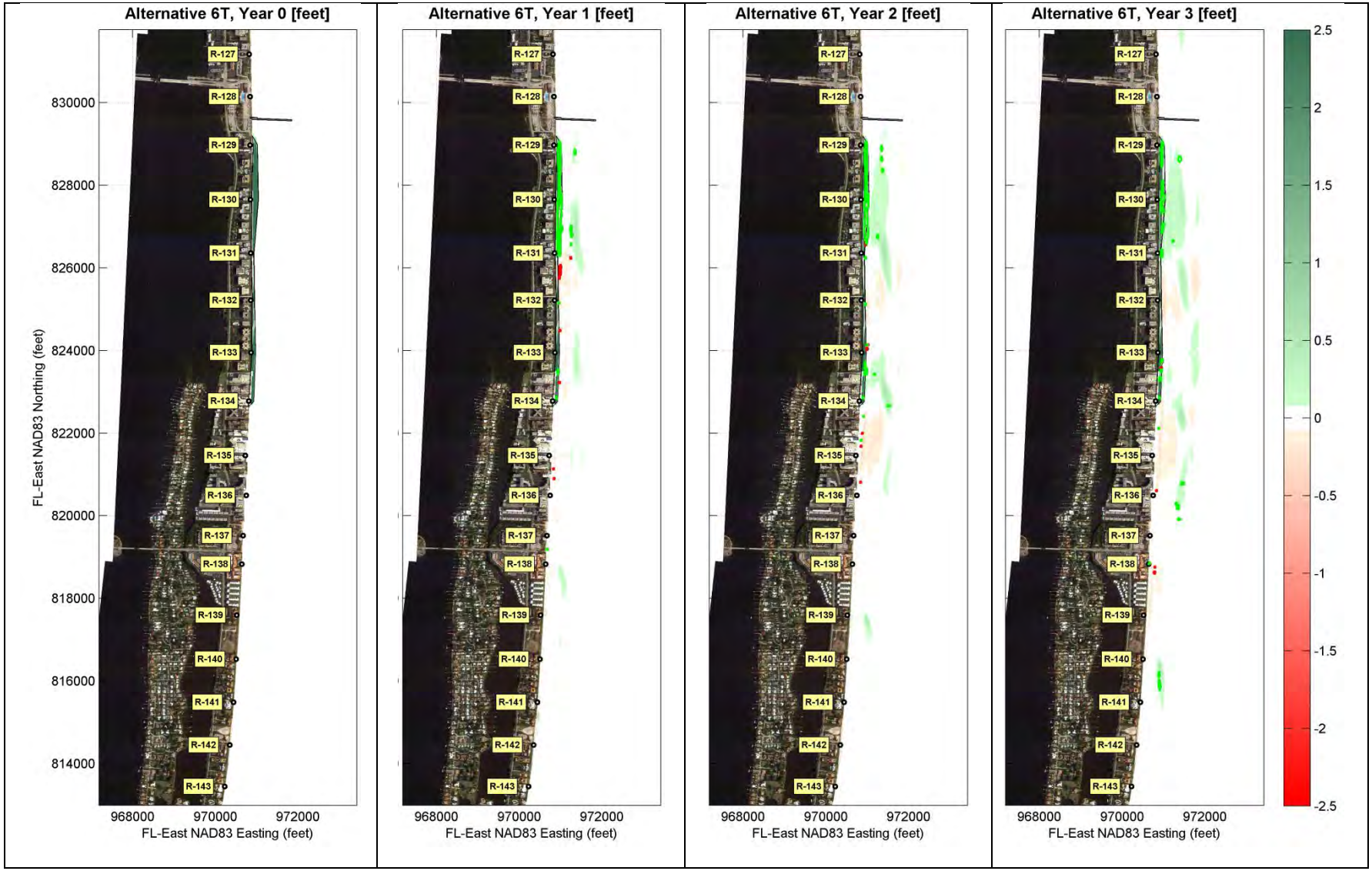

Figure 3-28. Temporal evolution of erosion (red) / sedimentation (green) for Alternative 6T, compared to No Action scenario - fill grain size 0.25 mm.

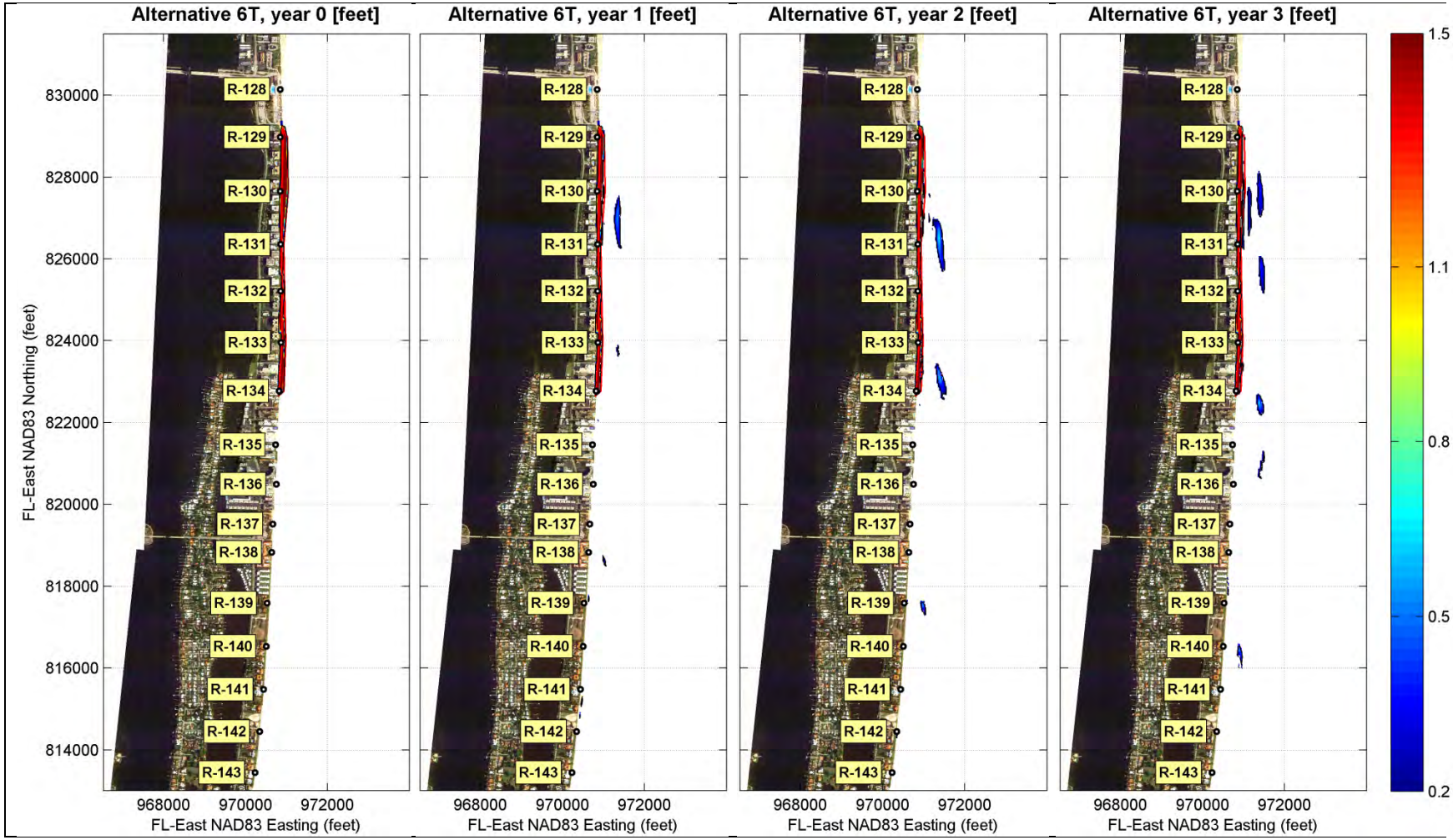

Figure 3-29. Sediment accumulation greater than 0.2 ft for Alternative 6T - fill grain size 0.25 mm.

3.1.6. Alternative 7a - The Coalition to Save Our Shoreline, Inc. (SOS) option with increased sand volume and the County Preferred Project

Combined Action

Model results given in Alternative 7a simulated with fill sediment grain size of 0.25 mm in the Town of Palm Beach's portion of the template appear in Figure 3-30 through Figure 3-33.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-32). At the end of the 3 year simulation period, there was an estimated coverage of 14.22 acres of hardbottom and an exposure of 1.98 acres attributed to the alternative as depicted in Figure 3-32. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -12.24 acres. The net change is 1.60 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

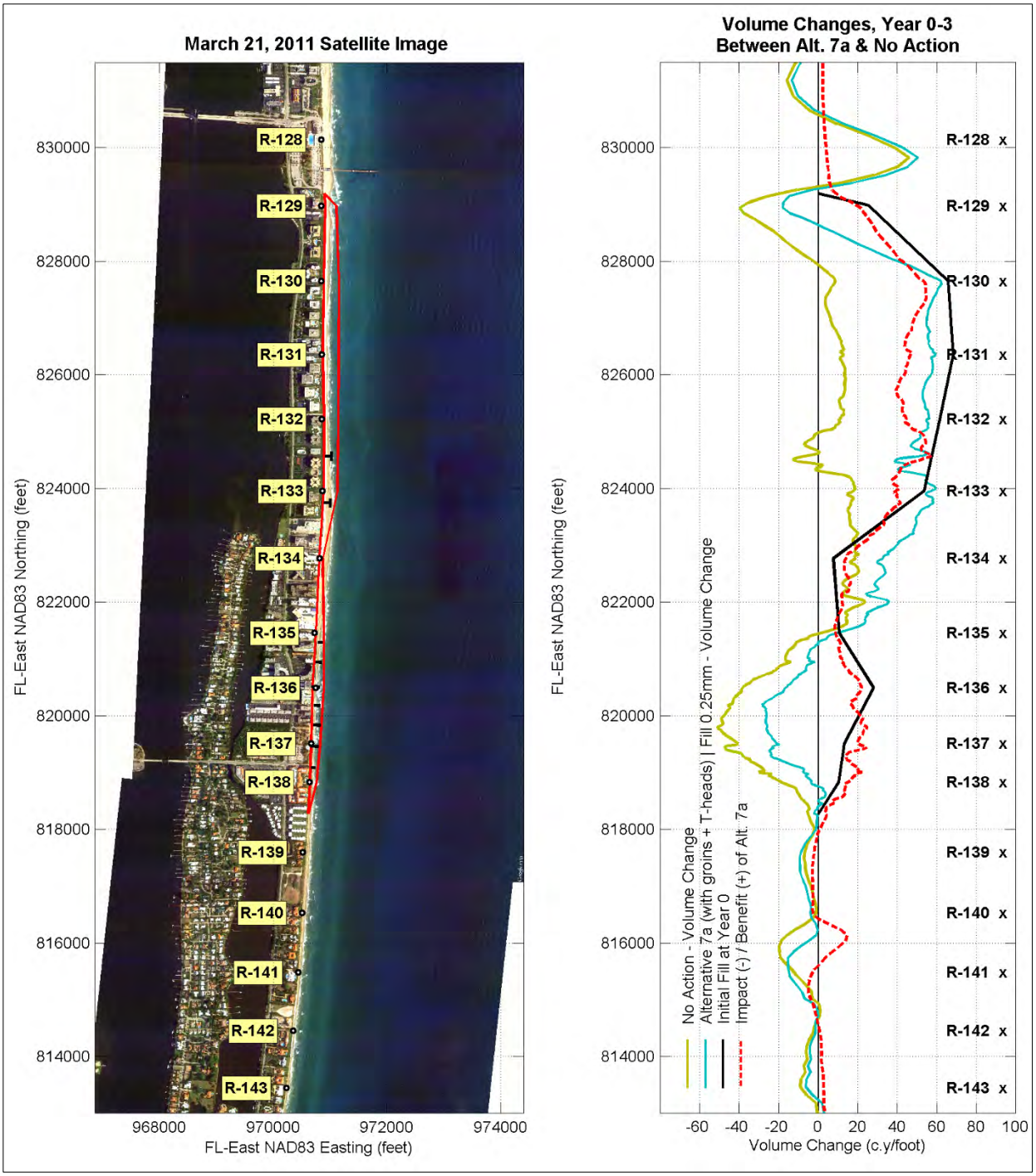

Figure 3-30. Volume changes, Alternative 7a - fill grain size 0.25 mm.

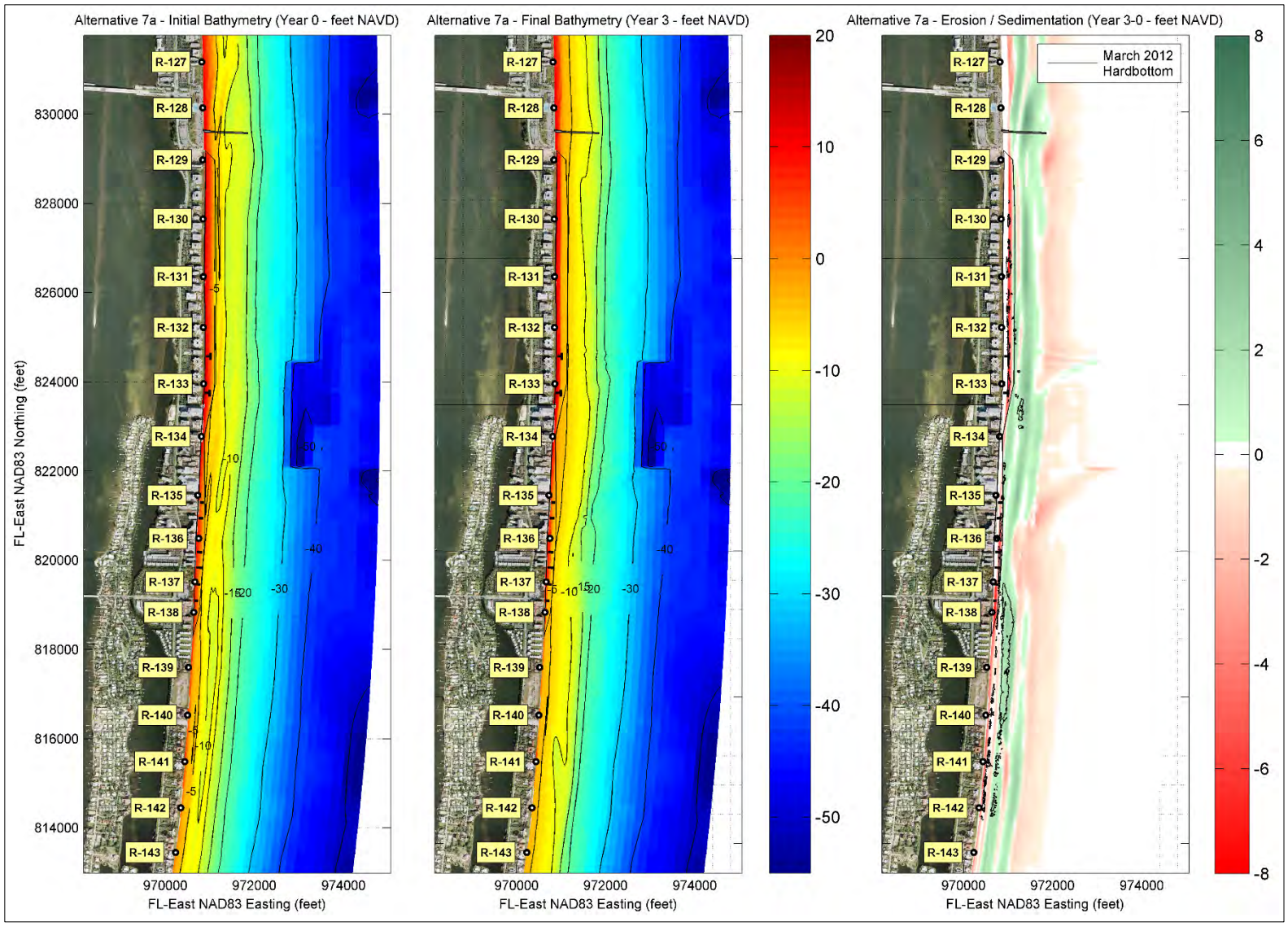

Figure 3-31. Erosion/sedimentation after 3 years of simulation, Alternative 7a - Fill grain size 0.25 mm.

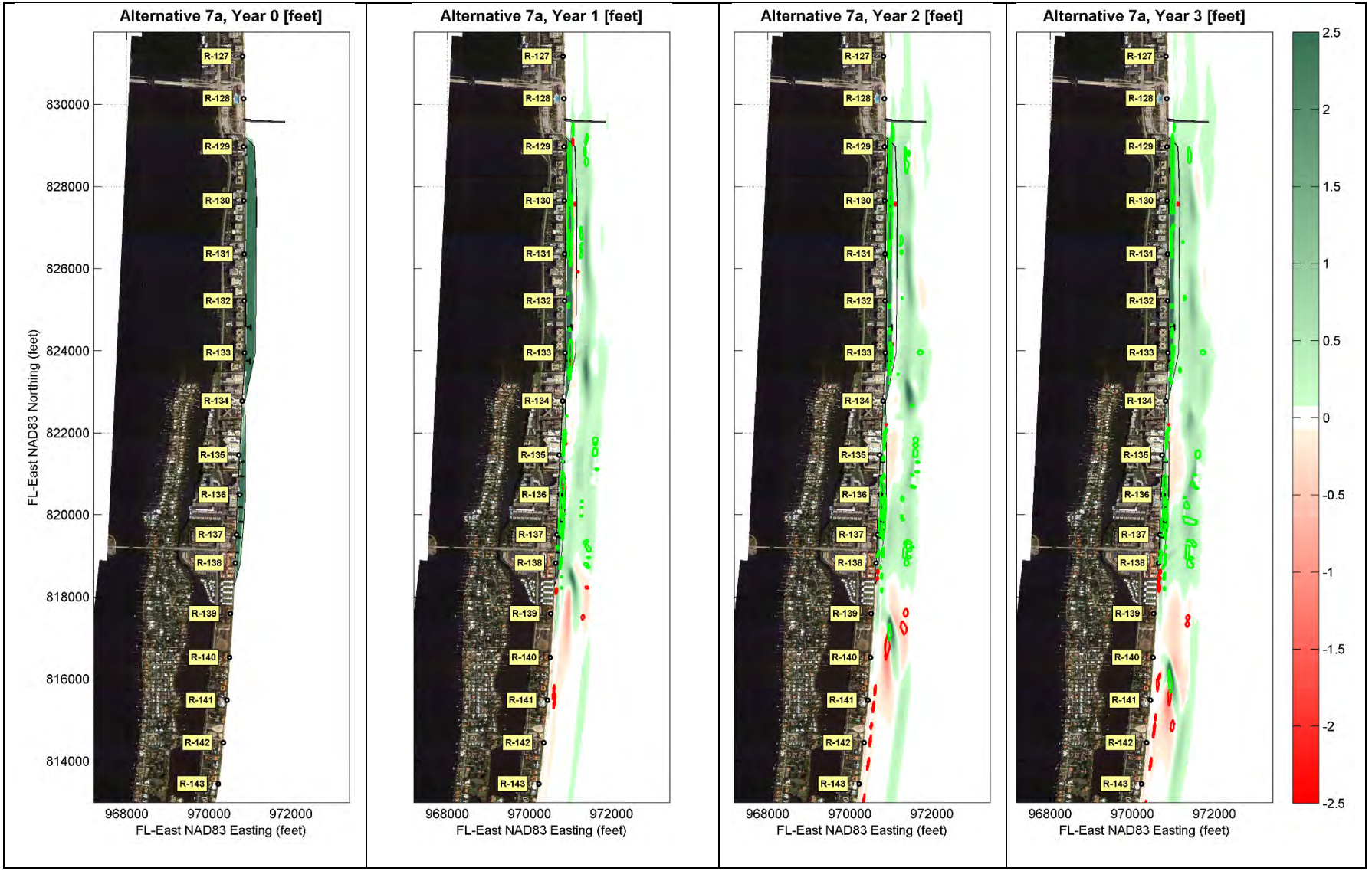

Figure 3-32. Temporal evolution of erosion (red) / sedimentation (green) for Alternative 7a, compared to No Action scenario - fill grain size 0.25 mm.

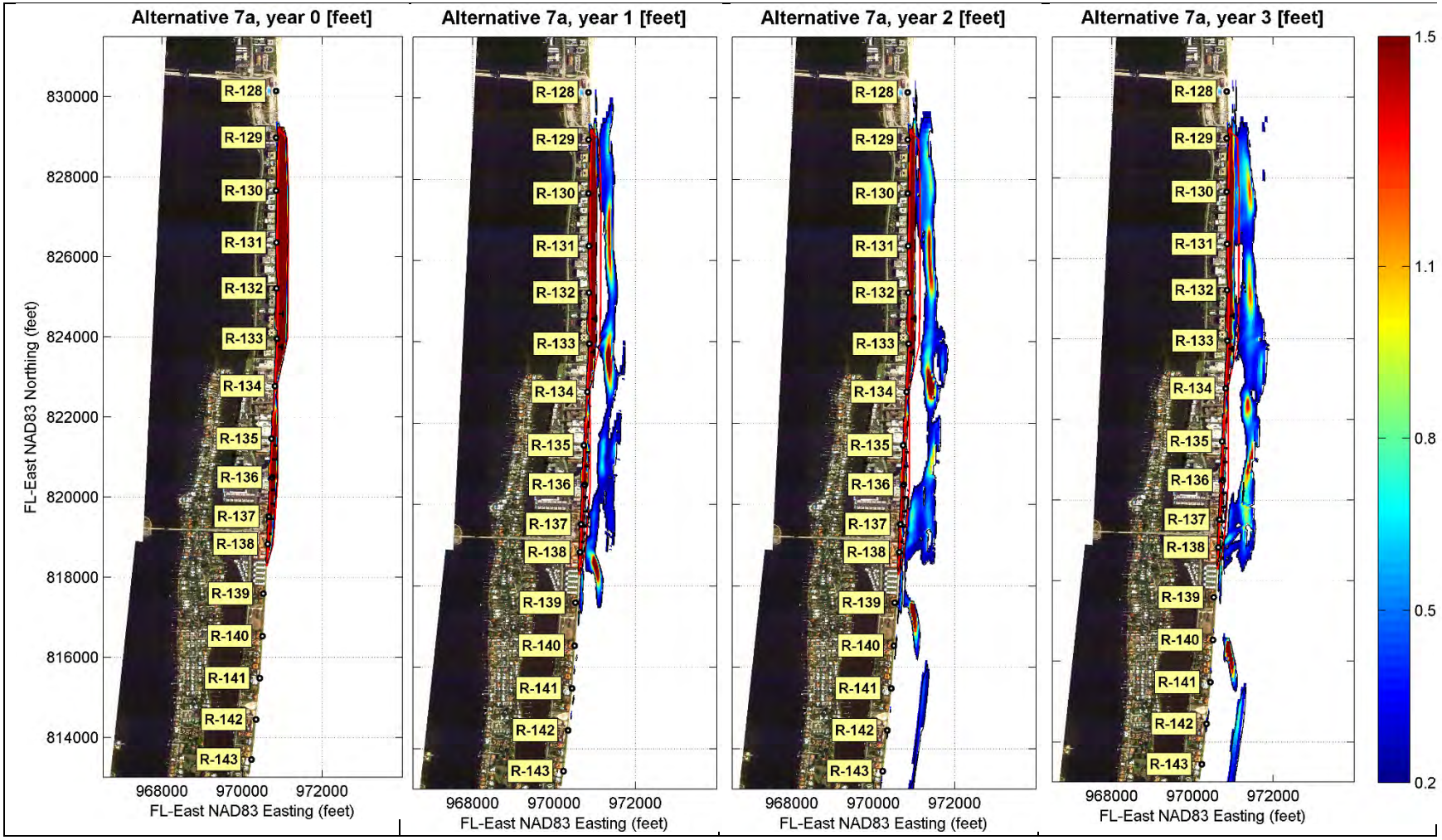

Figure 3-33. Sediment accumulation greater than 0.2 ft for Alternative 7a - fill grain size 0.25 mm.

Separated Action – Alternative 7aT (Town of Palm Beach portion of alternative)

Model results for Alternative 7aT are shown in Figure 3-34 through Figure 3-37.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-36). At the end of the 3 year simulation period, there was an estimated coverage of 8.56 acres of hardbottom and an exposure of 1.99 acres attributed to the alternative as depicted in Figure 3-36. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -6.57 acres. The net change is 1.03 acres greater (more coverage) than the net change observed for the same alternative but with a fill grain size of 0.36 mm.

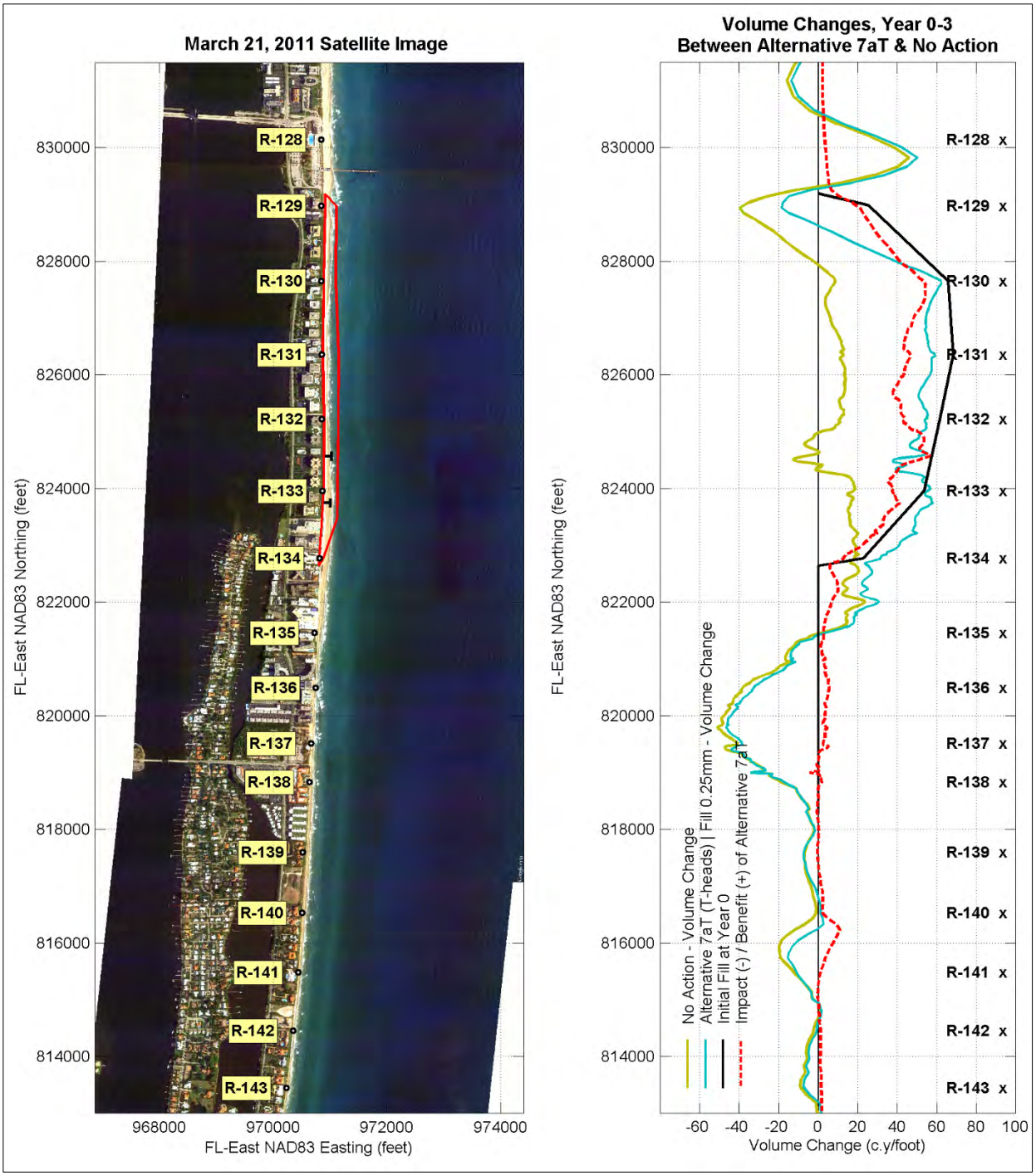

Figure 3-34. Volume vhanges, Alternative 7aT - fill grain size 0.25 mm.

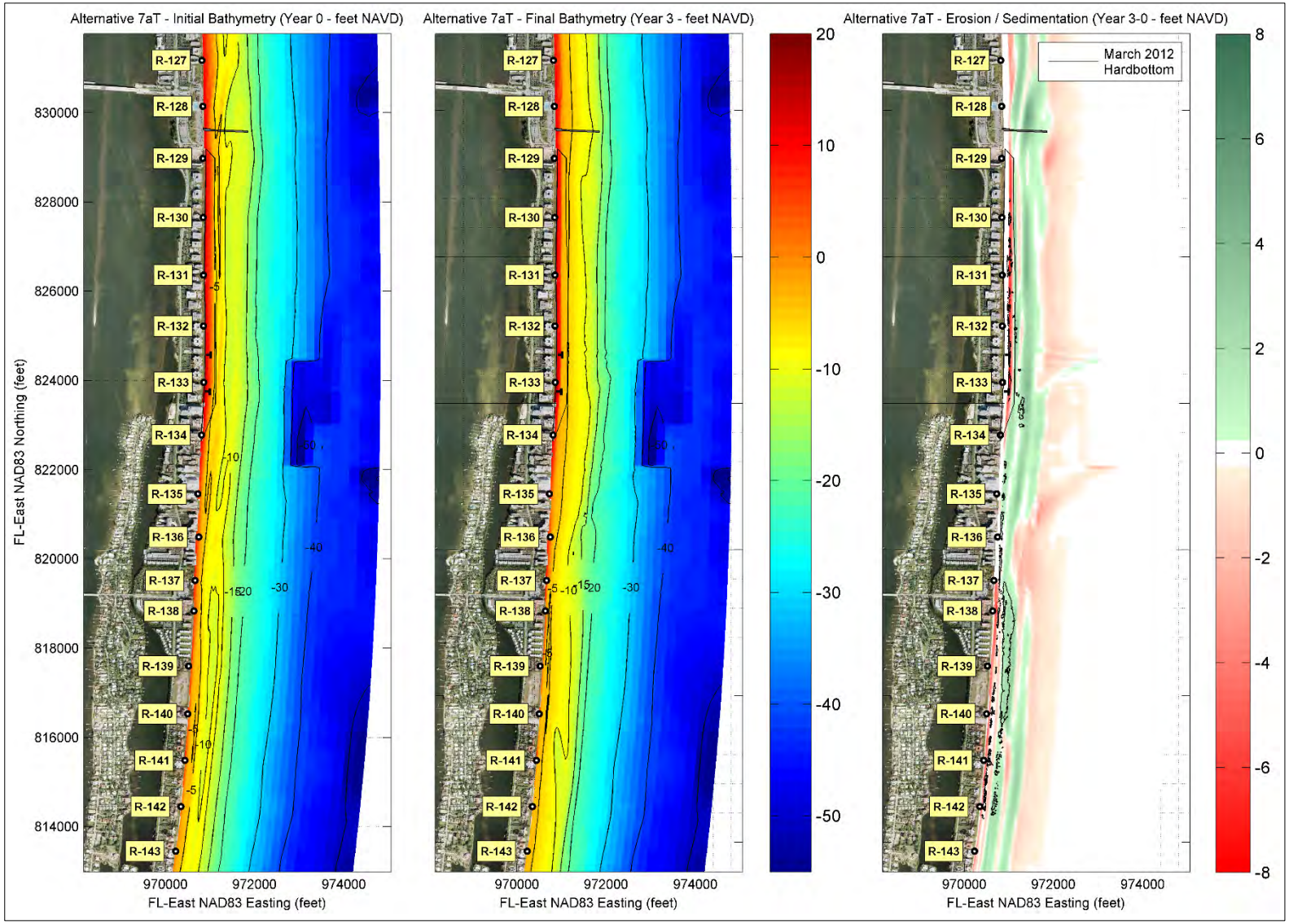

Figure 3-35. Erosion/sedimentation after 3 years of simulation, Alternative 7aT - fill grain size 0.25 mm.

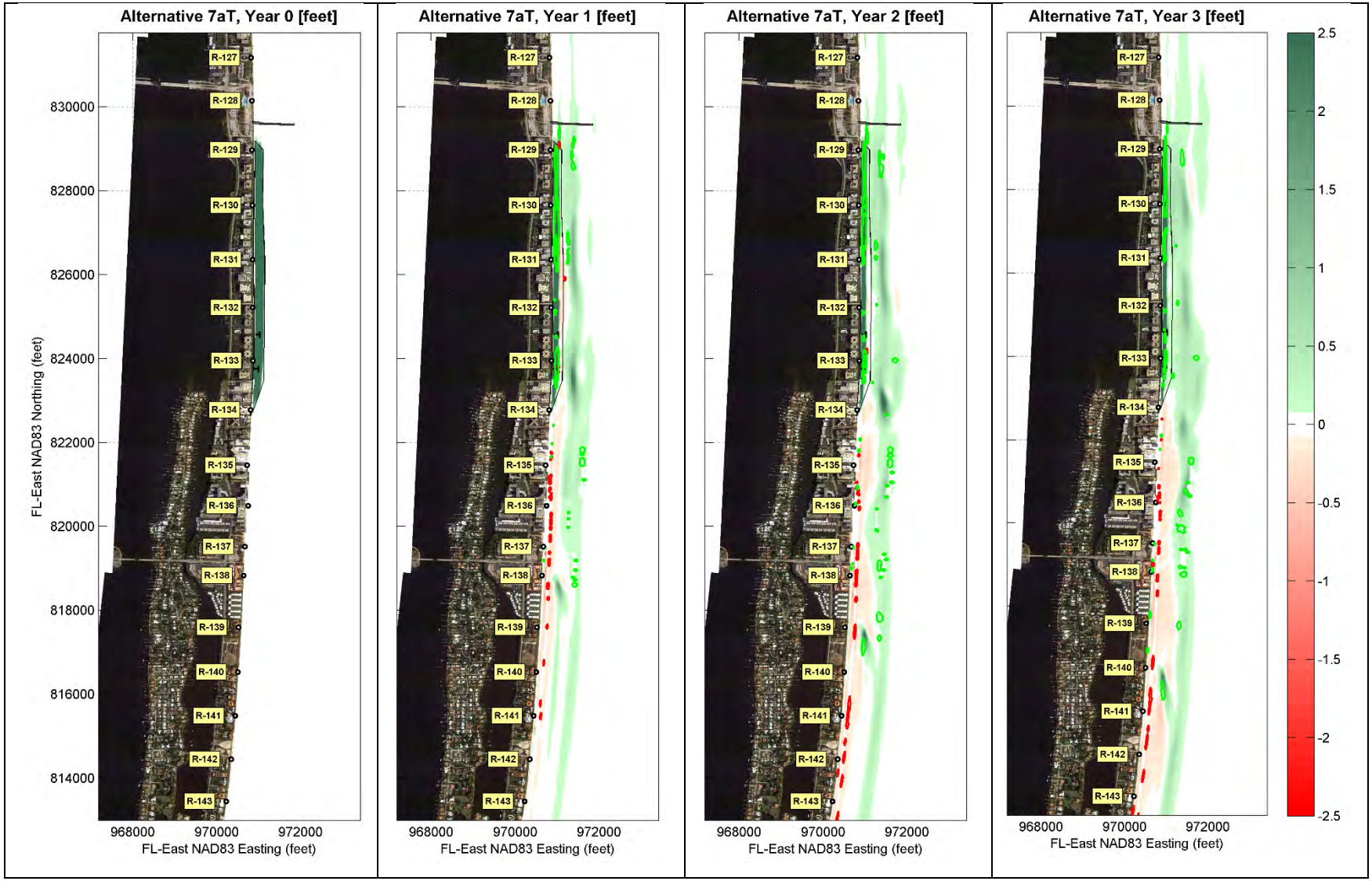

Figure 3-36. Temporal evolution of erosion (red) / sedimentation (green) for Alternative 7aT, compared to No Action scenario - fill grain size 0.25 mm.

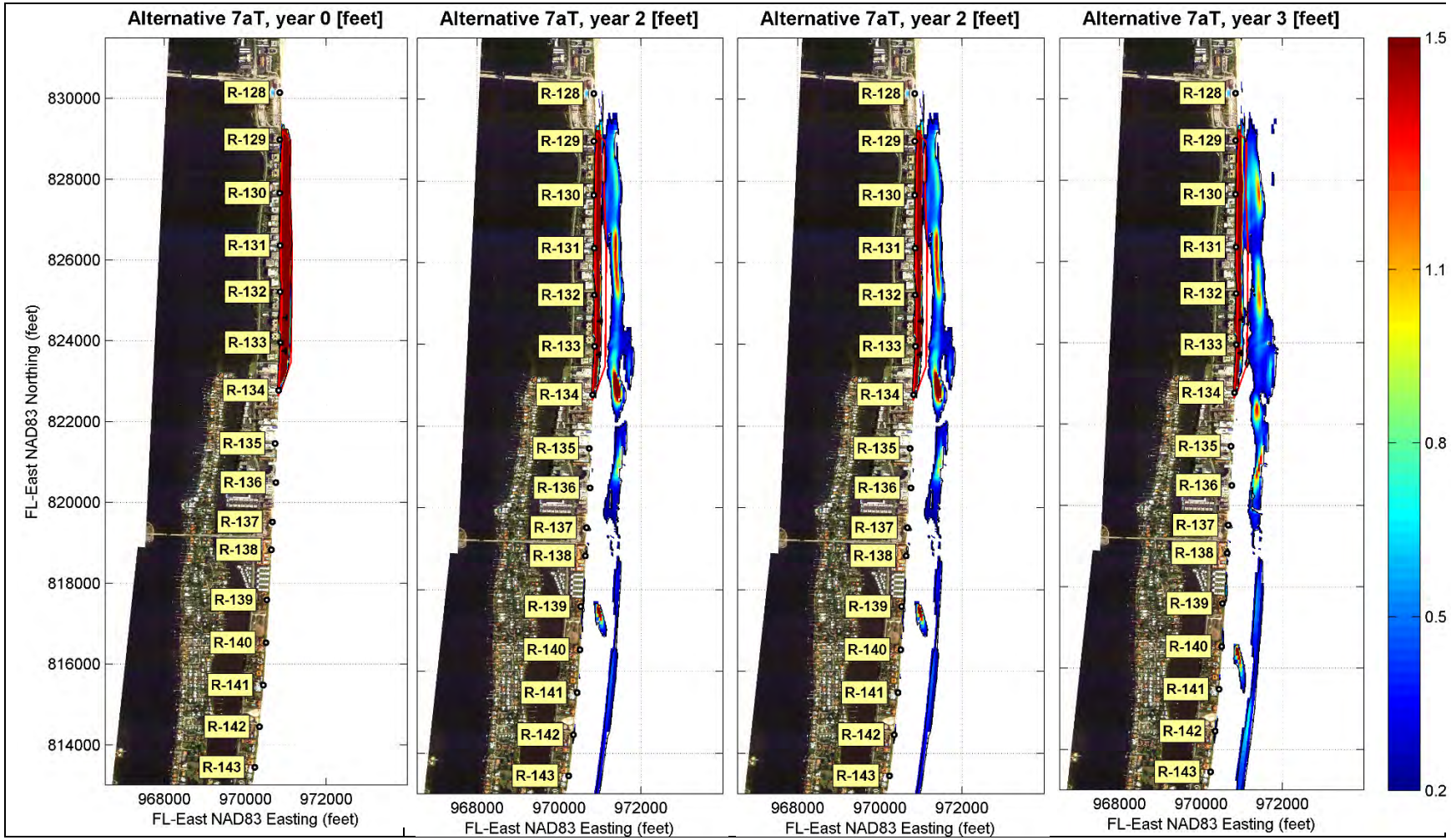

Figure 3-37. Sediment accumulation greater than 0.2 ft for Alternative 7aT - fill grain size 0.25 mm.

3.1.7. Alternative 7b – The Town of Palm Beach Increased Sand Volume with Two Shoreline Protection Structures (The Coalition to Save Our Shoreline, Inc. (SOS) Alternative) and the County Preferred Project

Combined Action

Model results given in Alternative 7b simulated with fill sediment grain size of 0.25 mm in the Town of Palm Beach's portion of the template appear in Figure 3-38 through Figure 3-41.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-40). At the end of the 3 year simulation period, there was an estimated coverage of 12.93 acres of hardbottom and an exposure of 2.08 acres attributed to the alternative as depicted in Figure 3-40. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -10.85 acres. The net change is 0.27 acres less (less coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

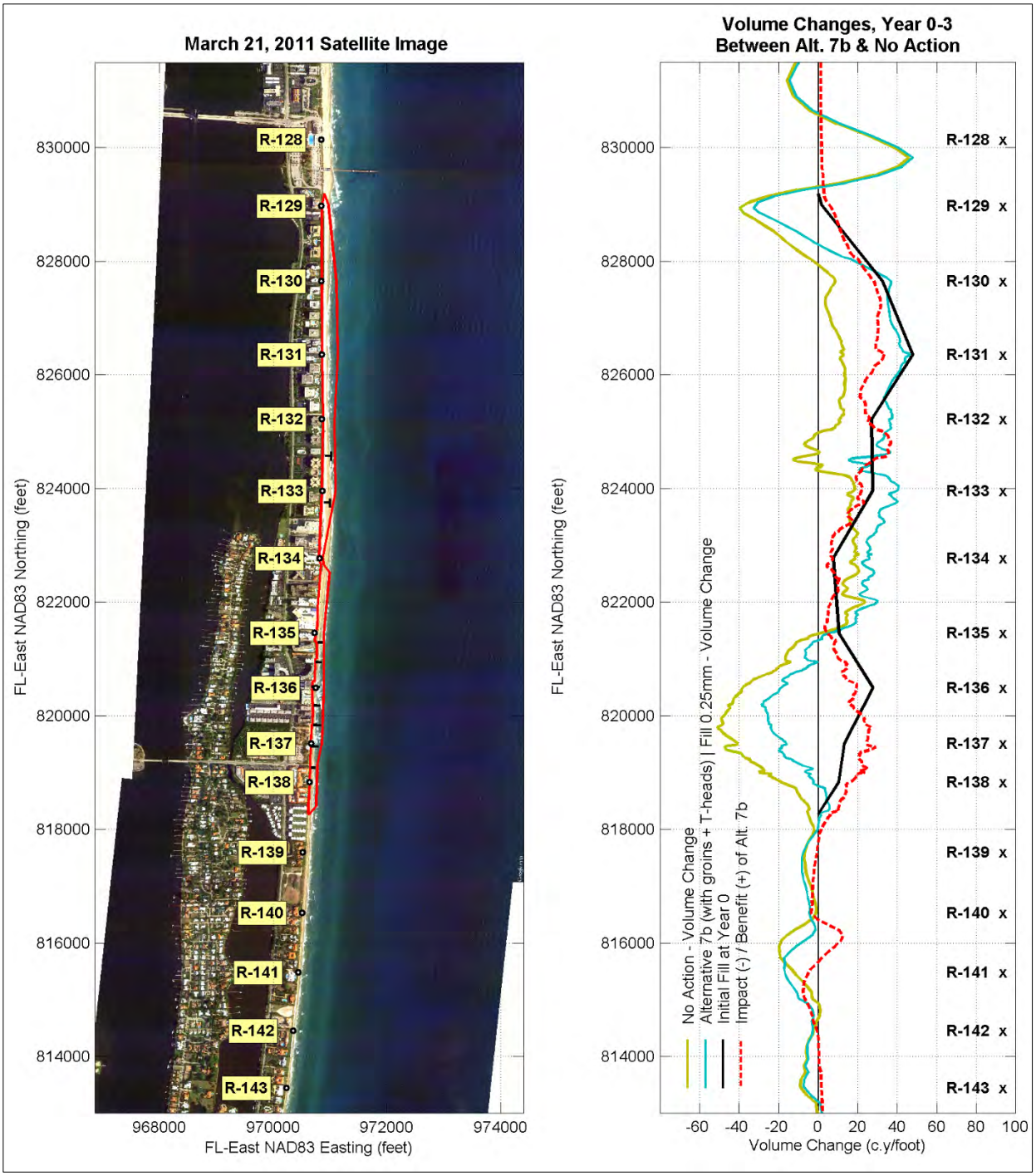

Figure 3-38. Volume changes for Alternative 7b – fill grain size 0.25 mm.

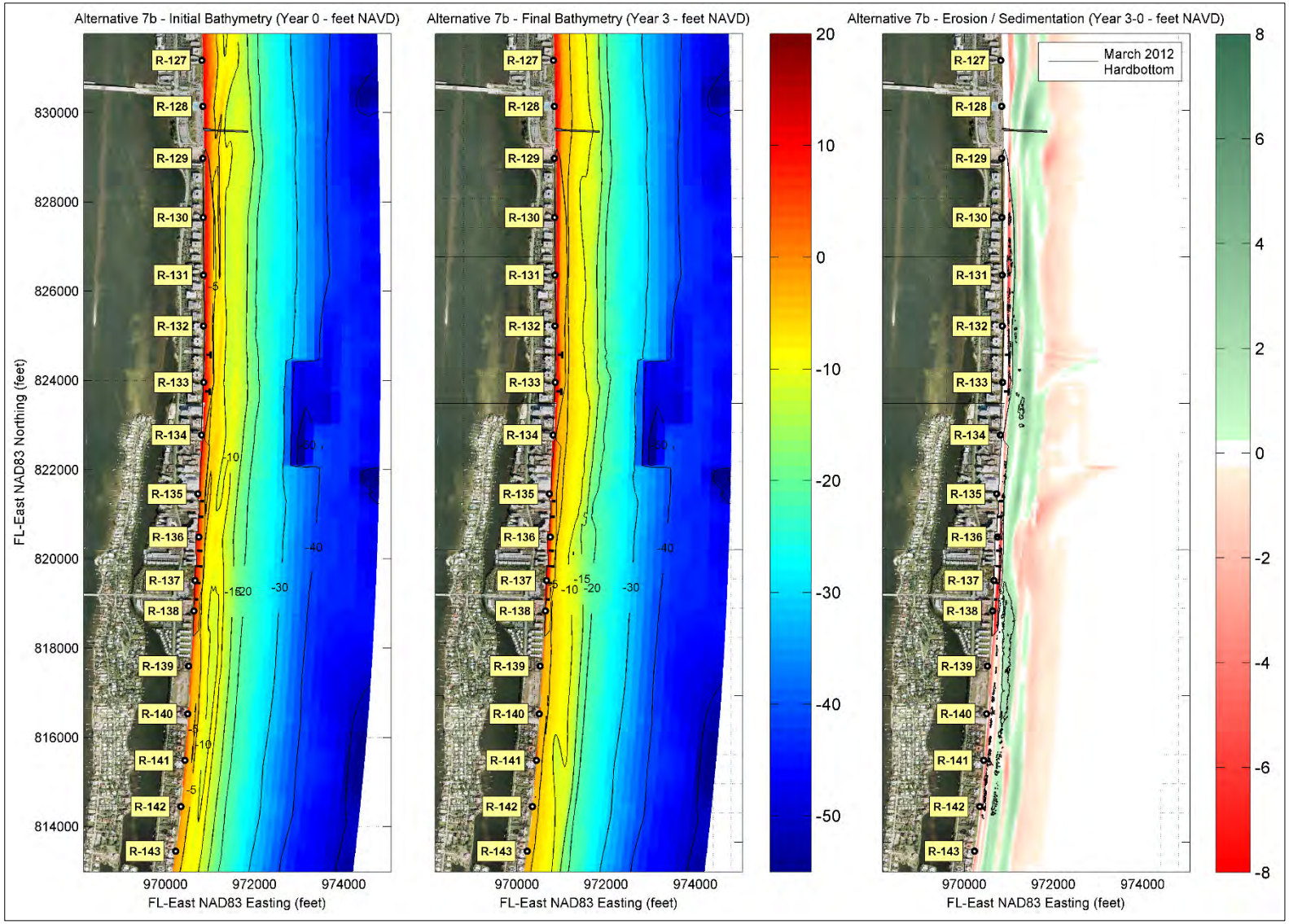

Figure 3-39. Erosion/Sedimentation after 3 years of simulation, Alternative 7b - Fill grain size 0.25 mm.

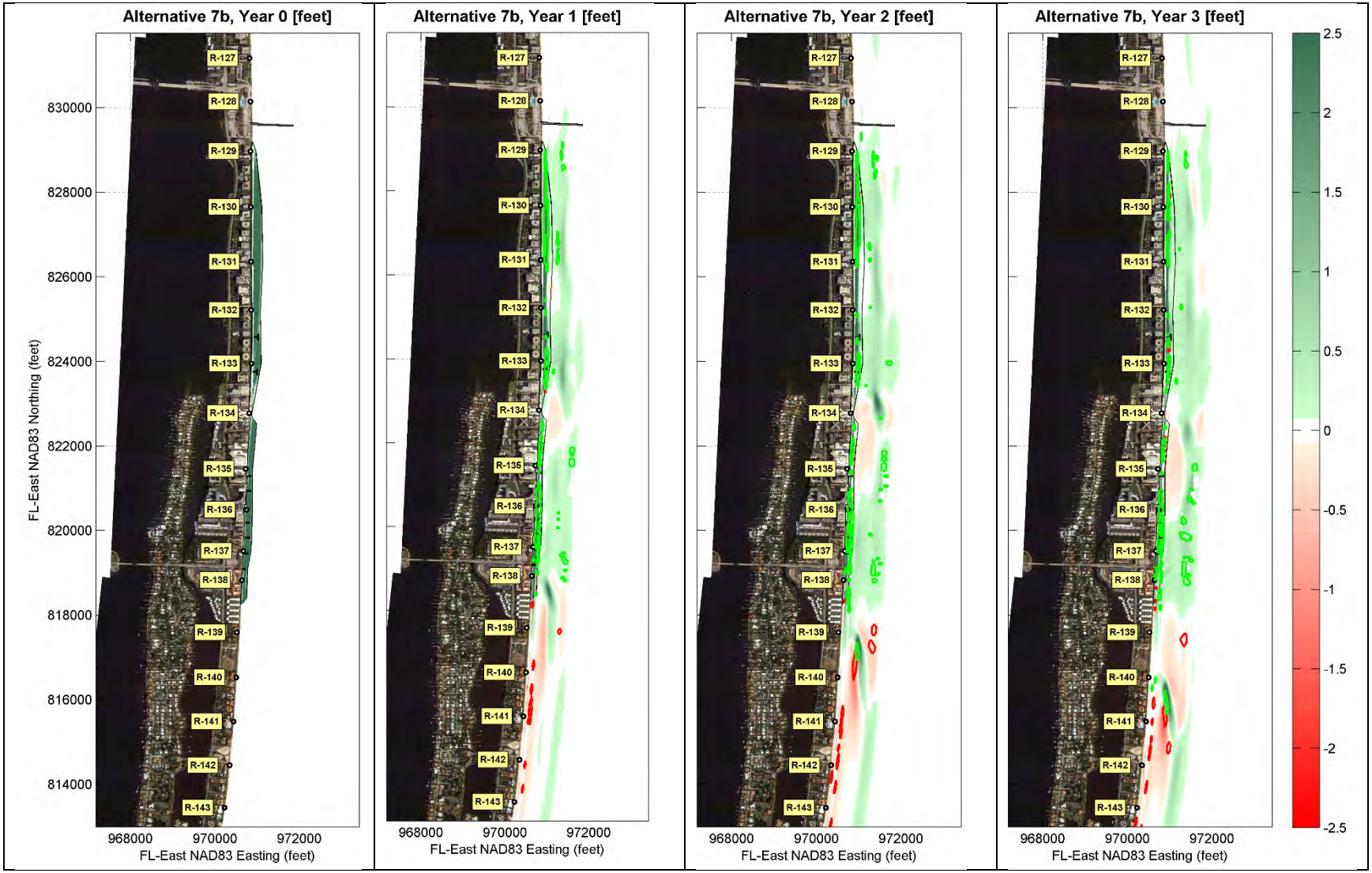

Figure 3-40. Temporal evolution of beach nourishment for Alternative 7b, compared to No Action scenario - fill grain size 0.25 mm.

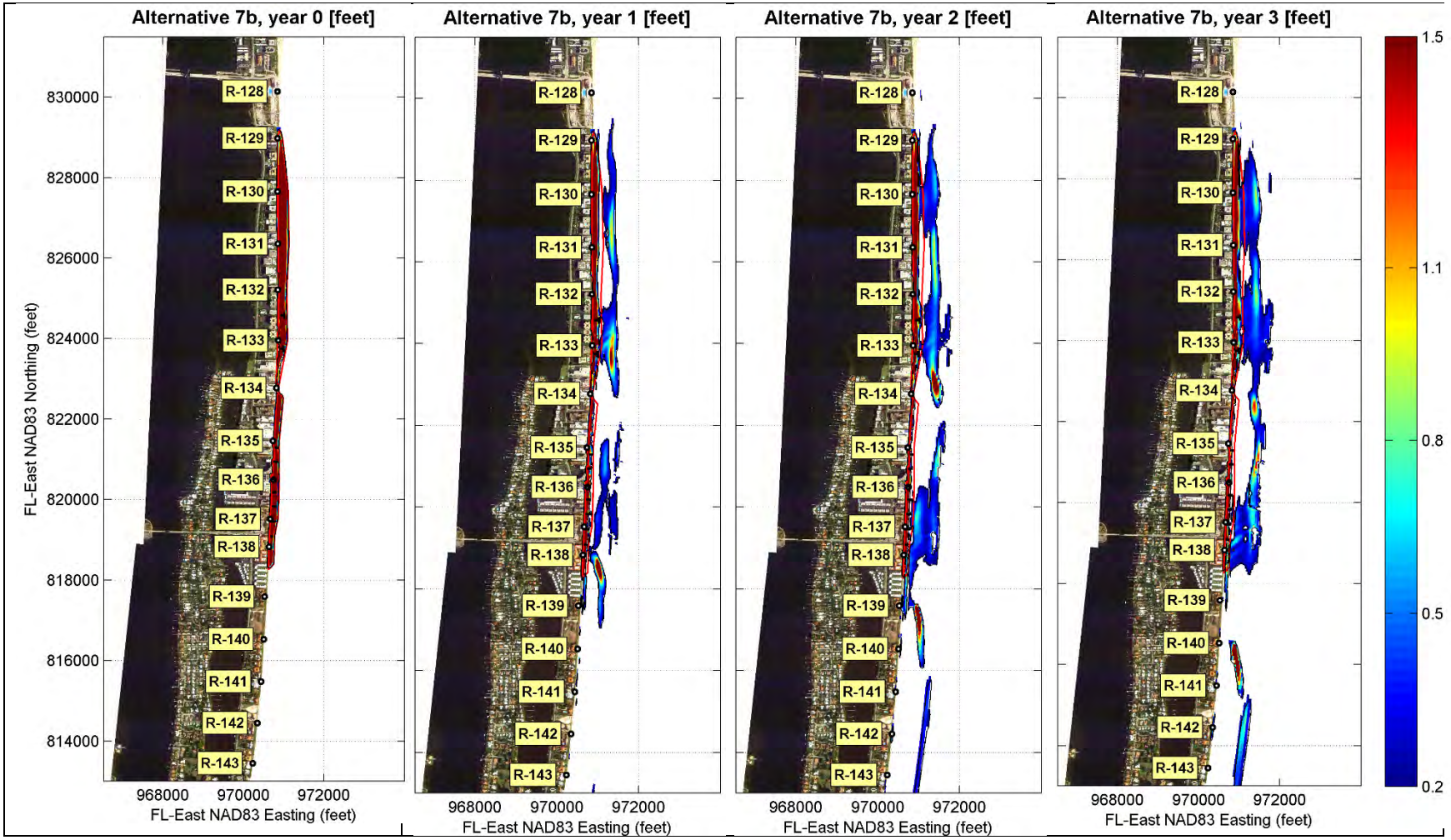

Figure 3-41. Sediment accumulation greater than 0.2 ft for Alternative 7b - fill grain size 0.25 mm.

Separated Action – Alternative 7bT (Town of Palm Beach portion of alternative)

Model results for Alternative 7bT simulated with fill sediment grain size of 0.25 mm in the Town of Palm Beach's portion of the template appear in Figure 3-42 through Figure 3-45.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-44). At the end of the 3 year simulation period, there was an estimated coverage of 5.70 acres of hardbottom and an exposure of 1.37 acres attributed to the alternative as depicted in Figure 3-44. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -4.32 acres. The net change is 0.23 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

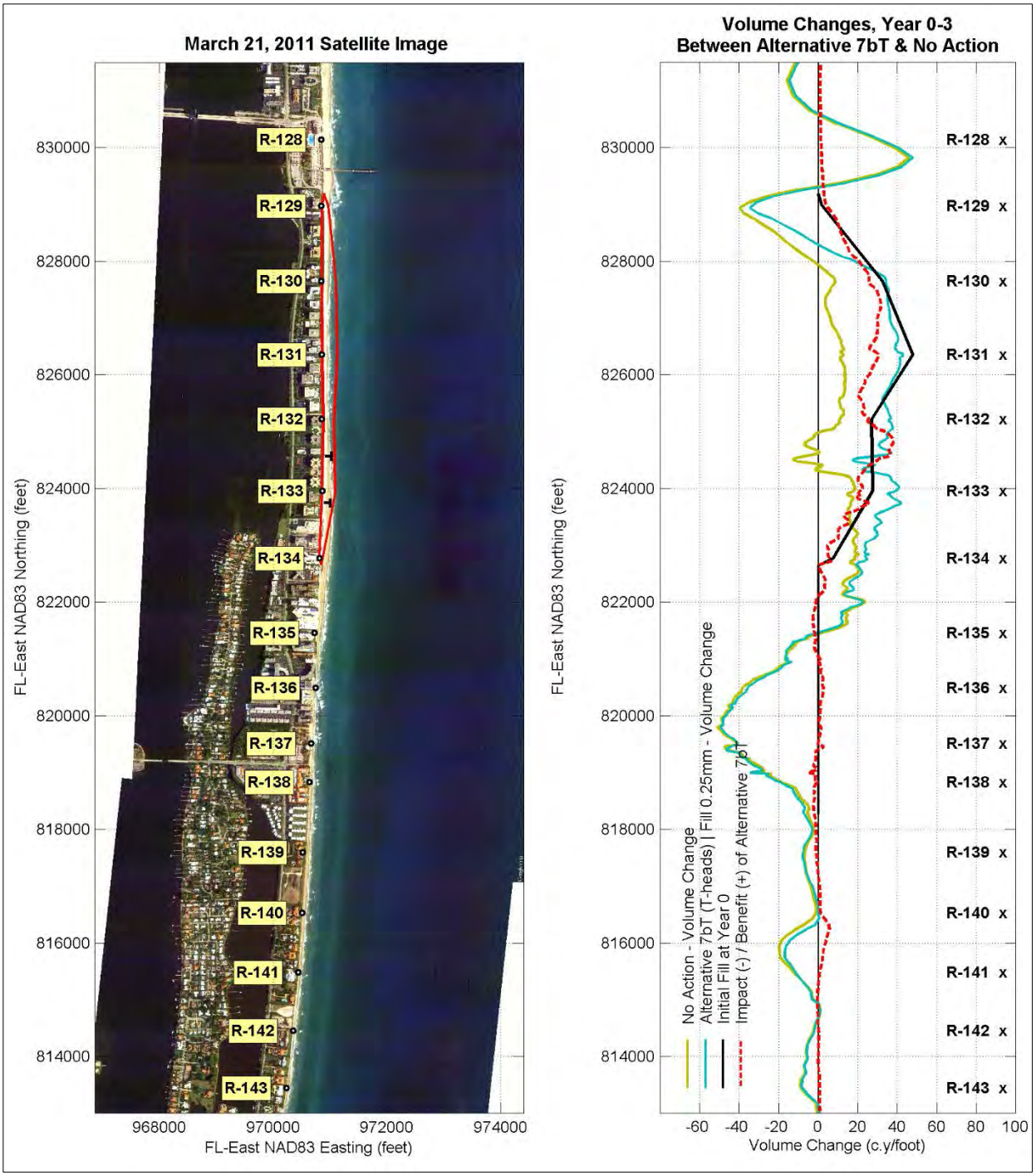

Figure 3-42. Volume changes for Alternative 7bT – fill grain size 0.25 mm.

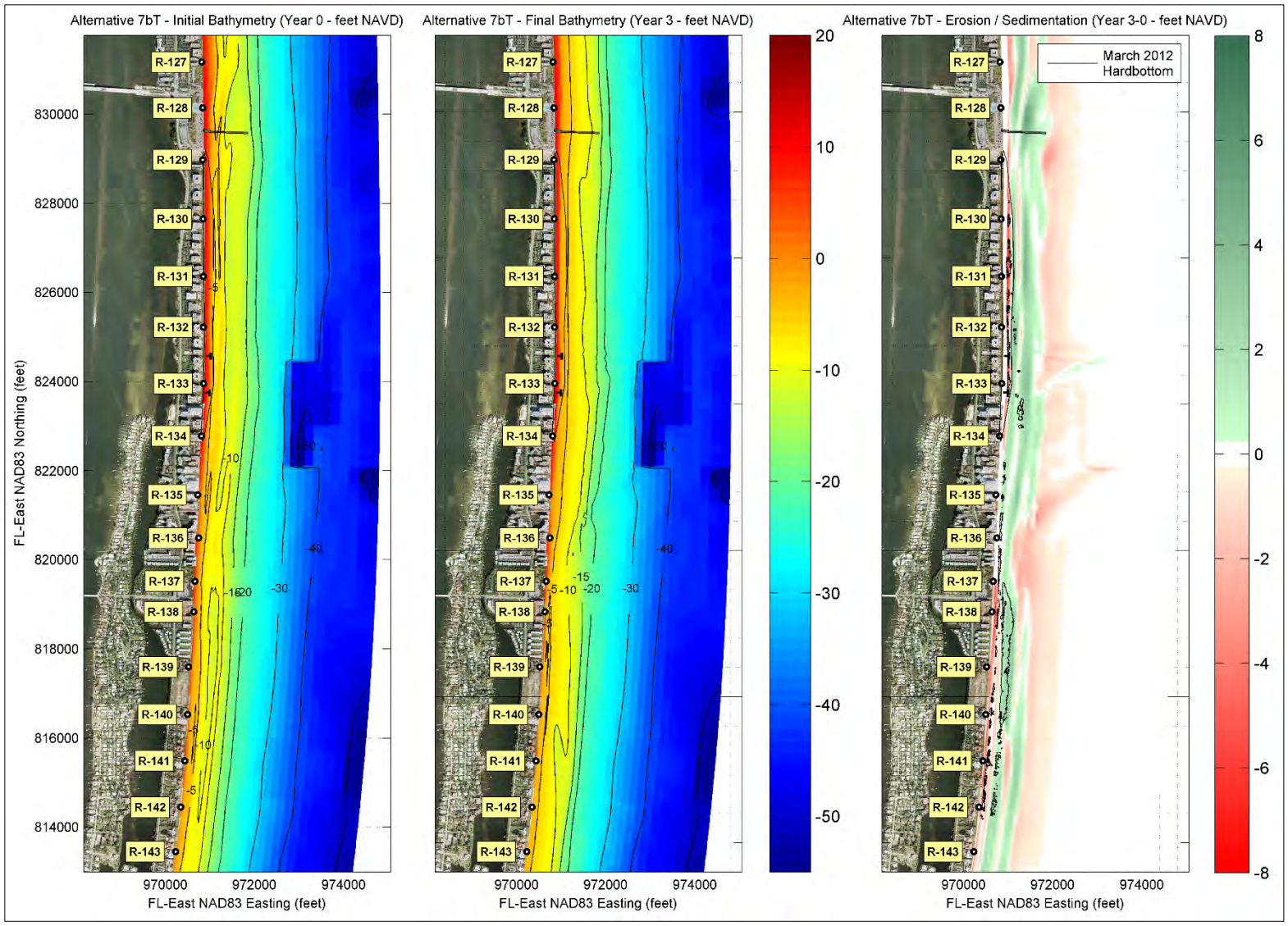

Figure 3-43. Erosion/Sedimentation after 3 years of simulation, Alternative 7bT - Fill grain size 0.25 mm.

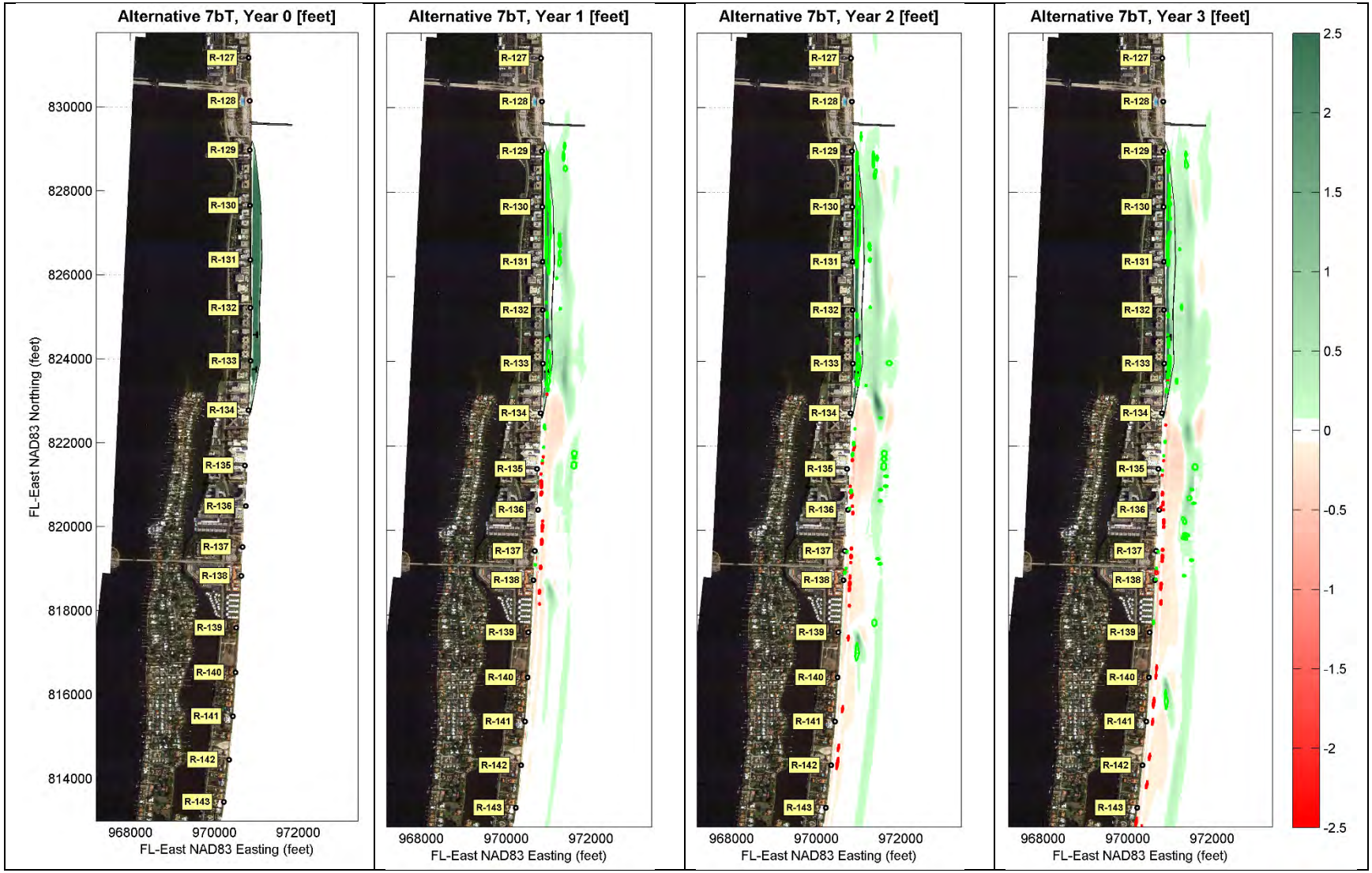

Figure 3-44. Temporal evolution of beach nourishment for Alternative 7bT, compared to No Action scenario - Fill grain size 0.25 mm.

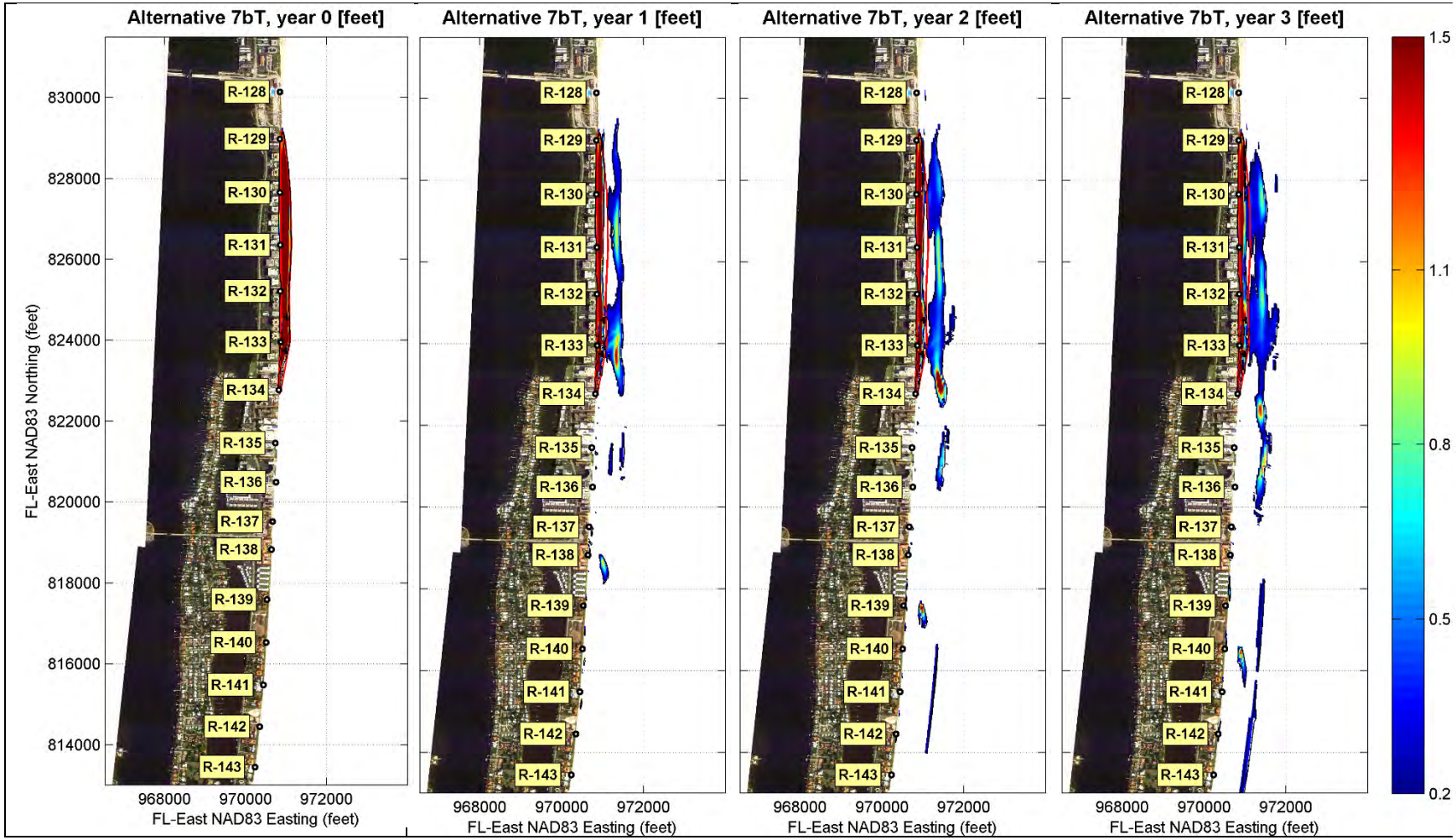

Figure 3-45. Sediment Accumulation greater than 0.2 ft for Alternative 7bT - Fill grain size 0.25 mm.

3.2. SEDIMENT GRAIN SIZE 0.60 mm

Results of the alternatives simulated with fill grain size 0.60 mm in the Town of Palm Beach's portion of the template are presented in this section. Figure 3-46 shows the annual rate of sediment transport of each alternative simulated in this additional scenarios simulation.

When compared to the fill grain size of 0.36 mm, the simulations with fill grain size of 0.60 mm suggests that coarser sediment grain has less potential to be transported and the fill remains nearby the template placed at the beach. As a consequence of the decrease in the sediment transport, more erosion is observed downdrift of the project area.

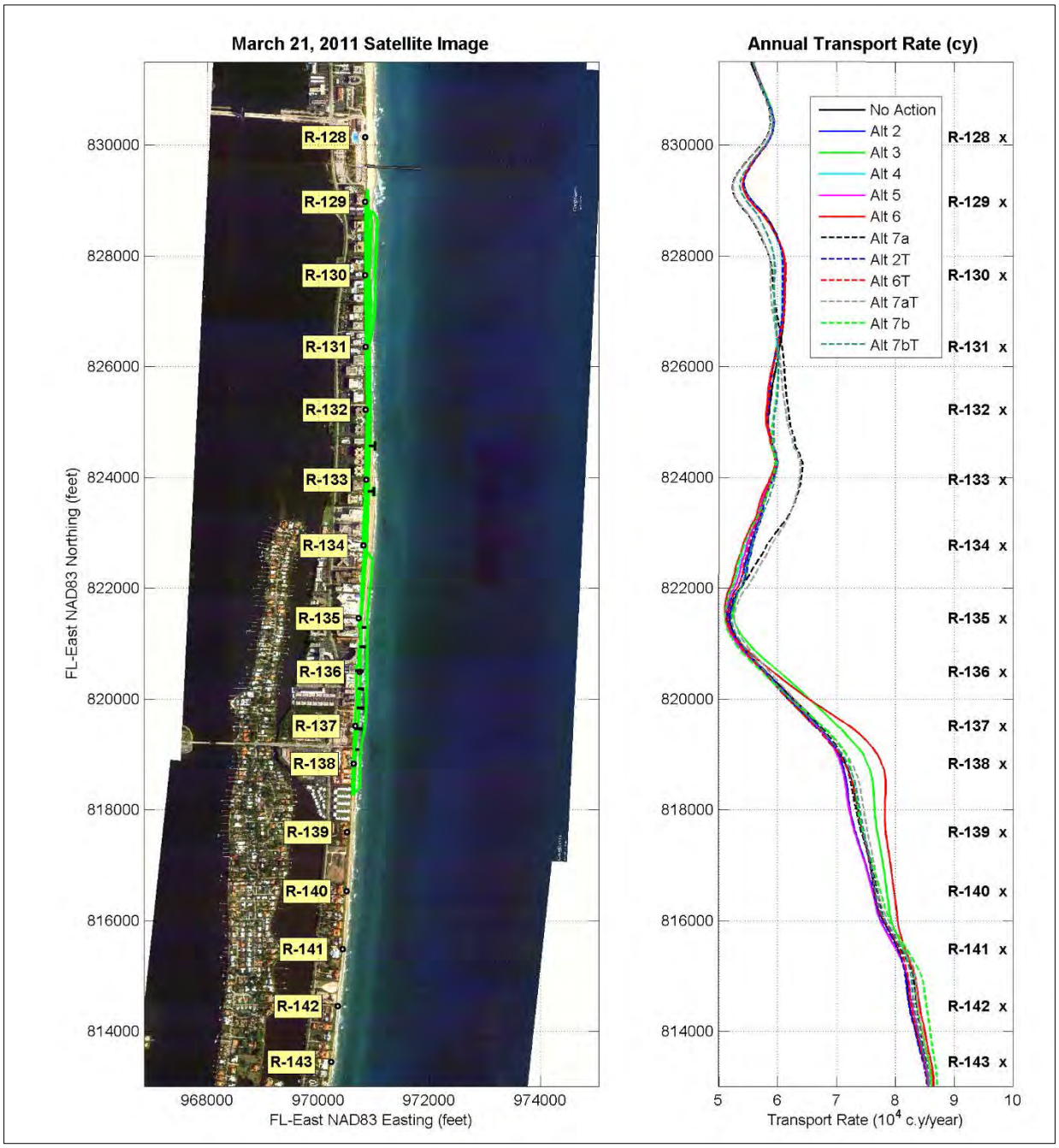

Figure 3-46. Annual Transport Rate (c.y.) for the Alternatives Simulated with Fill Grain Size of 0.60 mm.

3.2.1. Alternative 2 - The Applicants' Preferred Alternative (Proposed Action): Beach and Dune Fill with Shoreline Protection Structures Project

Combined Action

Model results for Alternative 2 simulated with fill grain size of 0.60 mm in Town of Palm Beach's portion of the template are shown in Figure 3-47 through Figure 3-50.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-49). At the end of 3 years, there was an estimated coverage of 9.15 acres of hardbottom and an exposure of 3.59 acres attributed to the alternative. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -5.55 acres. The net change is 0.77 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

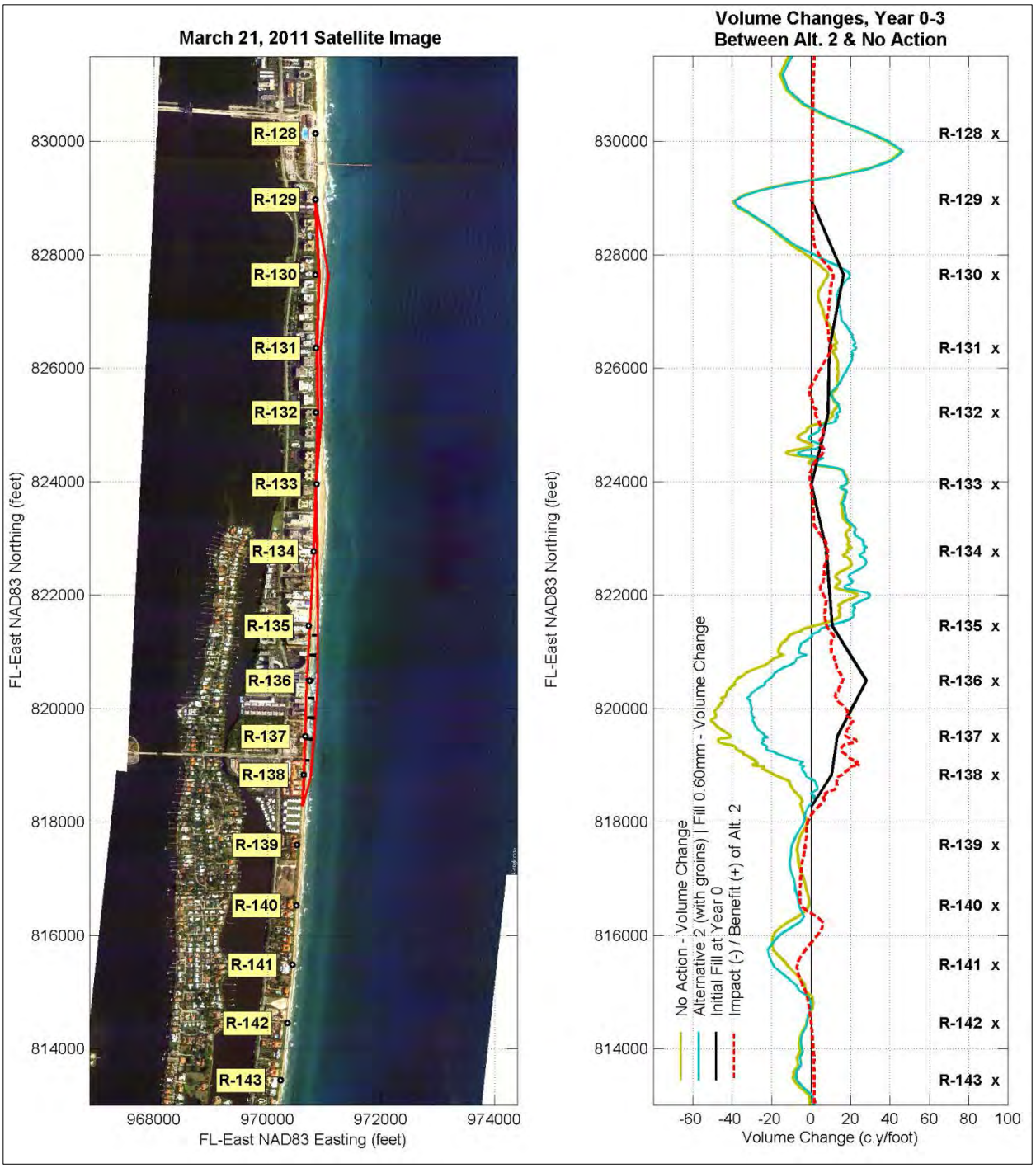

Figure 3-47. Volume changes for Alternative 2 – fill grain size 0.60 mm.

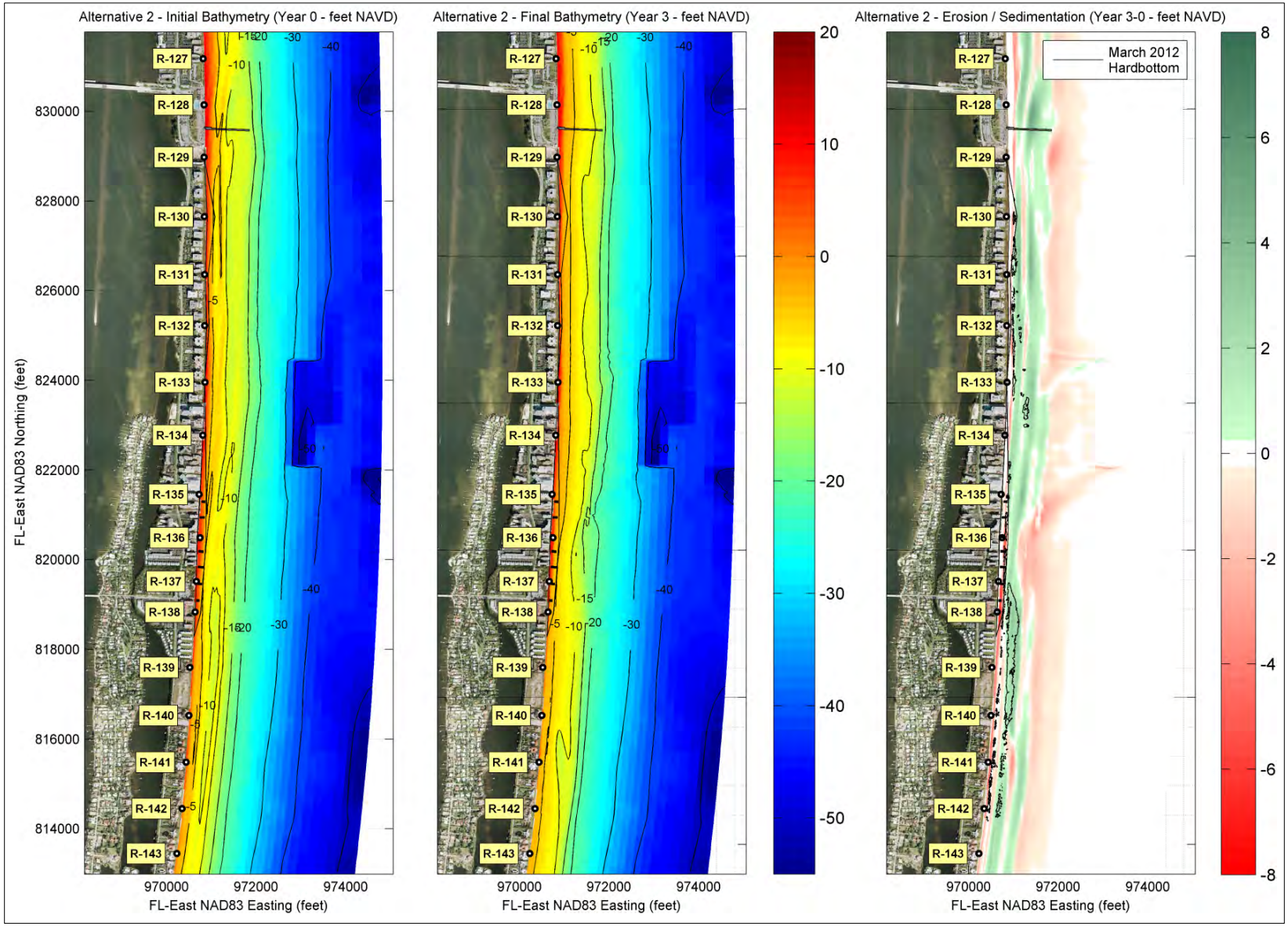

Figure 3-48. Erosion/sedimentation after 3 years of simulation, Alternative 2 - fill grain size 0.60 mm.

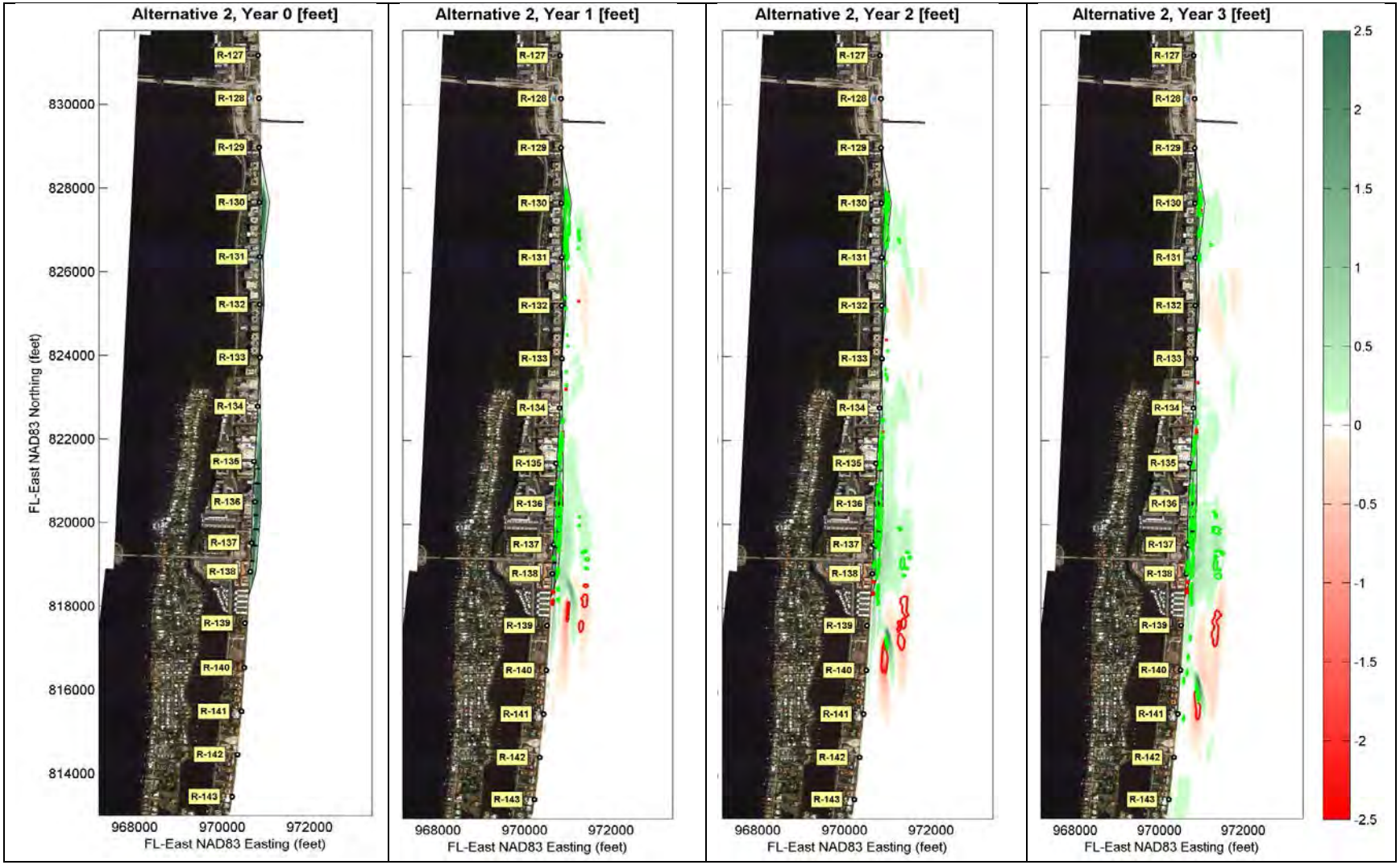

Figure 3-49. Temporal evolution of beach nourishment for Alternative 2, compared to No Action scenario - fill grain size 0.60mm.

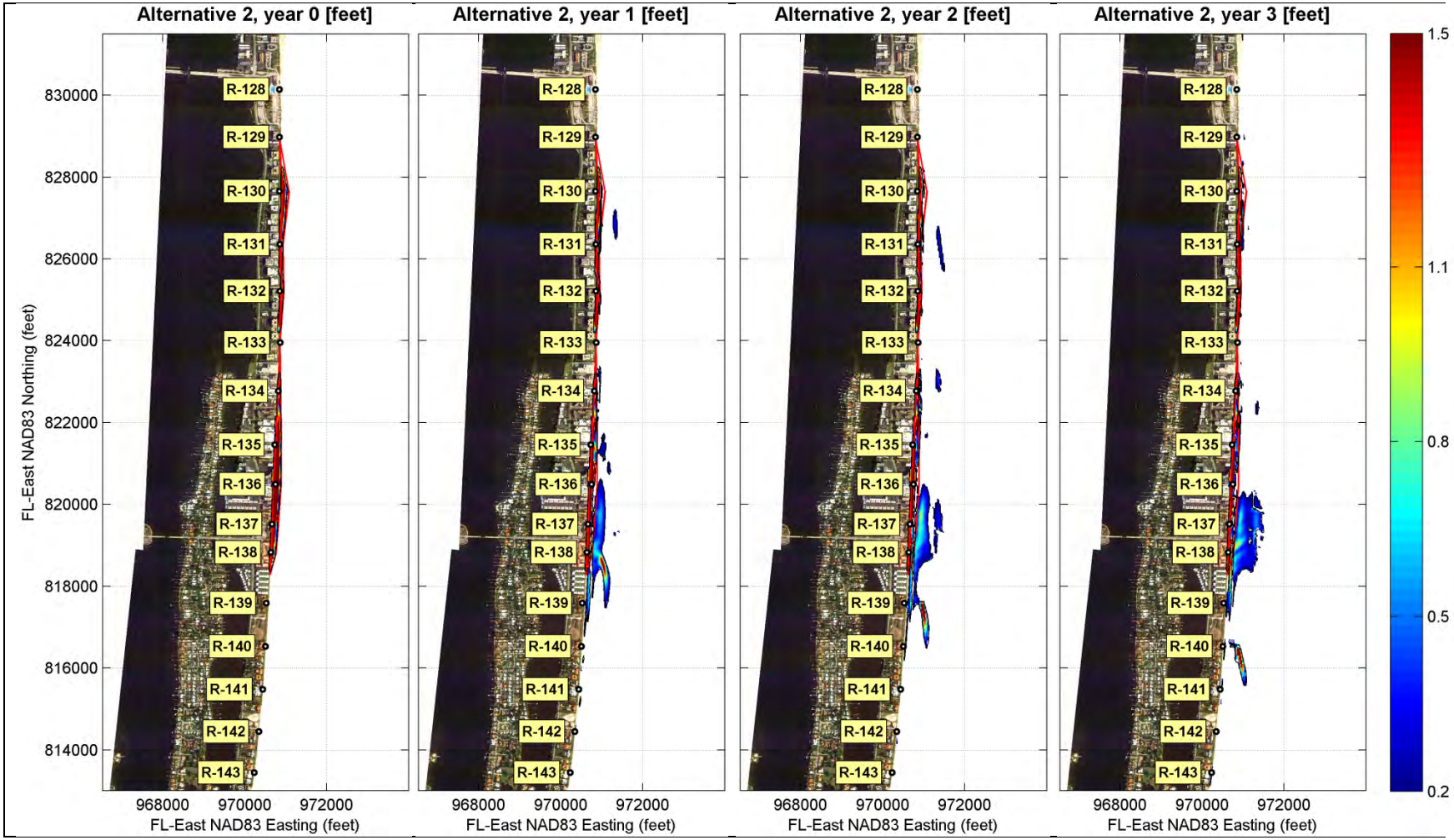

Figure 3-50. Sediment accumulation greater than 0.2 ft for Alternative 2 - fill grain size 0.60 mm.

Separated Action – Alternative 2T (Town of Palm Beach portion of alternative)

Model results for Alternative 2T with fill grain size of 0.60 mm in the Town of Palm Beach's portion of the template are shown in Figure 3-51 through Figure 3-54.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-53). At the end of the 3 year simulation period, there was an estimated coverage of 1.63 acres of hardbottom and an exposure of 0.42 acres attributed to the alternative. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -1.22 acres. The net change is 0.18 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

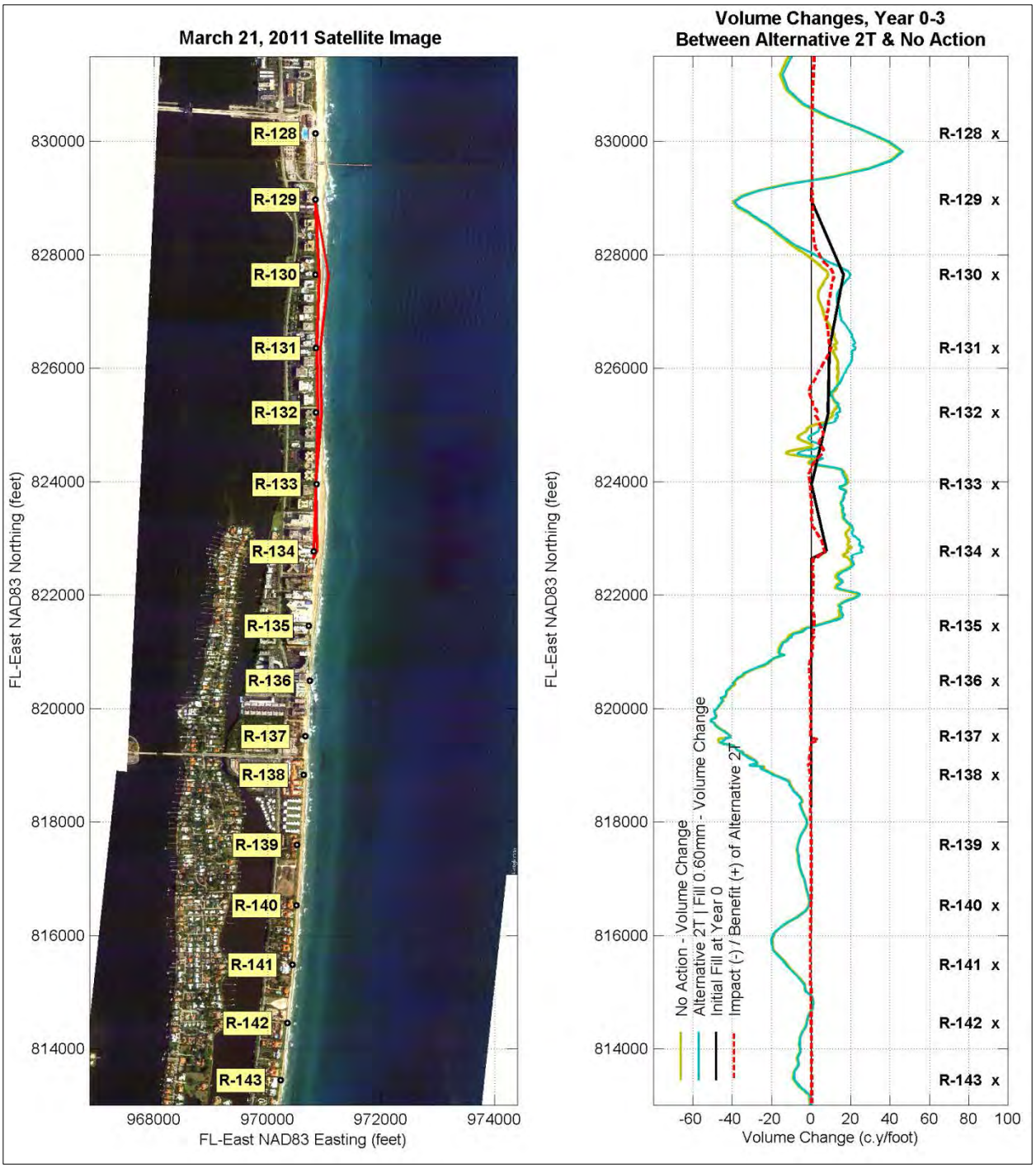

Figure 3-51. Volume changes for Alternative 2T – fill grain size 0.60 mm.

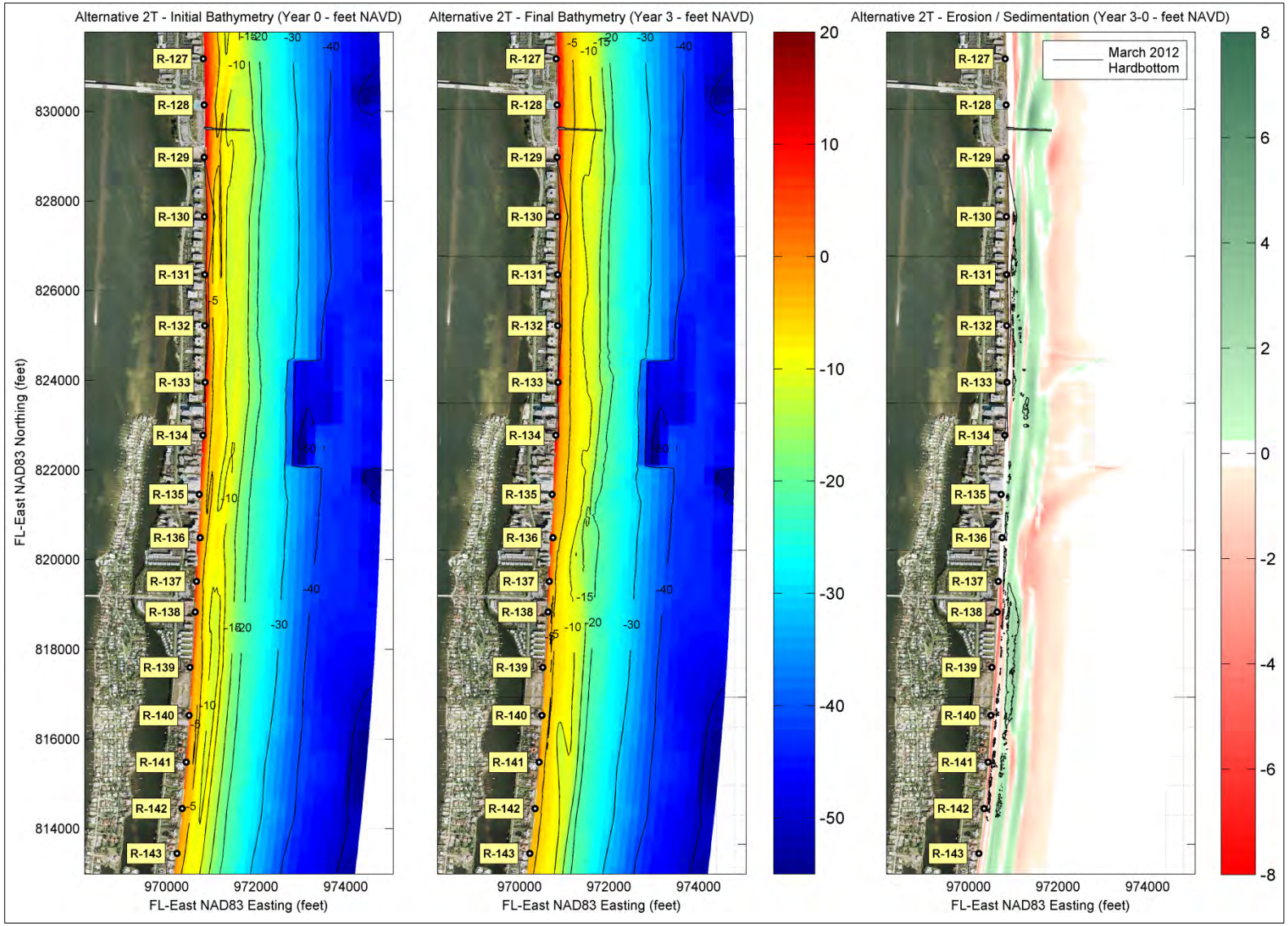

Figure 3-52. Erosion/sedimentation after 3 years of simulation, Alternative 2T - fill grain size 0.60 mm.

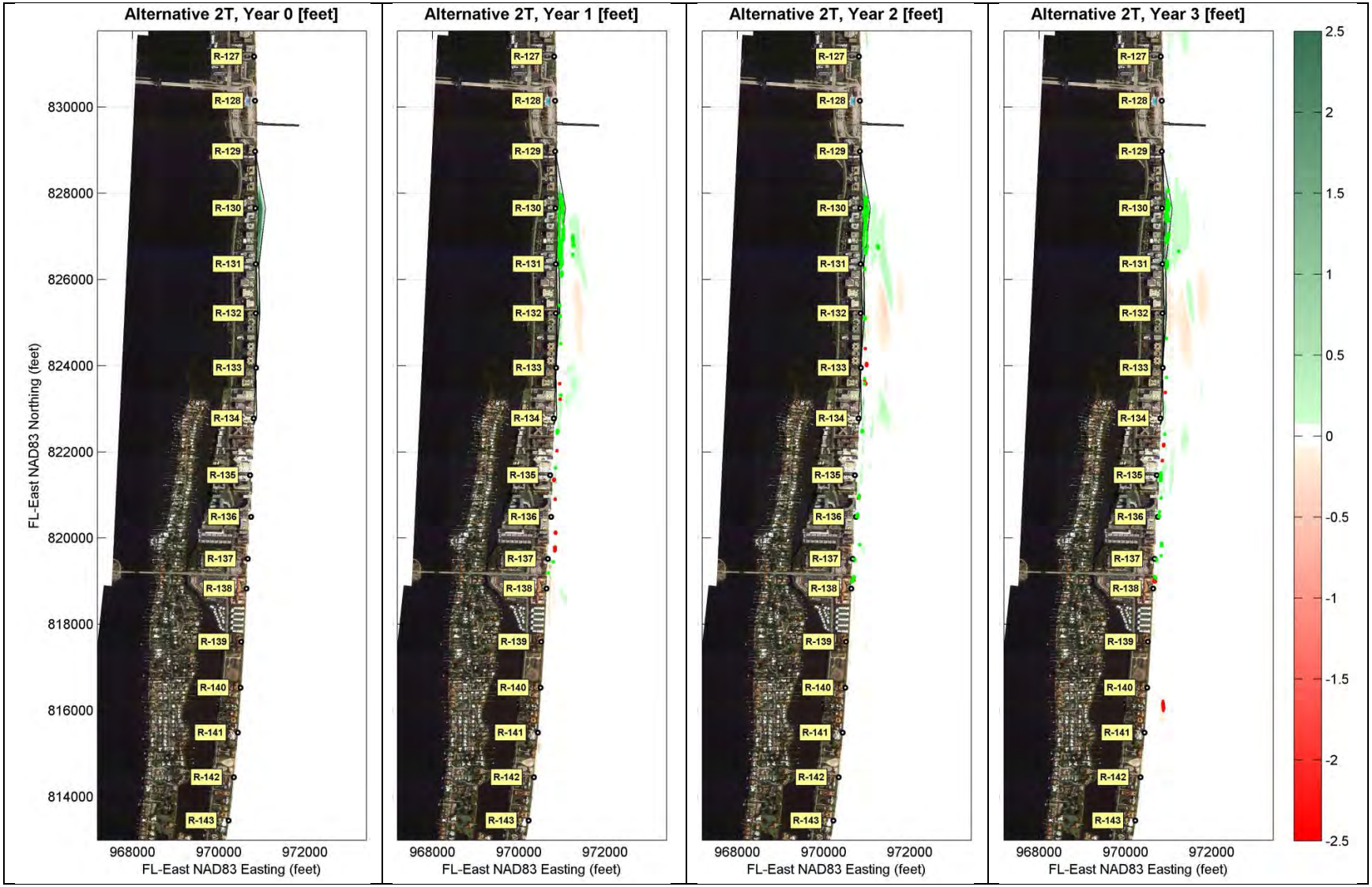

Figure 3-53. Temporal evolution of beach nourishment for Alternative 2T, compared to No Action scenario - fill grain size 0.60 mm.

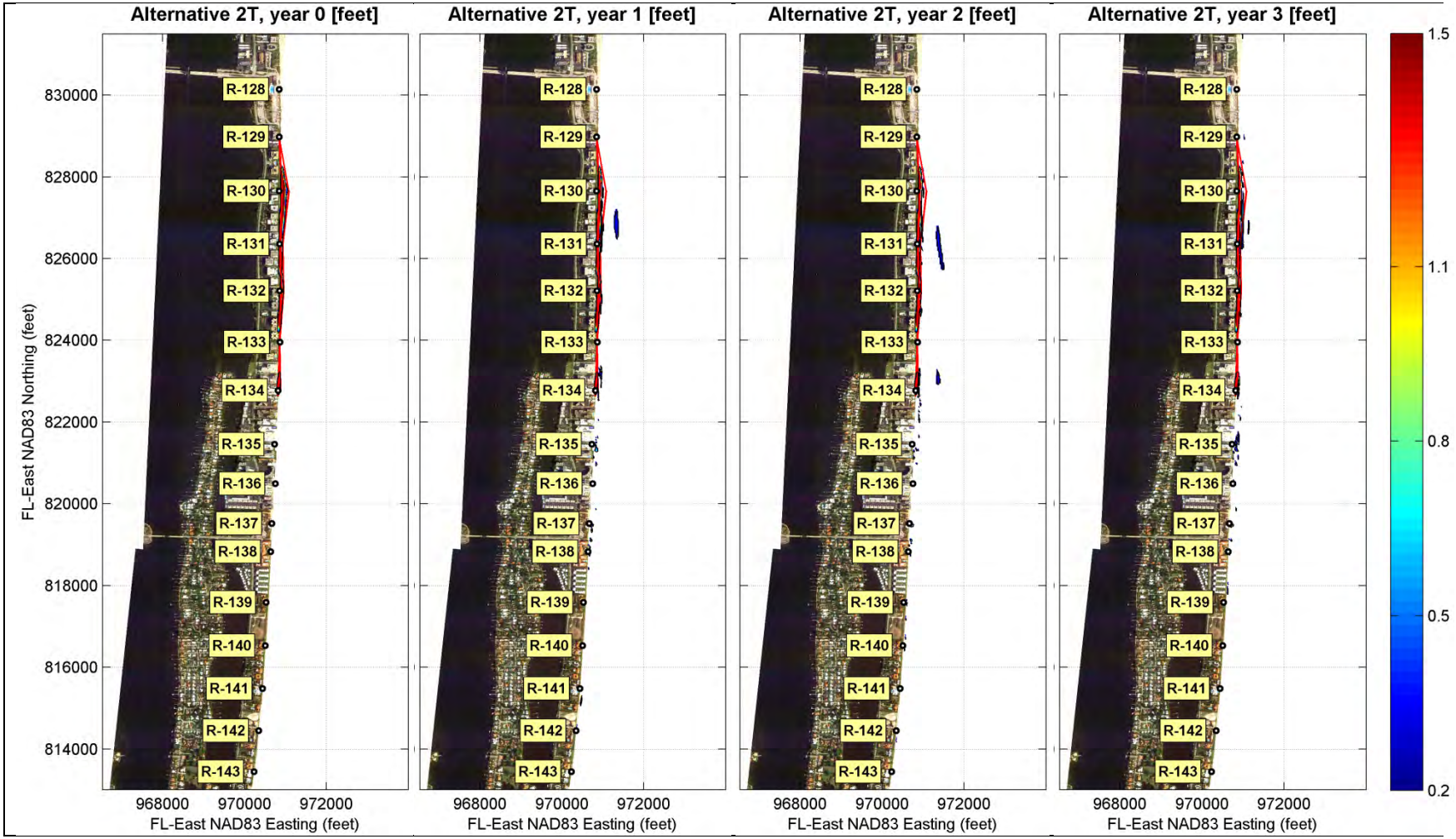

Figure 3-54. Sediment accumulation greater than 0.2 ft for Alternative 2T - fill grain size 0.60 mm.

3.2.2. Alternative 3 - The Applicants' Preferred Project without Shoreline Protection Structures

Alternative 3 features the same fill layout as Alternative 2, however groins were not included. Model results given in Alternative 3 appear in Figure 3-55 through Figure 3-58.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-57). At the end of the 3 year simulation period, there was an estimated coverage of 8.42 acres of hardbottom and an exposure of 0.84 acres attributed to the alternative as depicted in Figure 3-57. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -7.58 acres. The net change is 0.29 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

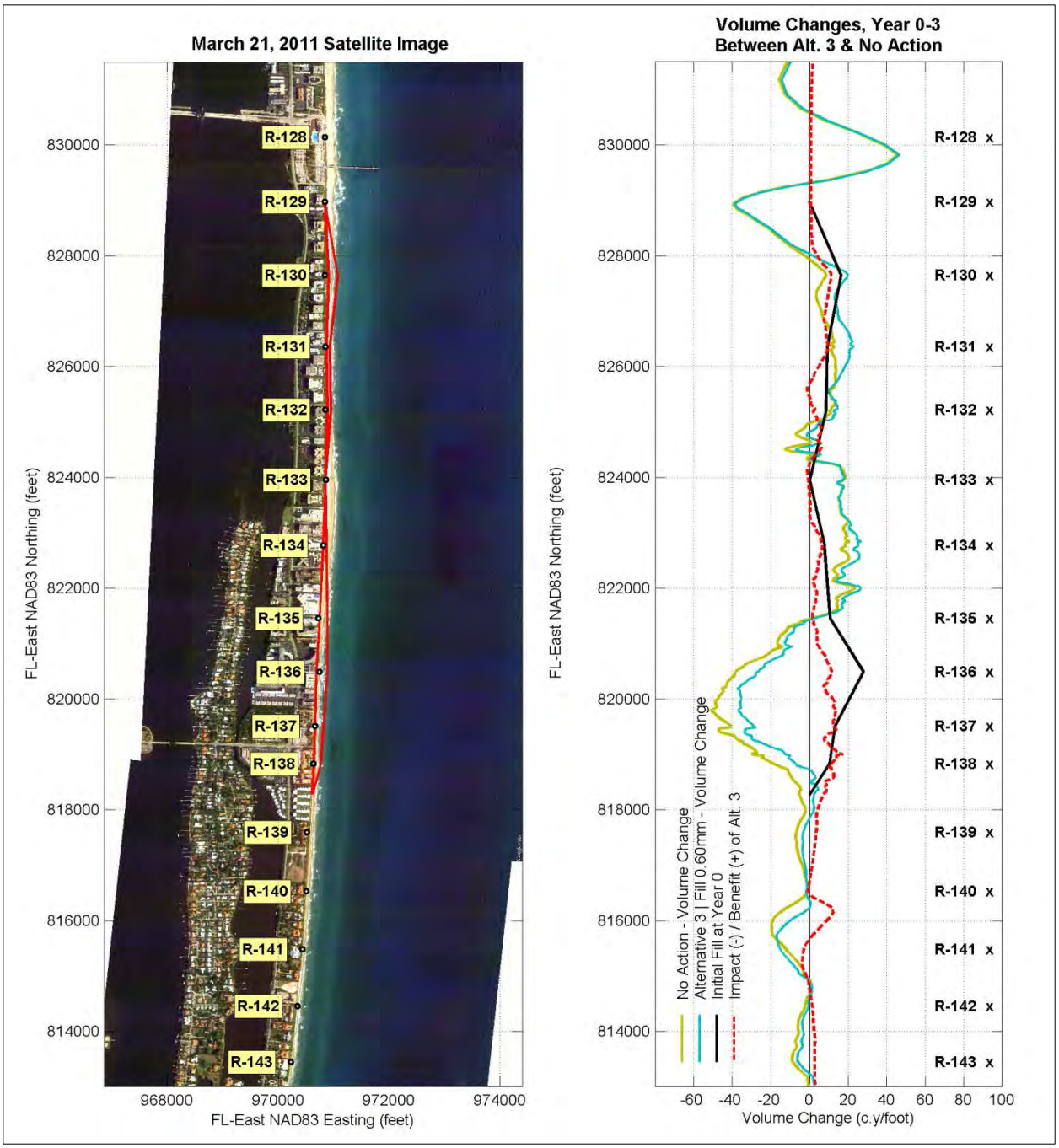

Figure 3-55. Volume changes for Alternative 3 – fill grain size 0.60 mm.

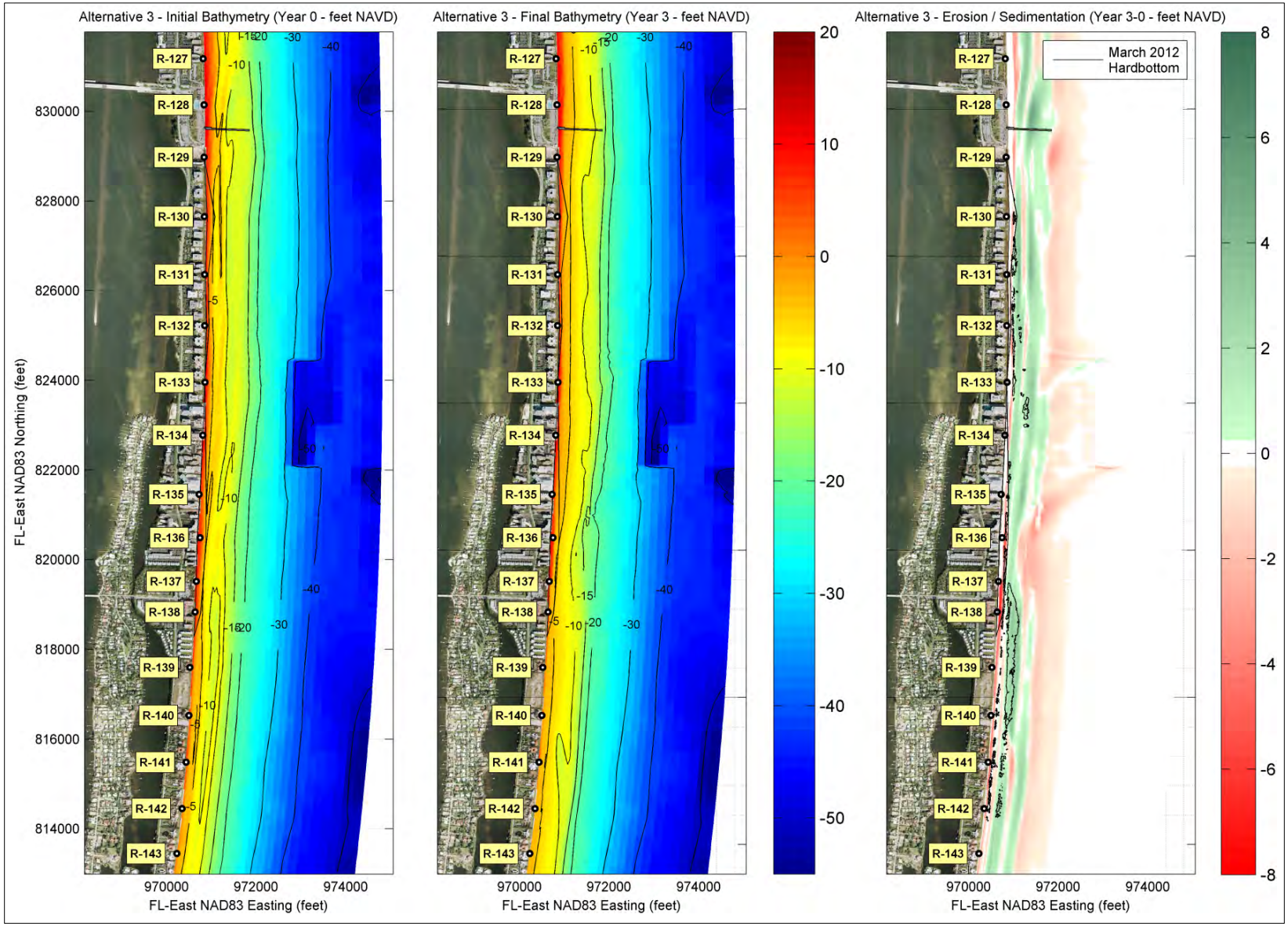

Figure 3-56. Erosion/Sedimentation after 3 years of simulation, Alternative 3 - Fill grain size 0.60 mm.

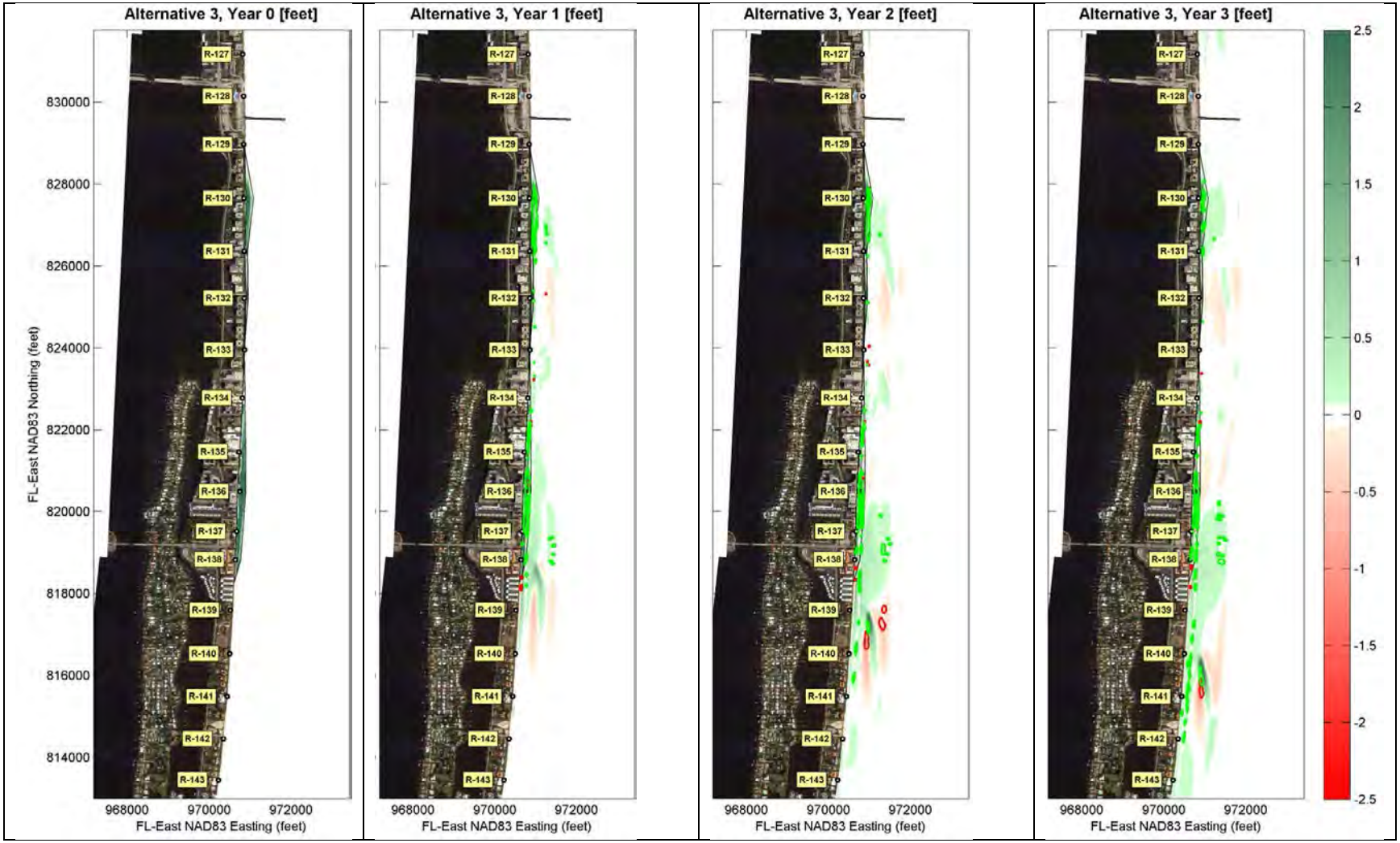

Figure 3-57. Temporal evolution of beach nourishment for Alternative 3, compared to No Action scenario - fill grain size 0.60 mm.

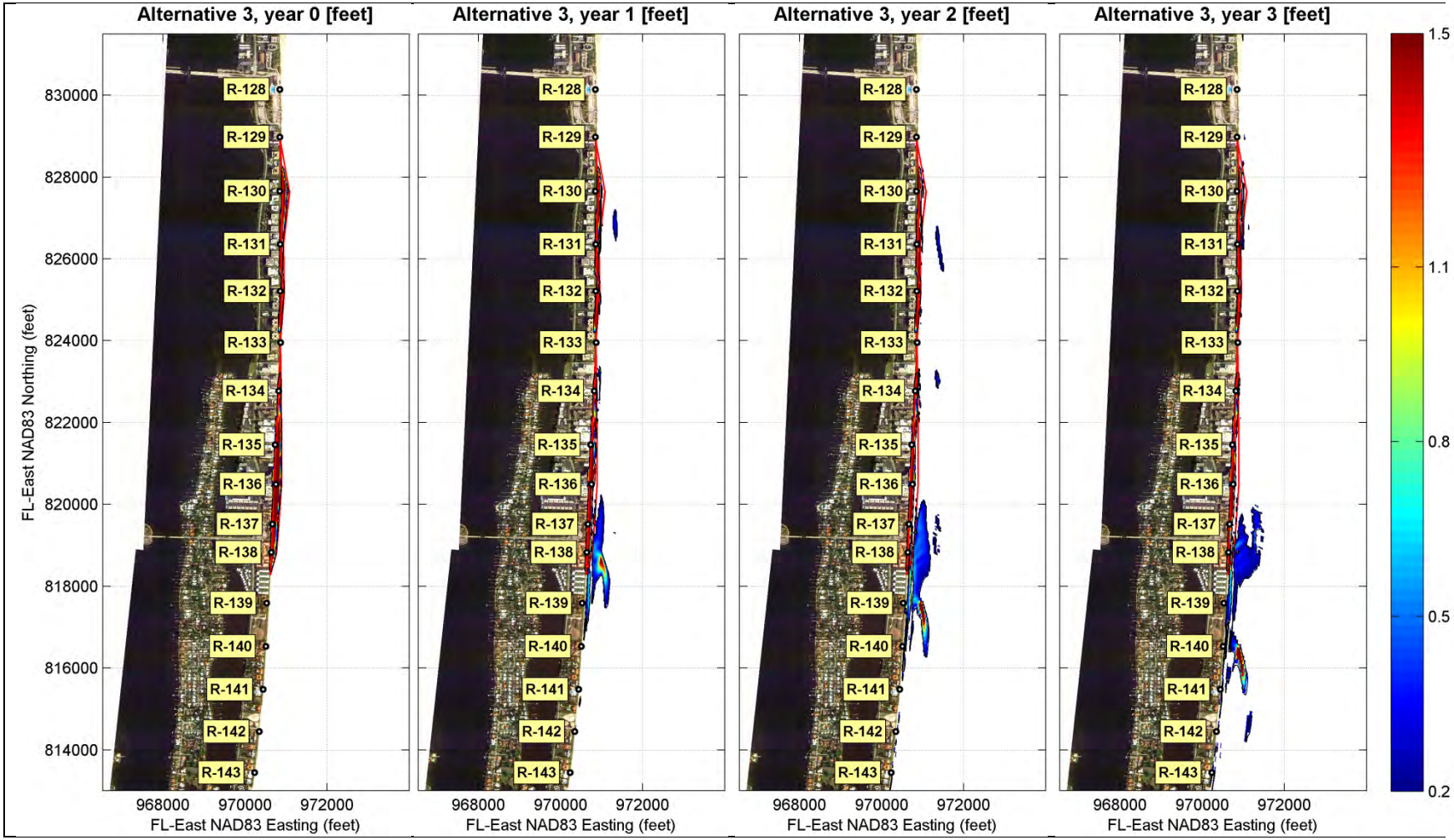

Figure 3-58. Sediment accumulation greater than 0.2 ft for Alternative 3 - fill grain size 0.60 mm.

3.2.3. Alternative 4 - The Town of Palm Beach Preferred Project and County Increased Sand Volume Project without Shoreline Protection Structures

Model results for Alternative 4 simulated with fill grain size of 0.60 mm in the Town of Palm Beach's portion of the template are shown in Figure 3-59 through Figure 3-62.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-61). At the end of the 3 year simulation period, there was an estimated coverage of 12.51 acres of hardbottom and an exposure of 0.57 acres attributed to the alternative as depicted in Figure 3-61. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -11.94 acres. The net change is 0.46 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

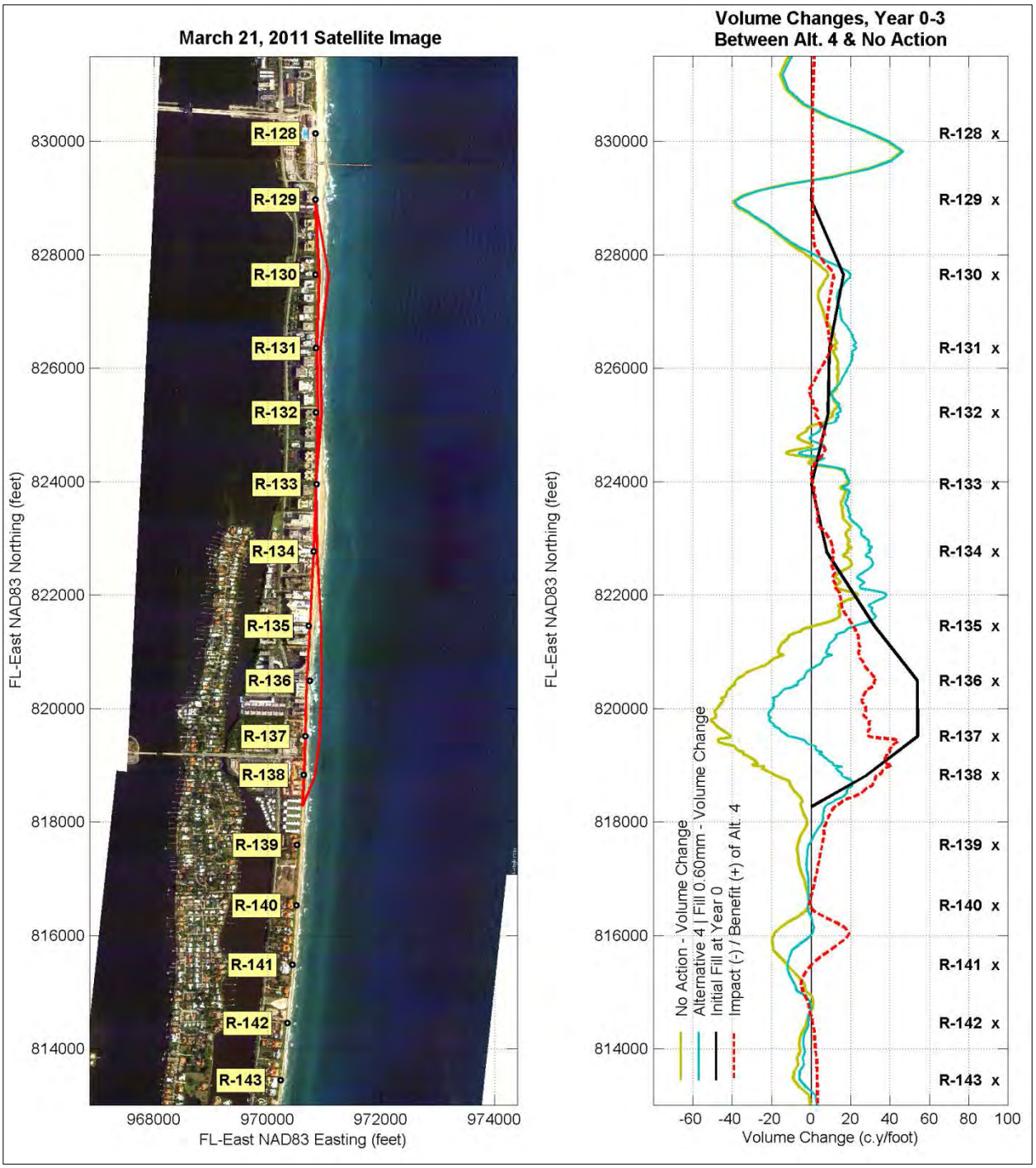

Figure 3-59. Volume changes for Alternative 4 – fill grain size 0.60 mm.

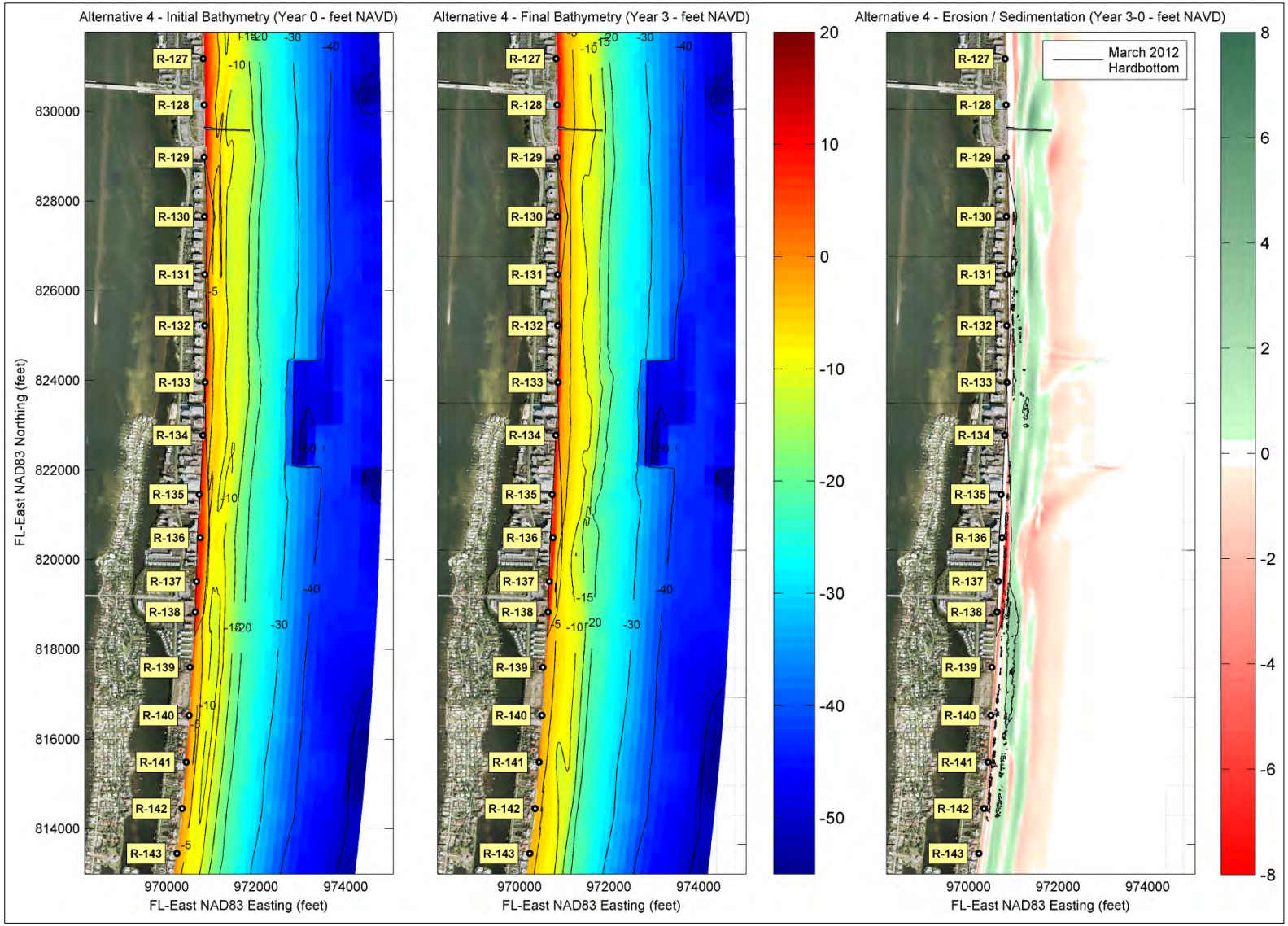

Figure 3-60. Erosion/sedimentation after 3 years of simulation, Alternative 4 - fill grain size 0.60 mm.

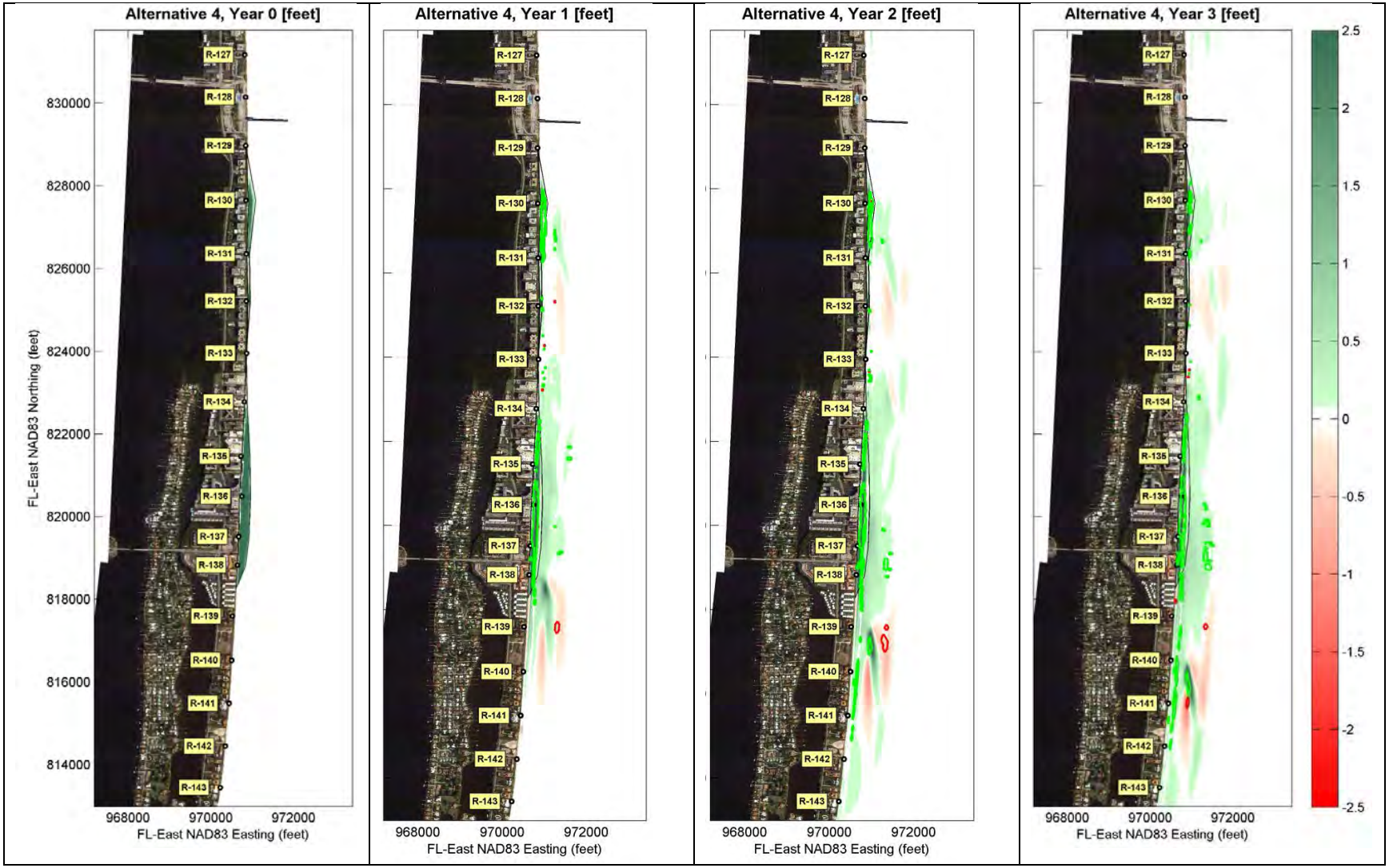

Figure 3-61. Temporal evolution of beach nourishment for Alternative 4, compared to No Action scenario - fill grain size 0.60 mm.

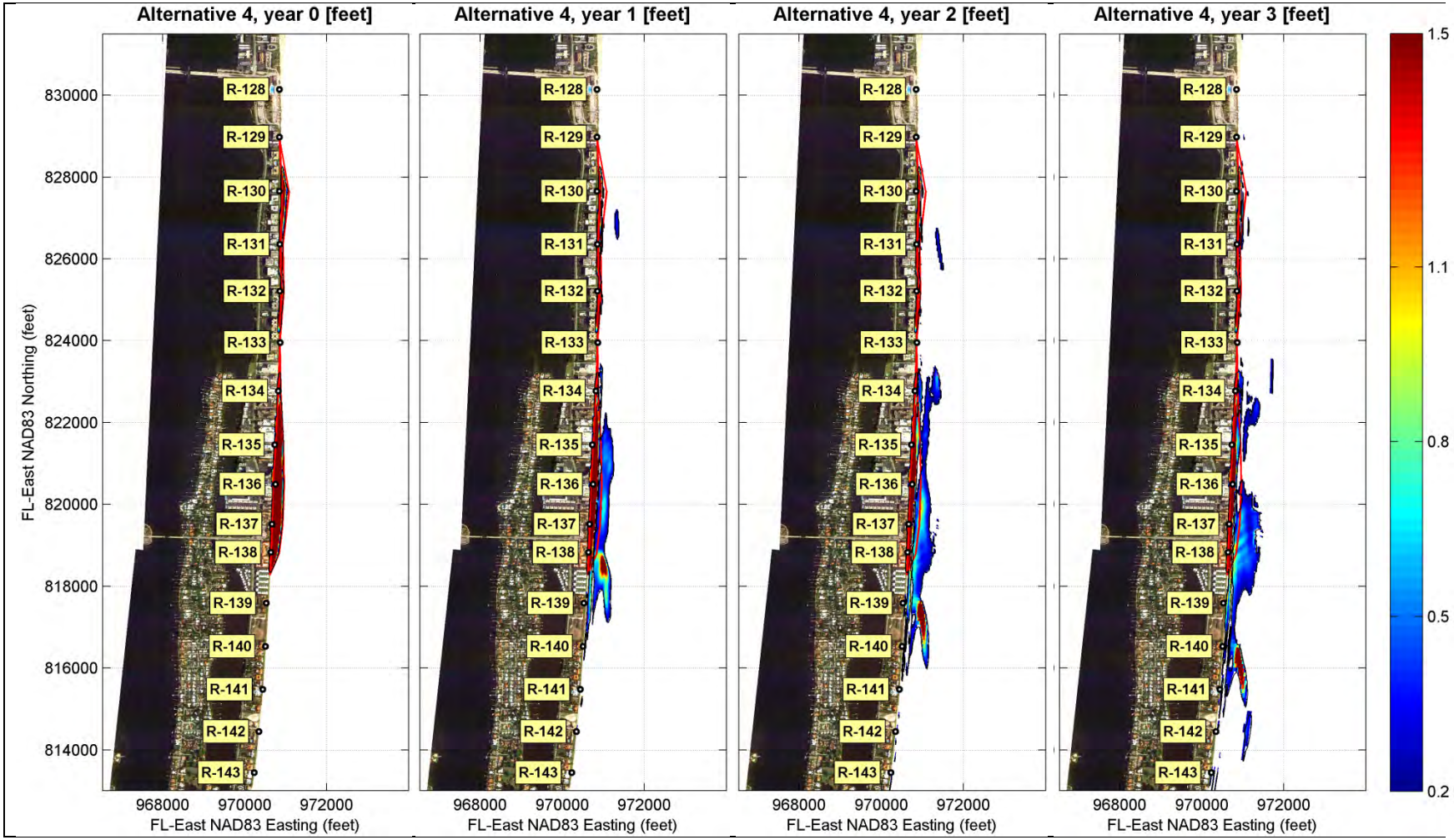

Figure 3-62. Sediment accumulation greater than 0.2 ft for Alternative 4 - fill grain size 0.60 mm.

3.2.4. Alternative 5 - The Town of Palm Beach Increased Sand Volume Project and County Preferred Project

Model results given in Alternative 5 with fill grain size of 0.60 mm in the Town of Palm Beach's portion of the template appear in Figure 3-63 through Figure 3-66.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-65). At the end of the 3 year simulation period, there was an estimated coverage of 11.31 acres of hardbottom and an exposure of 3.96 acres attributed to the alternative as depicted in Figure 3-65. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -7.35 acres. The net change is 0.71 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

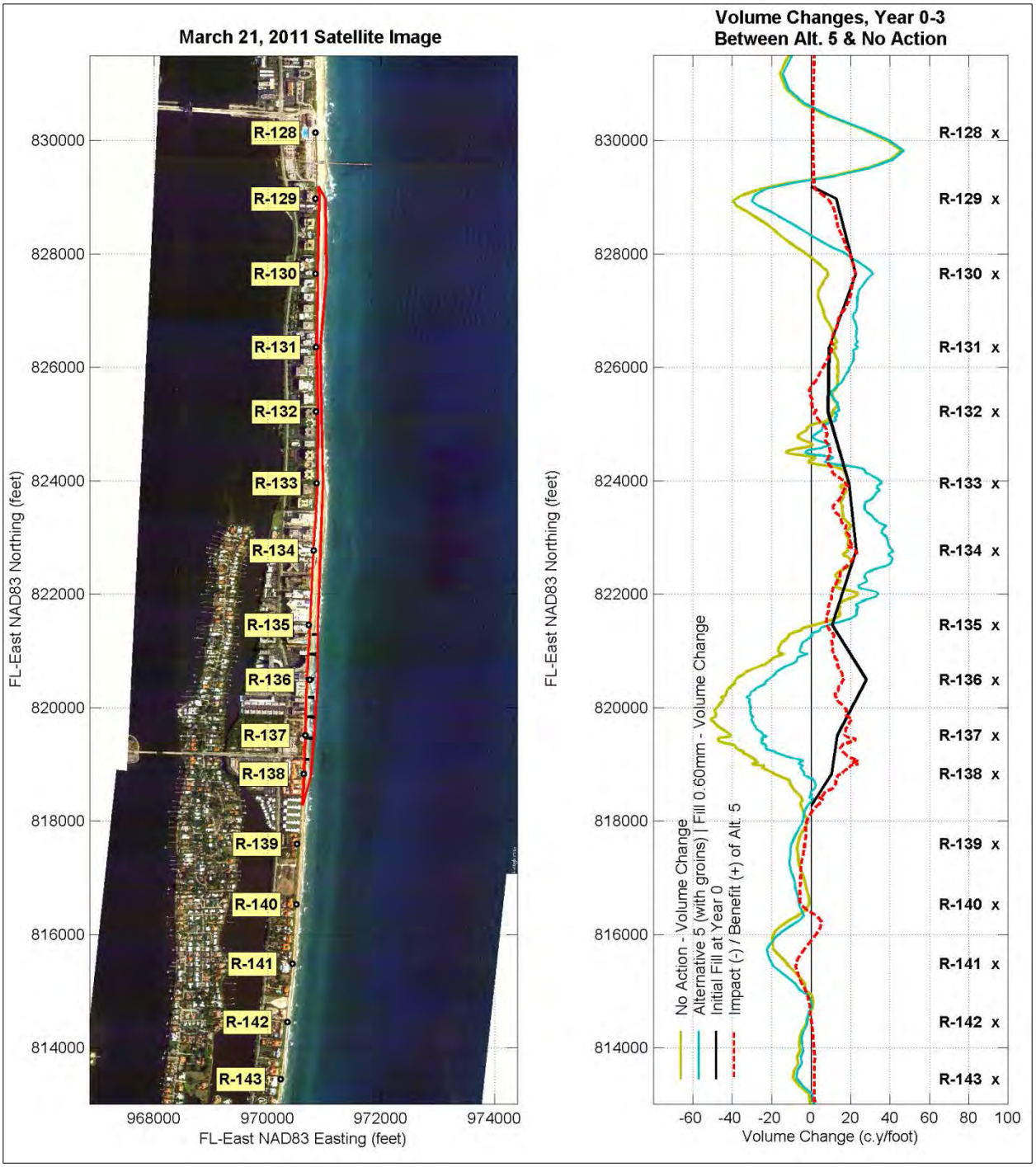

Figure 3-63. Volume changes for Alternative 5 – fill grain size 0.60 mm.

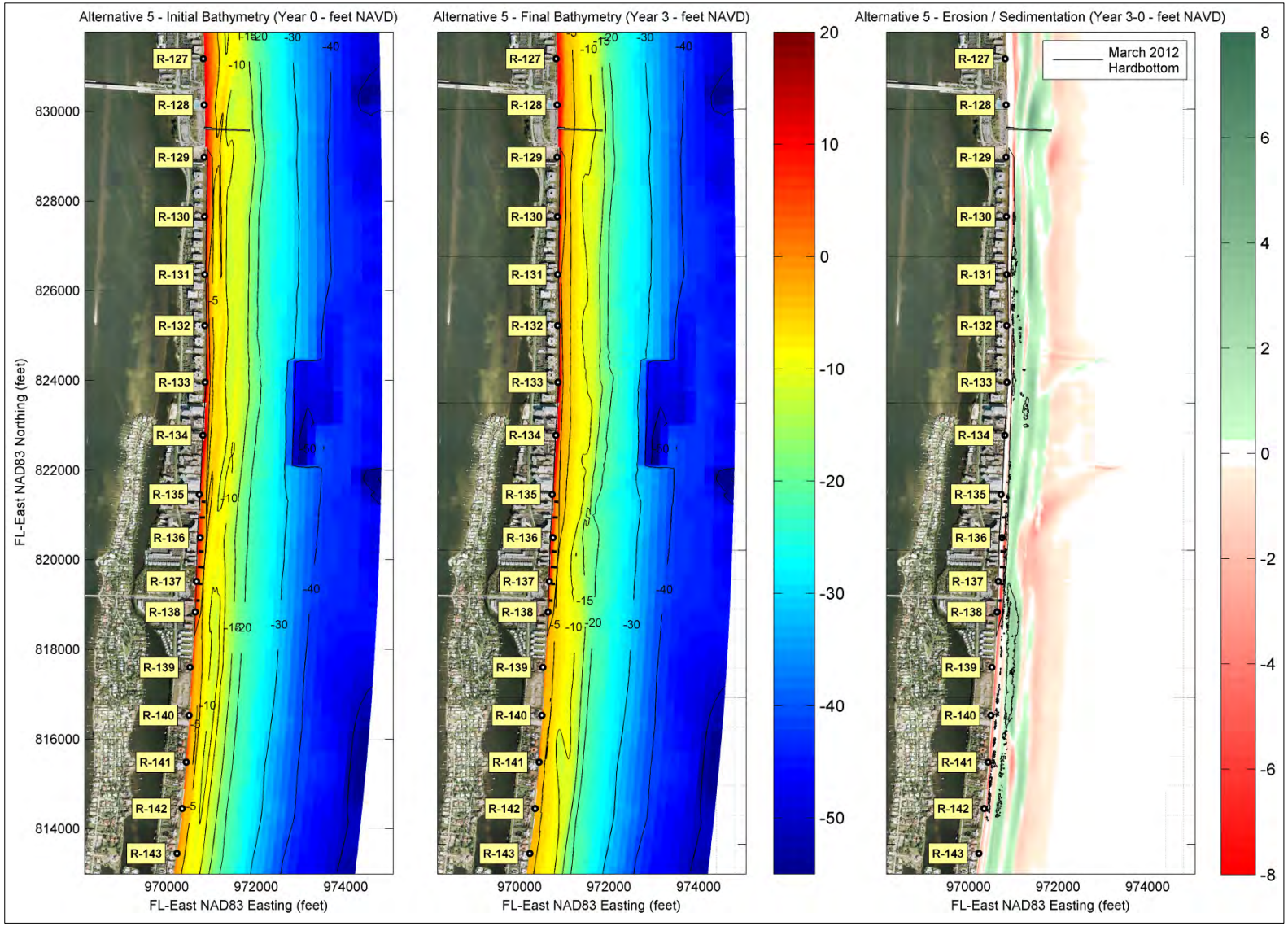

Figure 3-64. Erosion/Sedimentation after 3 years of simulation, Alternative 5 - Fill grain size 0.60 mm.

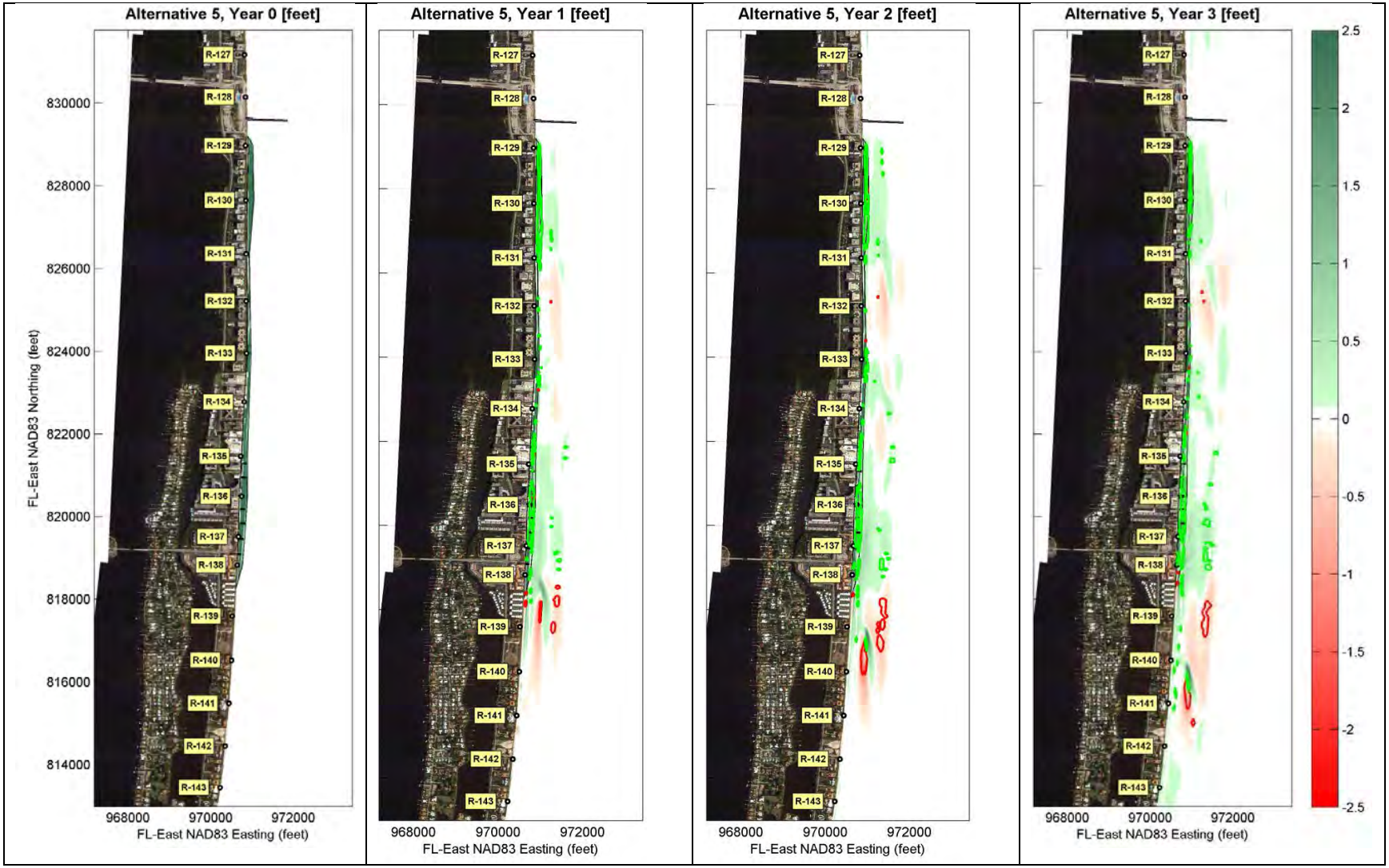

Figure 3-65. Temporal evolution of beach nourishment for Alternative 5, compared to No Action scenario - fill grain size 0.60 mm.

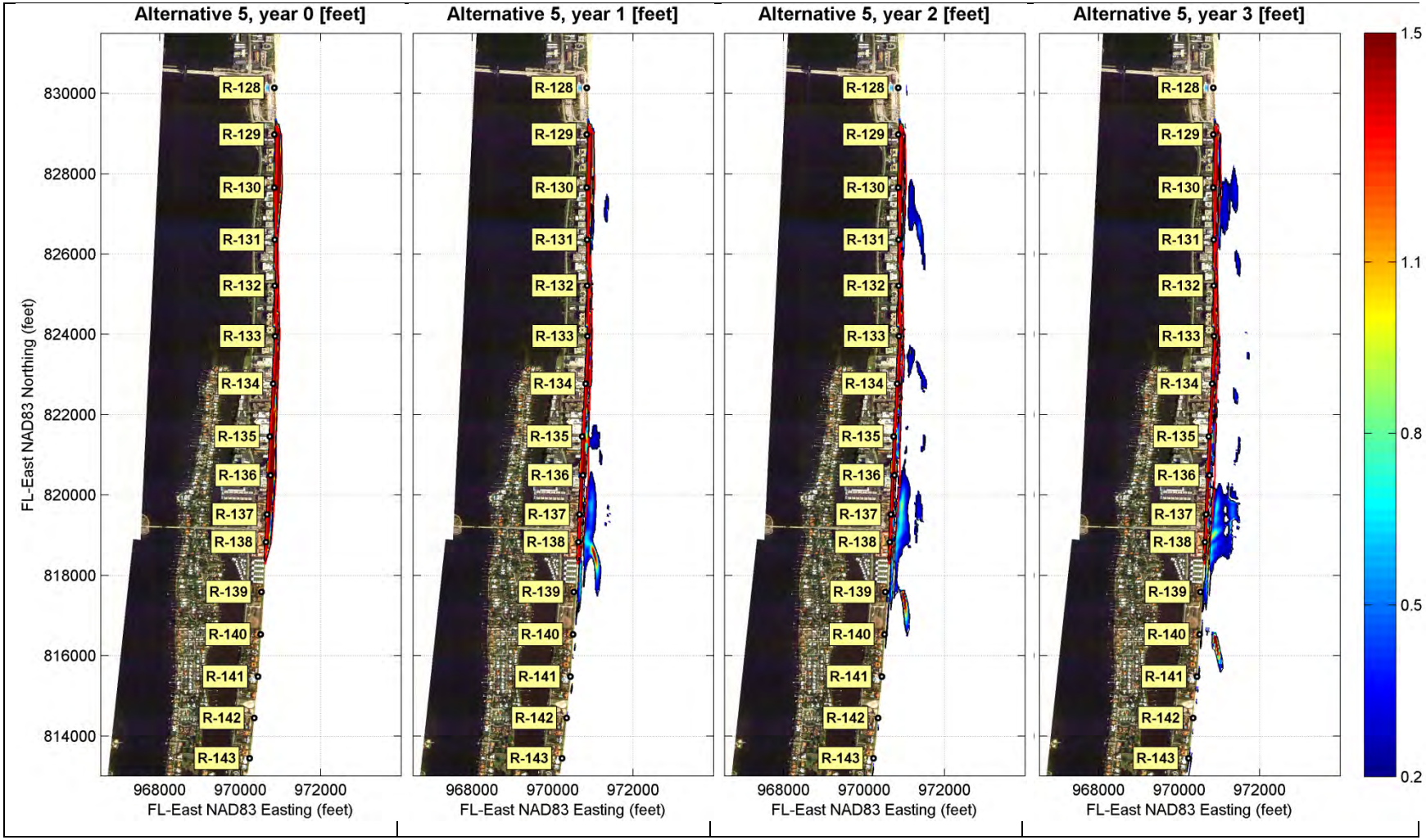

Figure 3-66. Sediment accumulation greater than 0.2 ft for Alternative 5 - fill grain size 0.60 mm.

3.2.5. Alternative 6 - The Town of Palm Beach Increased Sand Volume Project and County Increased Sand Volume without Shoreline Protection Structures Project

Combined Action

Model results given in Alternative 6 simulated with fill sediment grain size of 0.60 mm in the Town of Palm Beach's portion of the template appear in Figure 3-67 through Figure 3-70.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-69). At the end of the 3 year simulation period, there was an estimated coverage of 14.09 acres of hardbottom and an exposure of 0.64 acres attributed to the alternative as depicted in Figure 3-69. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -13.45 acres. The net change is 0.46 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

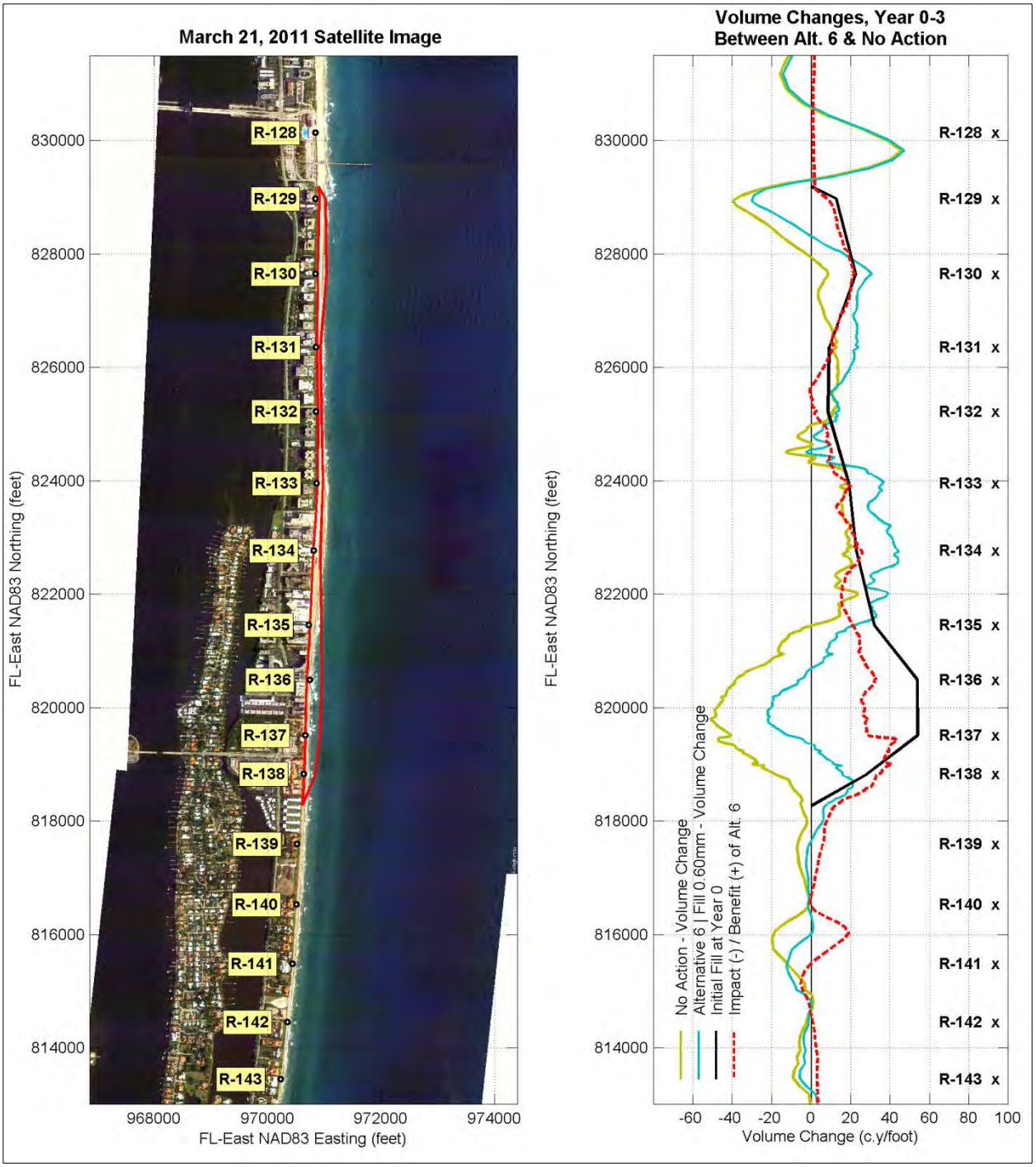

Figure 3-67. Volume changes for Alternative 6 – fill grain size 0.60 mm.

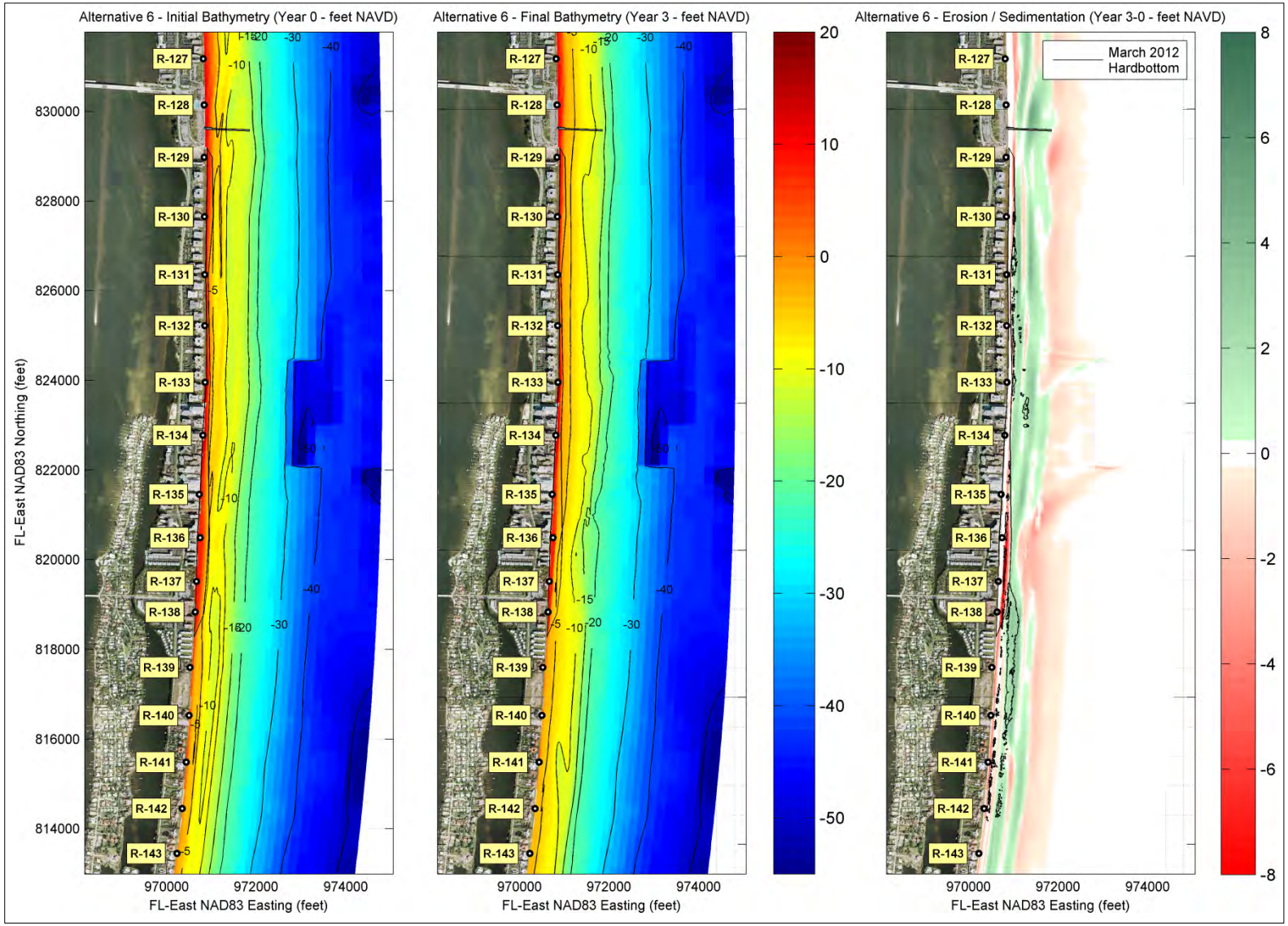

Figure 3-68. Erosion/sedimentation after 3 years of simulation, Alternative 6 - fill grain size 0.60 mm.

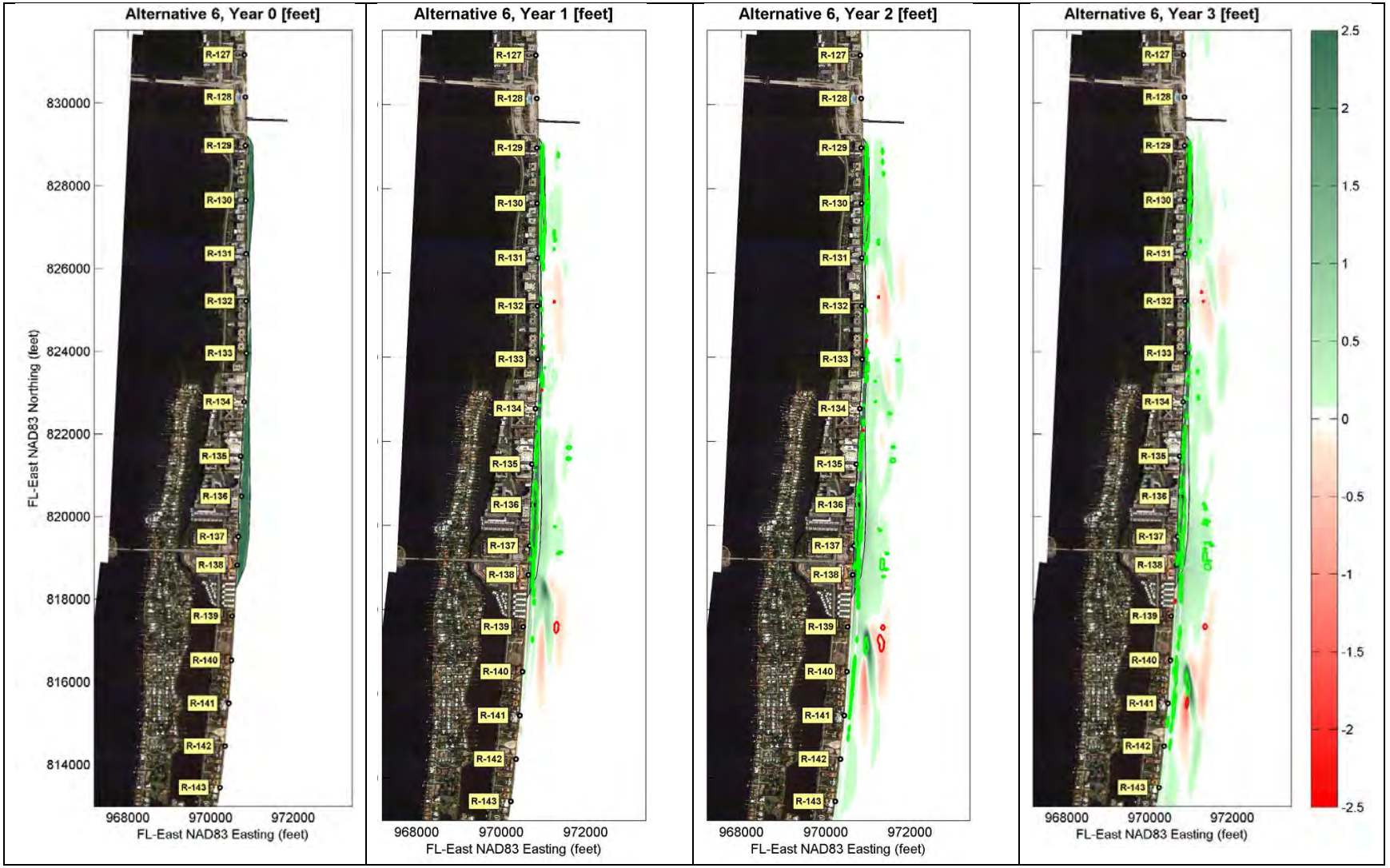

Figure 3-69. Temporal evolution of beach nourishment for Alternative 6, compared to No Action scenario - fill grain size 0.60 mm.

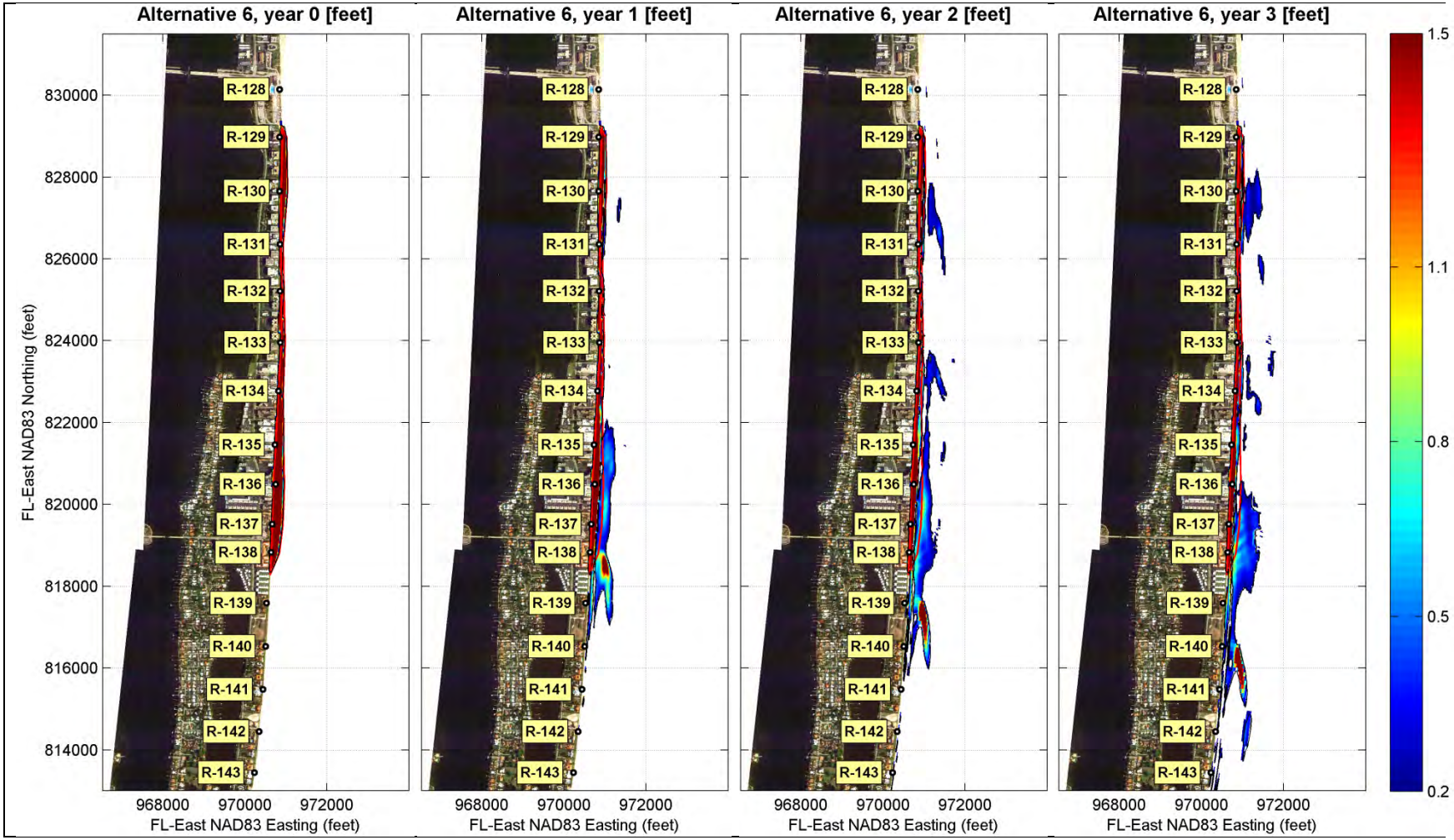

Figure 3-70. Sediment accumulation greater than 0.2 ft for Alternative 6 - fill grain size 0.60 mm.

Separated Action – Alternative 6T (Town of Palm Beach portion of alternative)

Model results for Alternative 6T grain size 0.60 mm in the Town of Palm Beach's portion of the template are shown in Figure 3-71 through Figure 3-74.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-73). At the end of the 3 year simulation period, there was an estimated coverage of 3.31 acres of hardbottom and an exposure of 0.99 acres attributed to the alternative as depicted in Figure 3-73. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -2.32 acres. The net change is 0.11 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

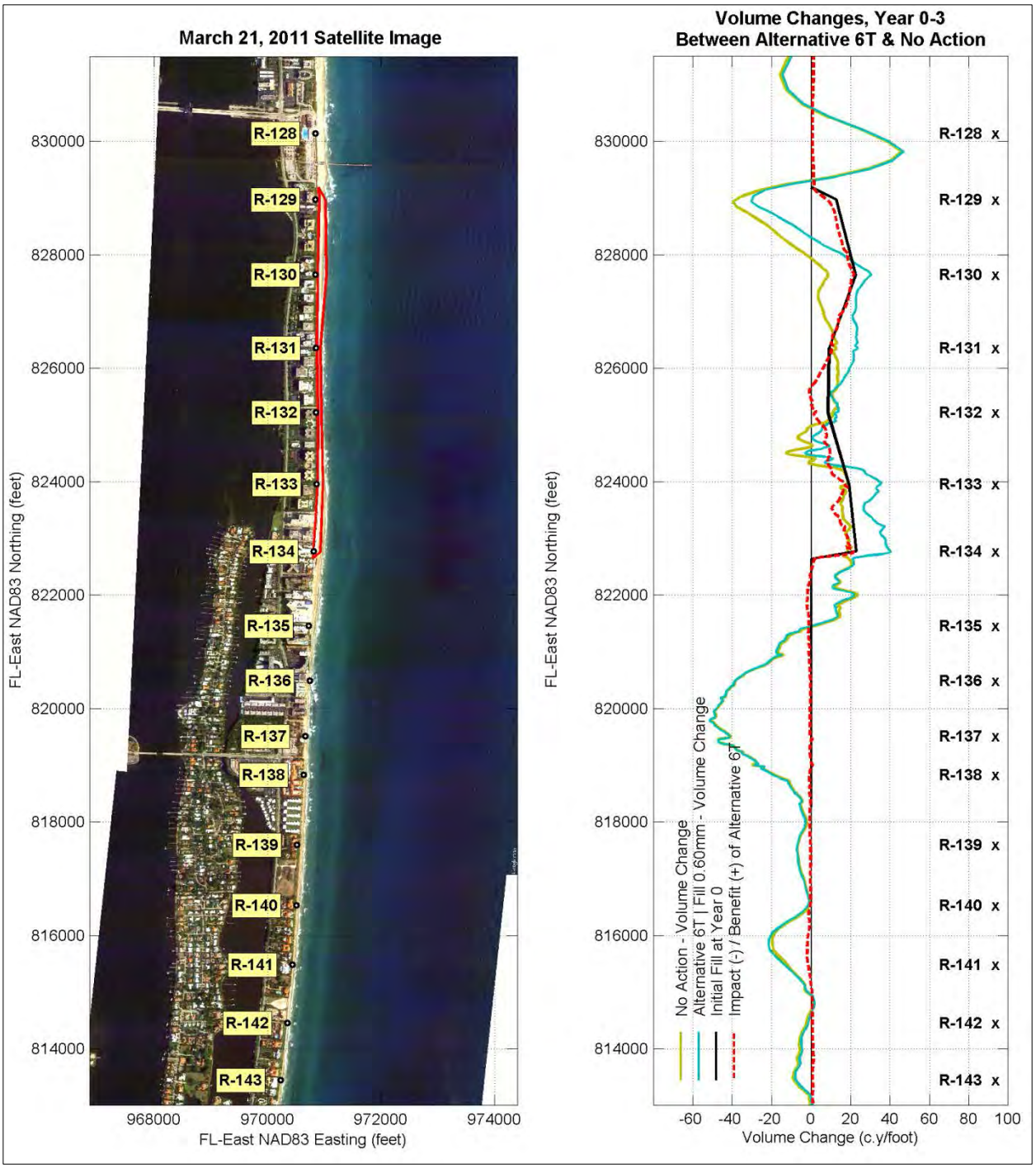

Figure 3-71. Volume changes for Alternative 6T – fill grain size 0.60 mm.

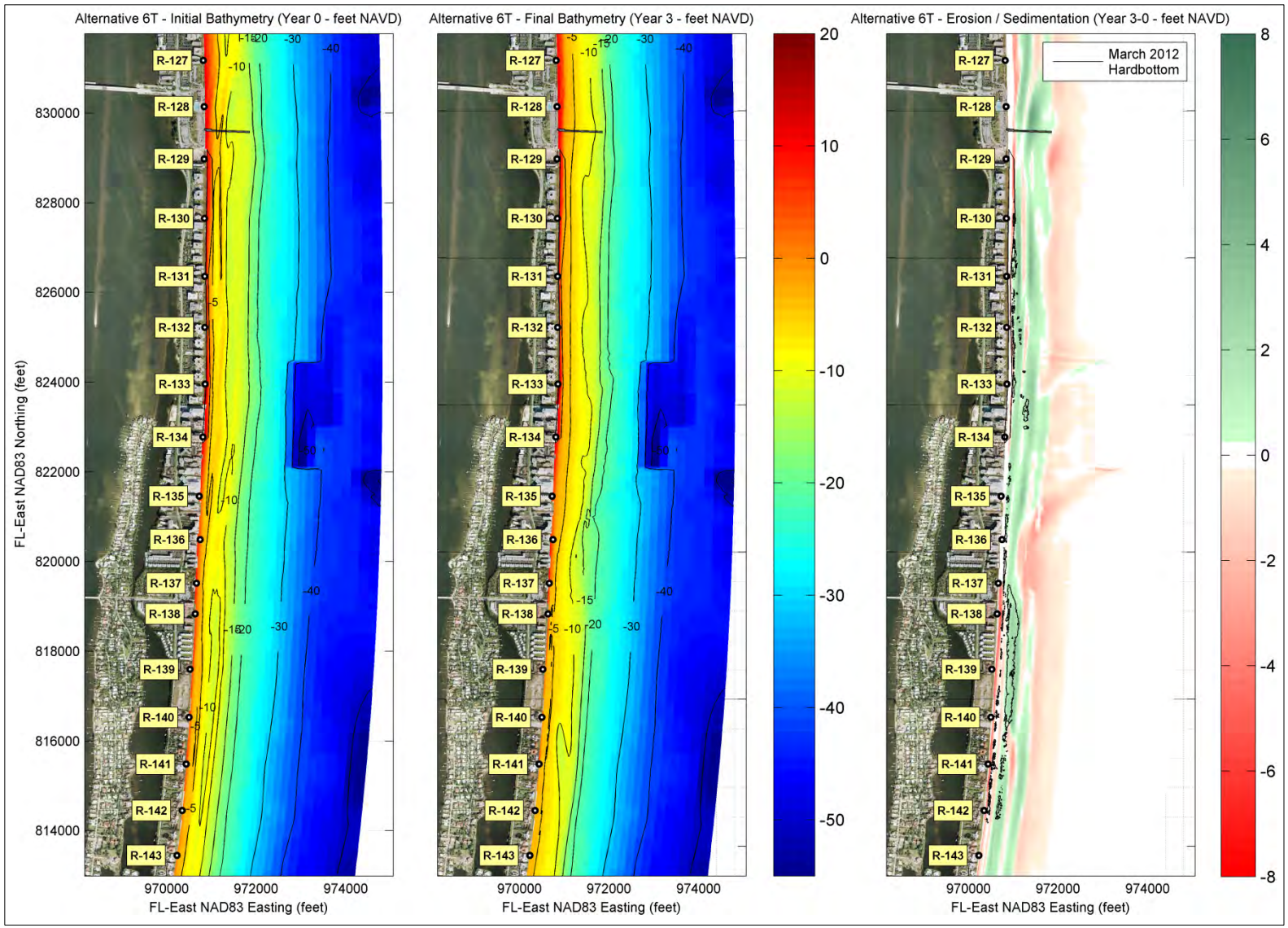

Figure 3-72. Erosion/sedimentation after 3 years of simulation, Alternative 6T - fill grain size 0.60 mm.

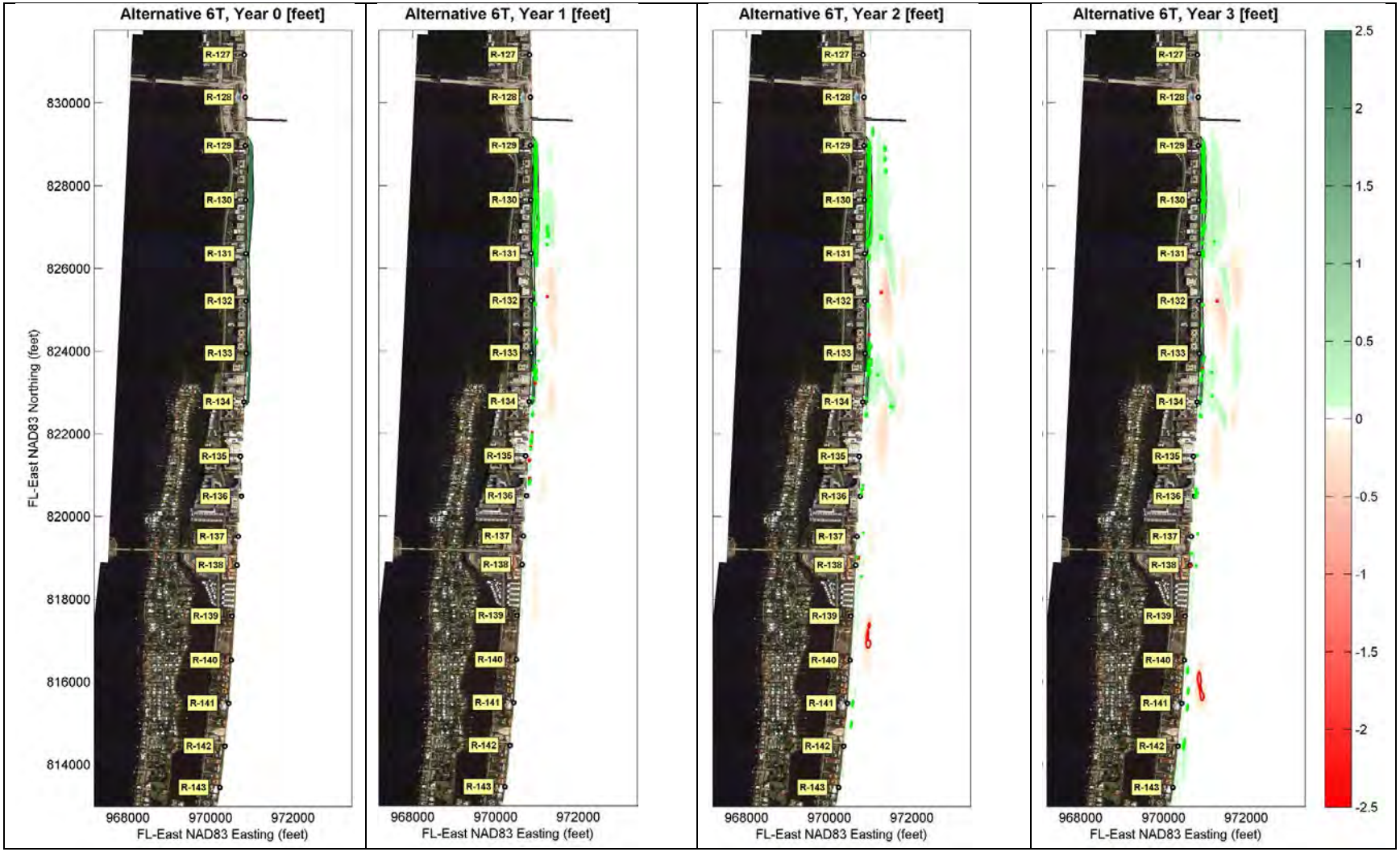

Figure 3-73. Temporal evolution of beach nourishment for Alternative 6T, compared to No Action scenario - fill grain size 0.60 mm.

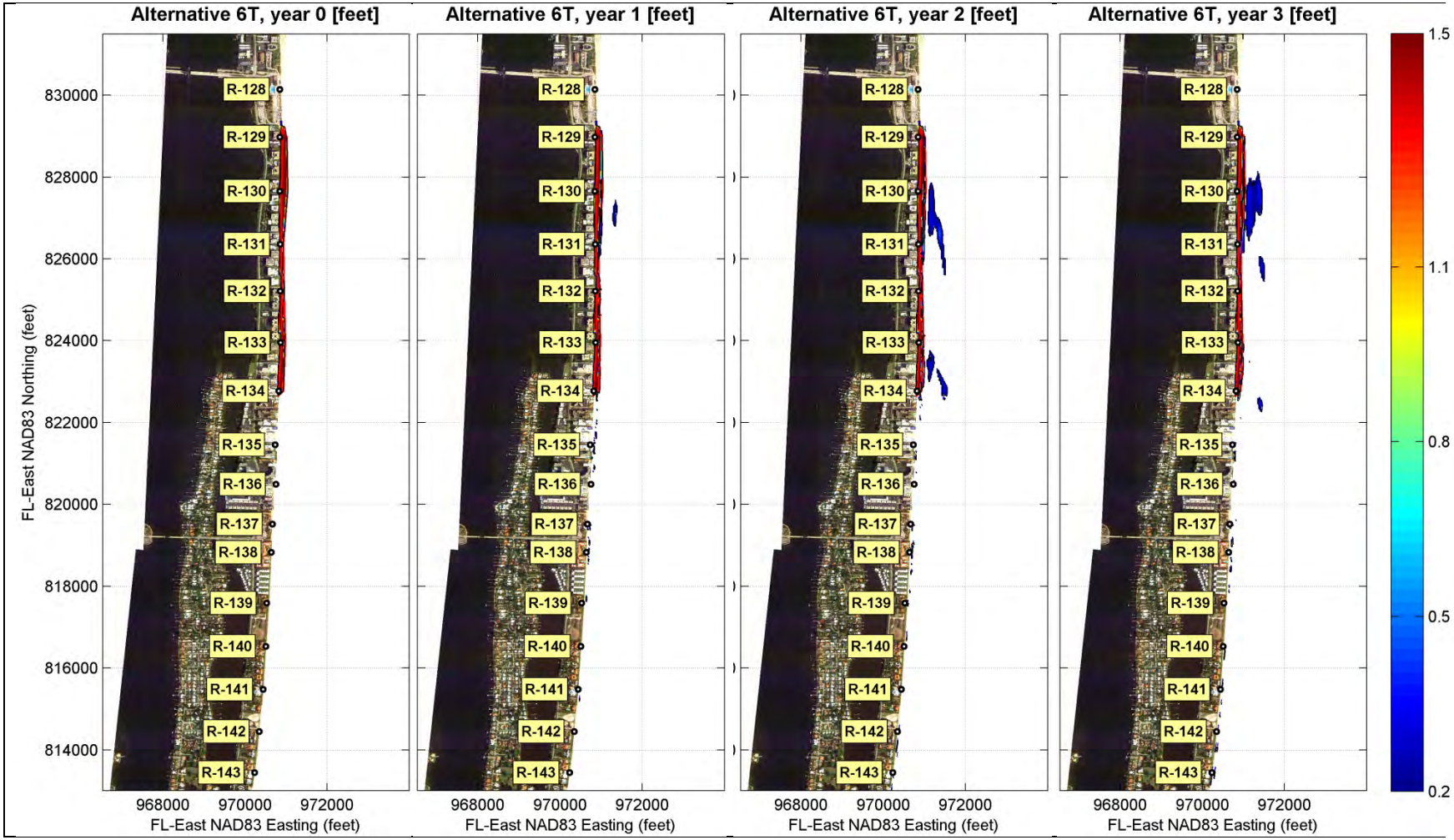

Figure 3-74. Sediment accumulation greater than 0.2 ft for Alternative 6T - fill grain size 0.60 mm.

3.2.6. Alternative 7a - The Coalition to Save Our Shoreline, Inc. (SOS) option with increased sand volume and the County Preferred Project

Combined Action

Model results given in Alternative 7a simulated with fill sediment grain size of 0.60 mm in the Town of Palm Beach's portion of the template appear in Figure 3-75 through Figure 3-78.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-77). At the end of the 3 year simulation period, there was an estimated coverage of 15.21 acres of hardbottom and an exposure of 5.56 acres attributed to the alternative as depicted in Figure 3-77. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -9.65 acres. The net change is 0.99 acres less (less coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

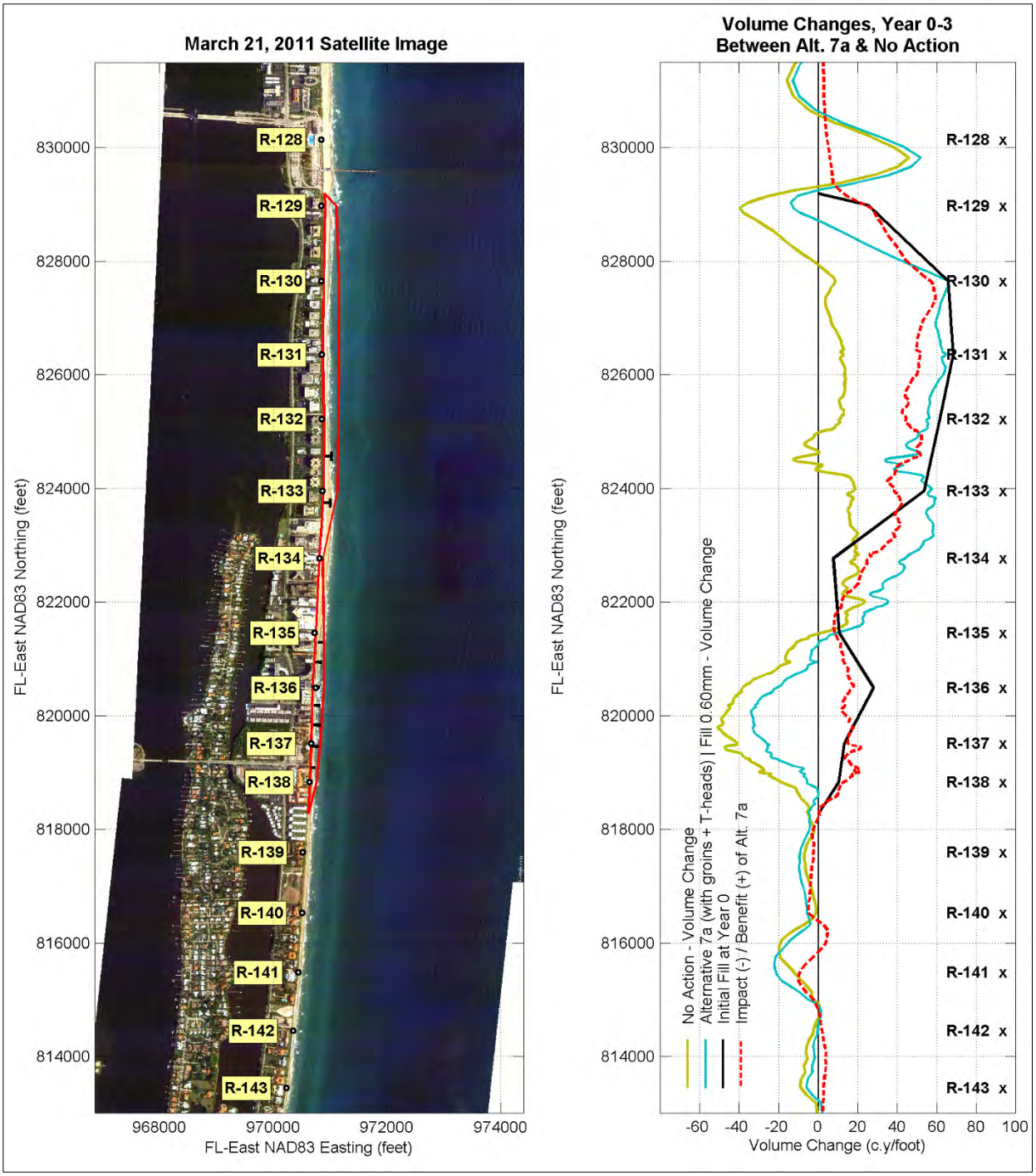

Figure 3-75. Volume changes for Alternative 7a – fill grain size 0.60 mm.

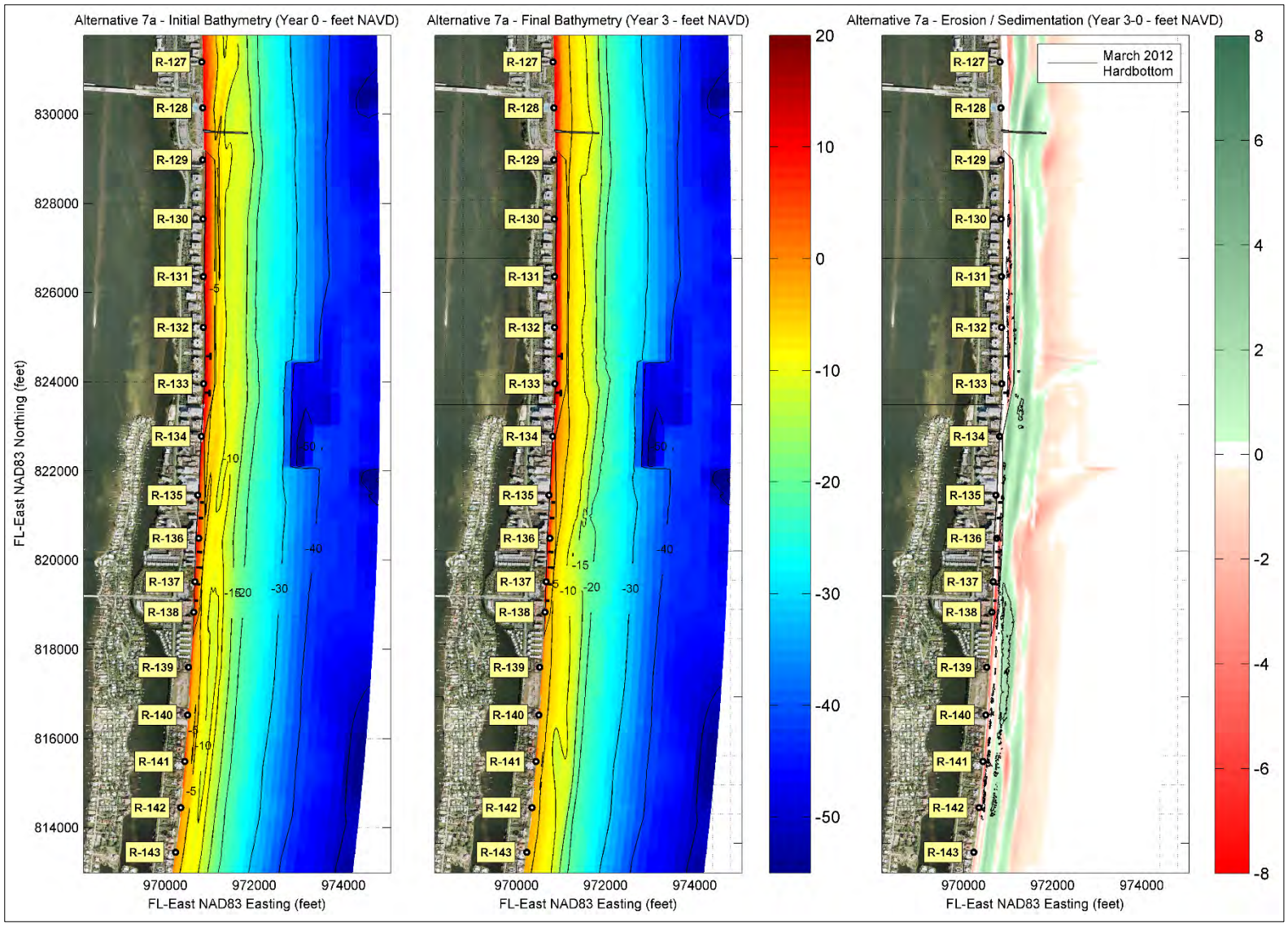

Figure 3-76. Erosion/Sedimentation after 3 years of simulation, Alternative 7a - Fill grain size 0.60 mm.

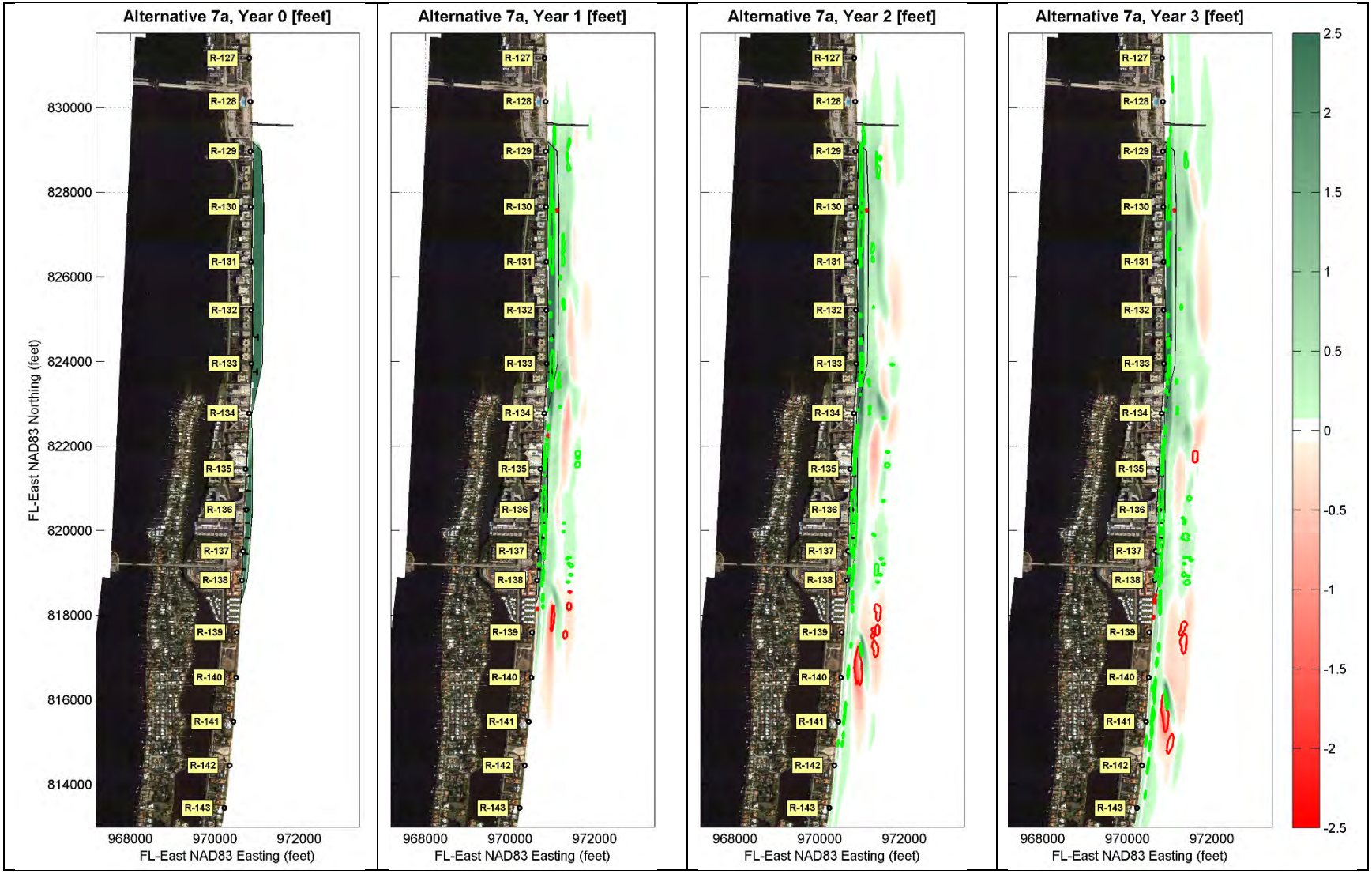

Figure 3-77. Temporal evolution of beach nourishment for Alternative 7a, compared to No Action scenario - fill grain size 0.60 mm.

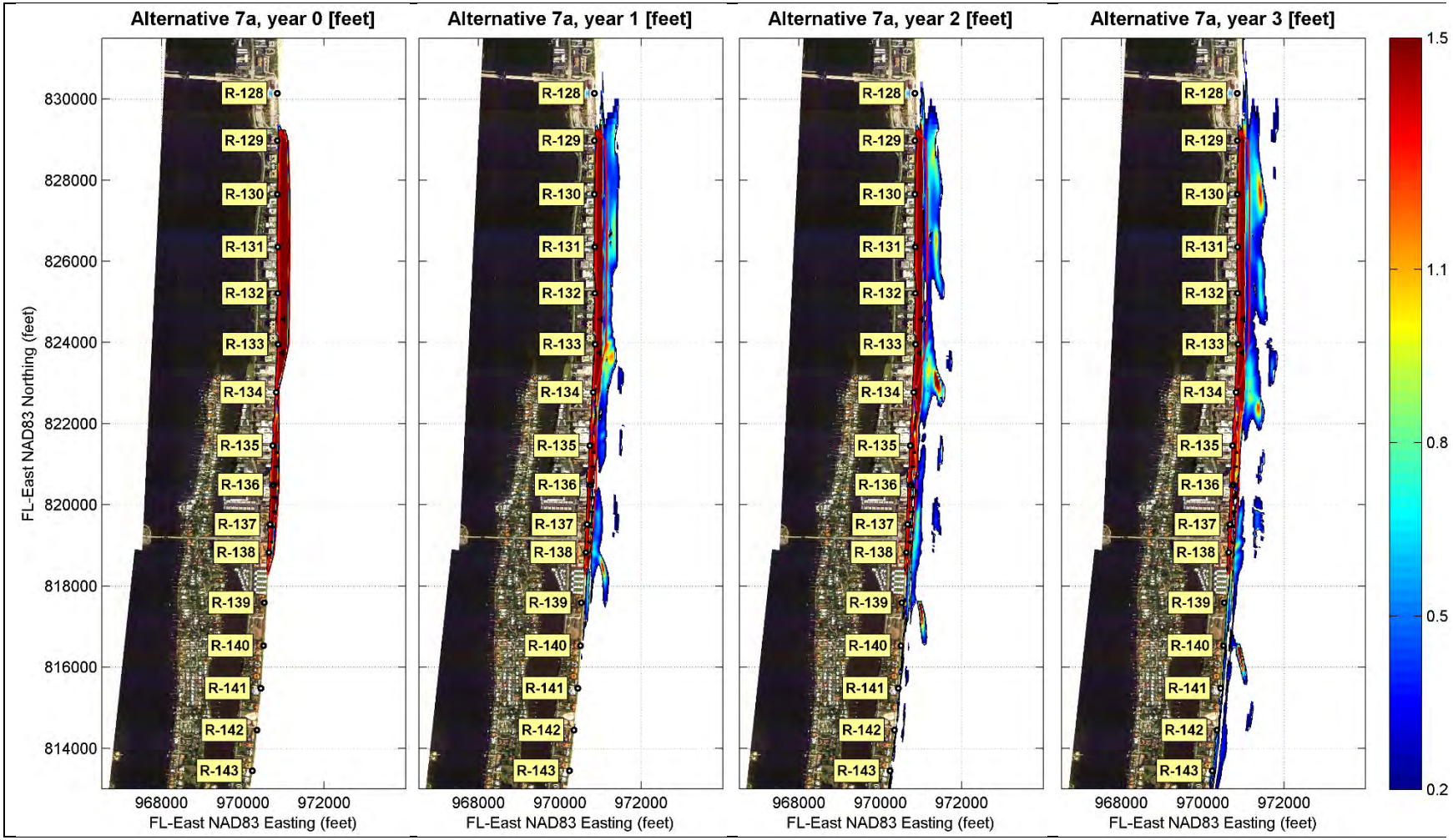

Figure 3-78. Sediment accumulation greater than 0.2 ft for Alternative 7a - fill grain size 0.60 mm.

Separated Action – Alternative 7aT (Town of Palm Beach portion of alternative)

Model results for Alternative 7aT simulated with fill sediment grain size of 0.60 mm in the Town of Palm Beach's portion of the template appear in Figure 3-79 through Figure 3-82.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-81). At the end of the 3 year simulation period, there was an estimated coverage of 9.40 acres of hardbottom and an exposure of 4.03 acres attributed to the alternative as depicted in Figure 3-81. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -5.37 acres. The net change is 0.17 acres less (less coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

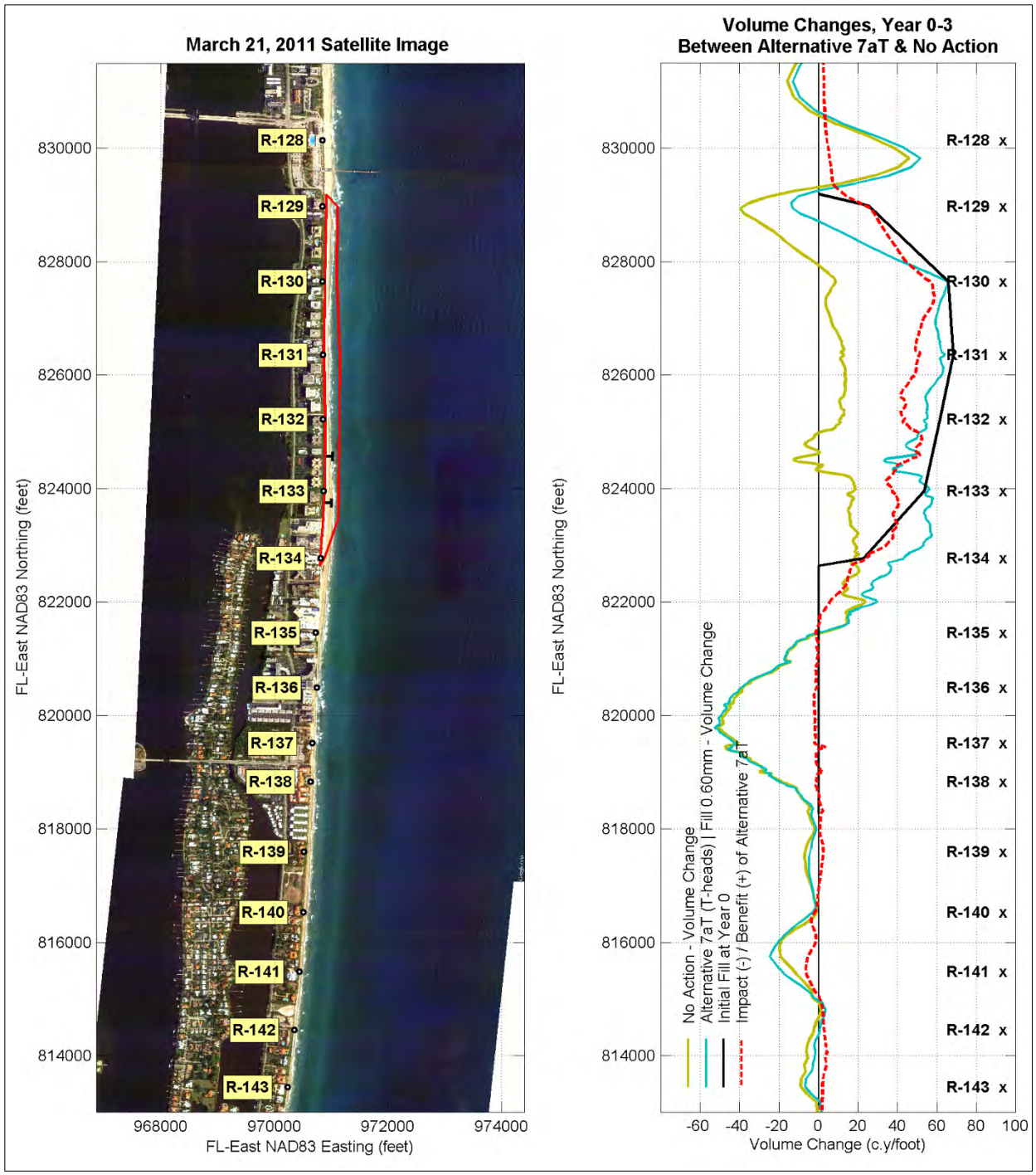

Figure 3-79. Volume changes for Alternative 7aT – fill grain size 0.60 mm.

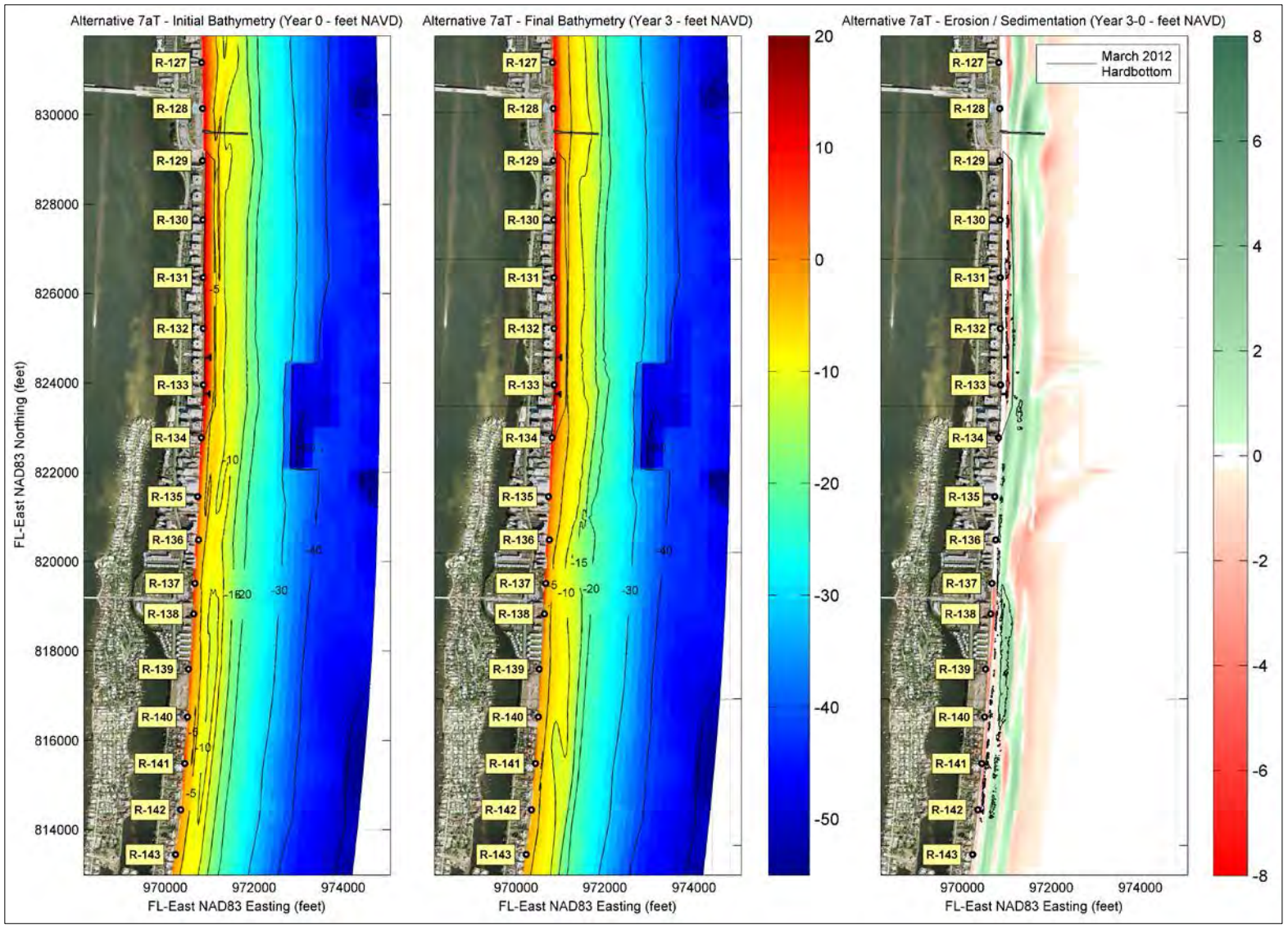

Figure 3-80. Erosion/Sedimentation after 3 years of simulation, Alternative 7aT - Fill grain size 0.60 mm.

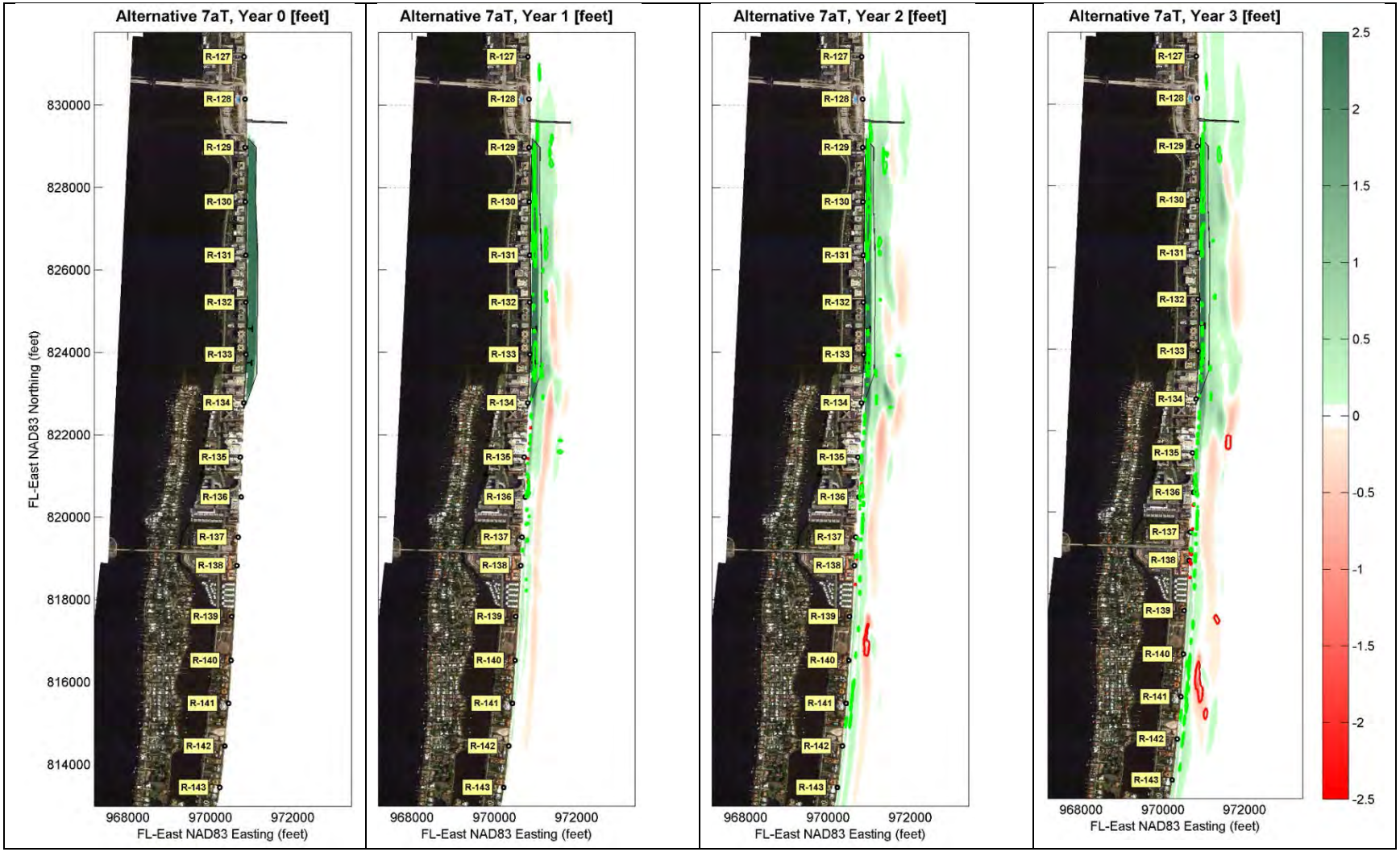

Figure 3-81. Temporal evolution of beach nourishment for Alternative 7aT, compared to No Action scenario - fill grain size 0.60 mm.

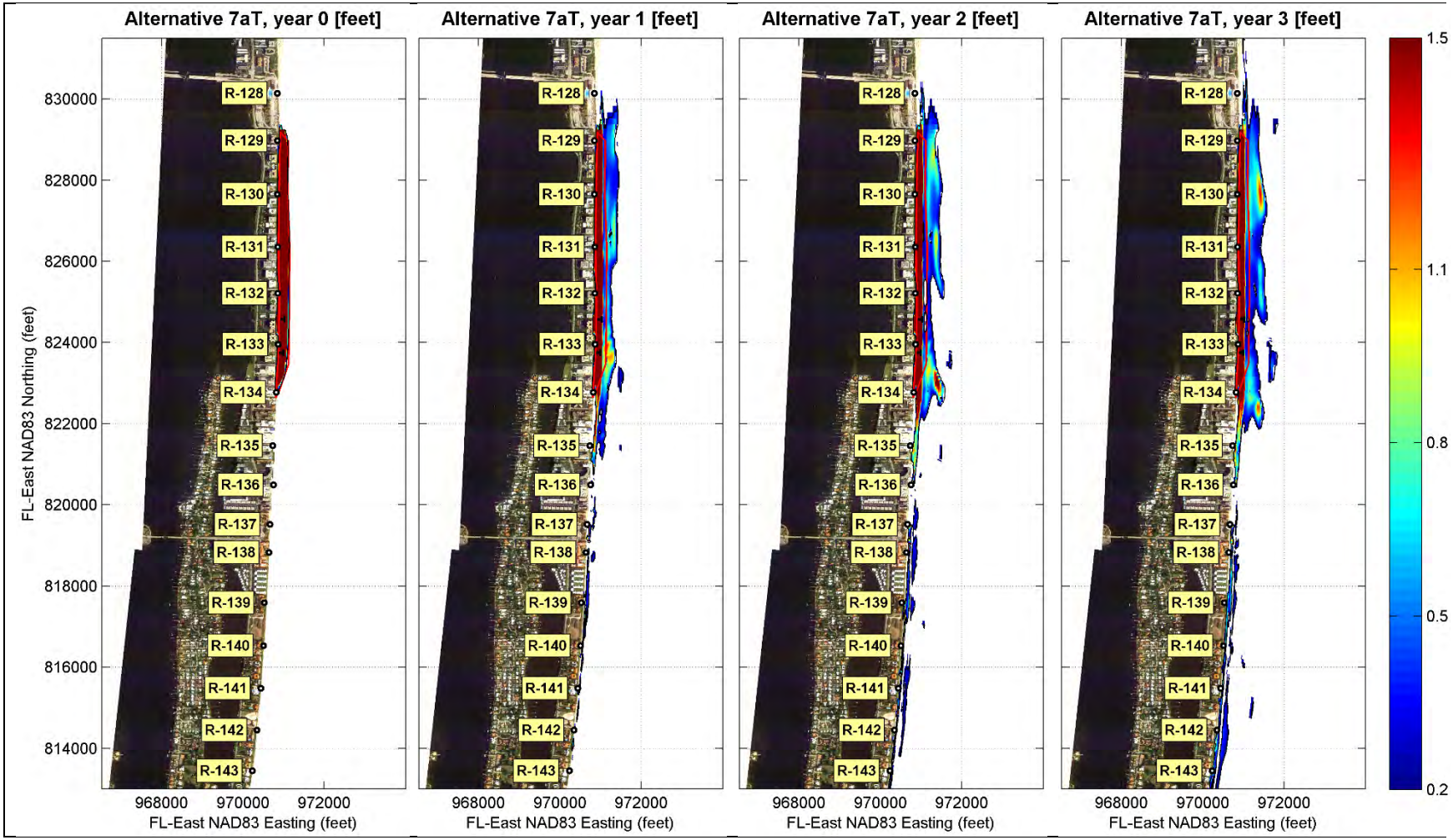

Figure 3-82. Sediment accumulation greater than 0.2 ft for Alternative 7aT - fill grain size 0.60 mm.

3.2.7. Alternative 7b – The Town of Palm Beach Increased Sand Volume with Two Shoreline Protection Structures (The Coalition to Save Our Shoreline, Inc. (SOS) Alternative) and the County Preferred Project

Combined Action

Model results given in Alternative 7b simulated with fill sediment grain size of 0.60 mm in the Town of Palm Beach's portion of the template appear in Figure 3-83 through Figure 3-86.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-85). At the end of the 3 year simulation period, there was an estimated coverage of 14.46 acres of hardbottom and an exposure of 7.21 acres attributed to the alternative as depicted in Figure 3-85. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -7.25 acres. The net change is 0.99 acres less (less coverage) than the net change observed for the same alternative with a fill grain size of 3.87 mm.

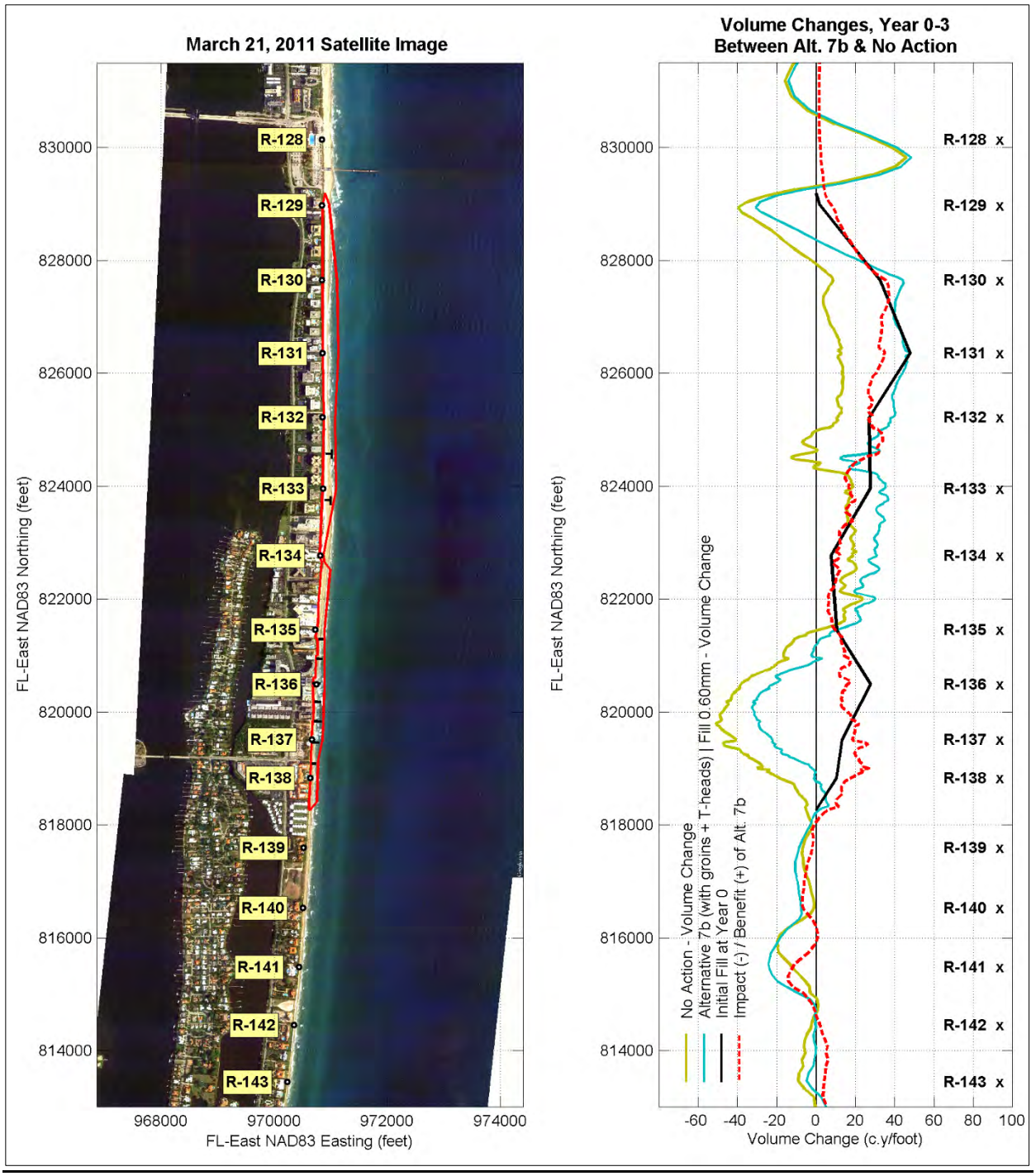

Figure 3-83. Volume changes for Alternative 7b – fill grain size 0.60 mm.

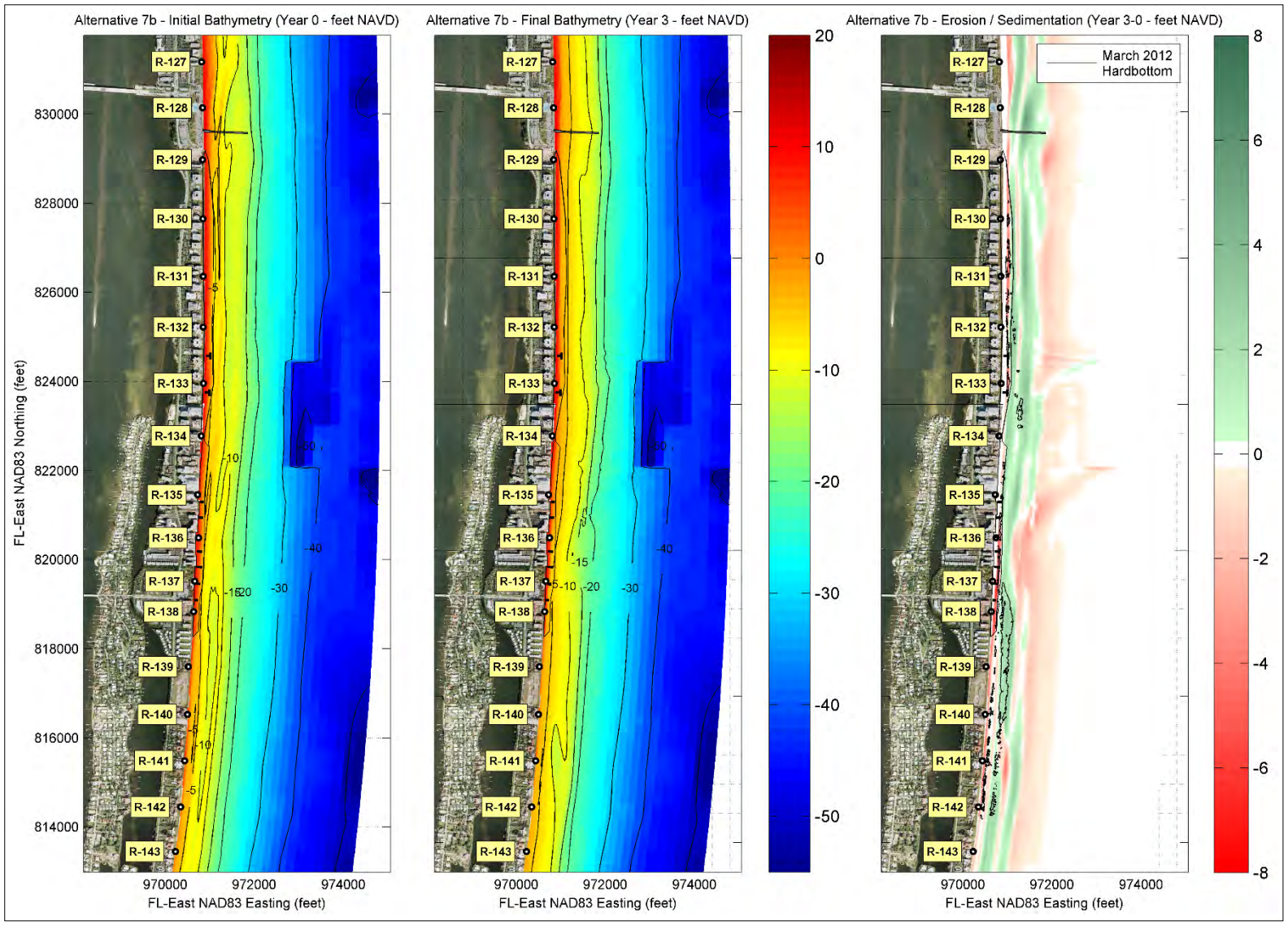

Figure 3-84. Erosion/sedimentation after 3 years of simulation, Alternative 7b - fill grain size 0.60 mm.

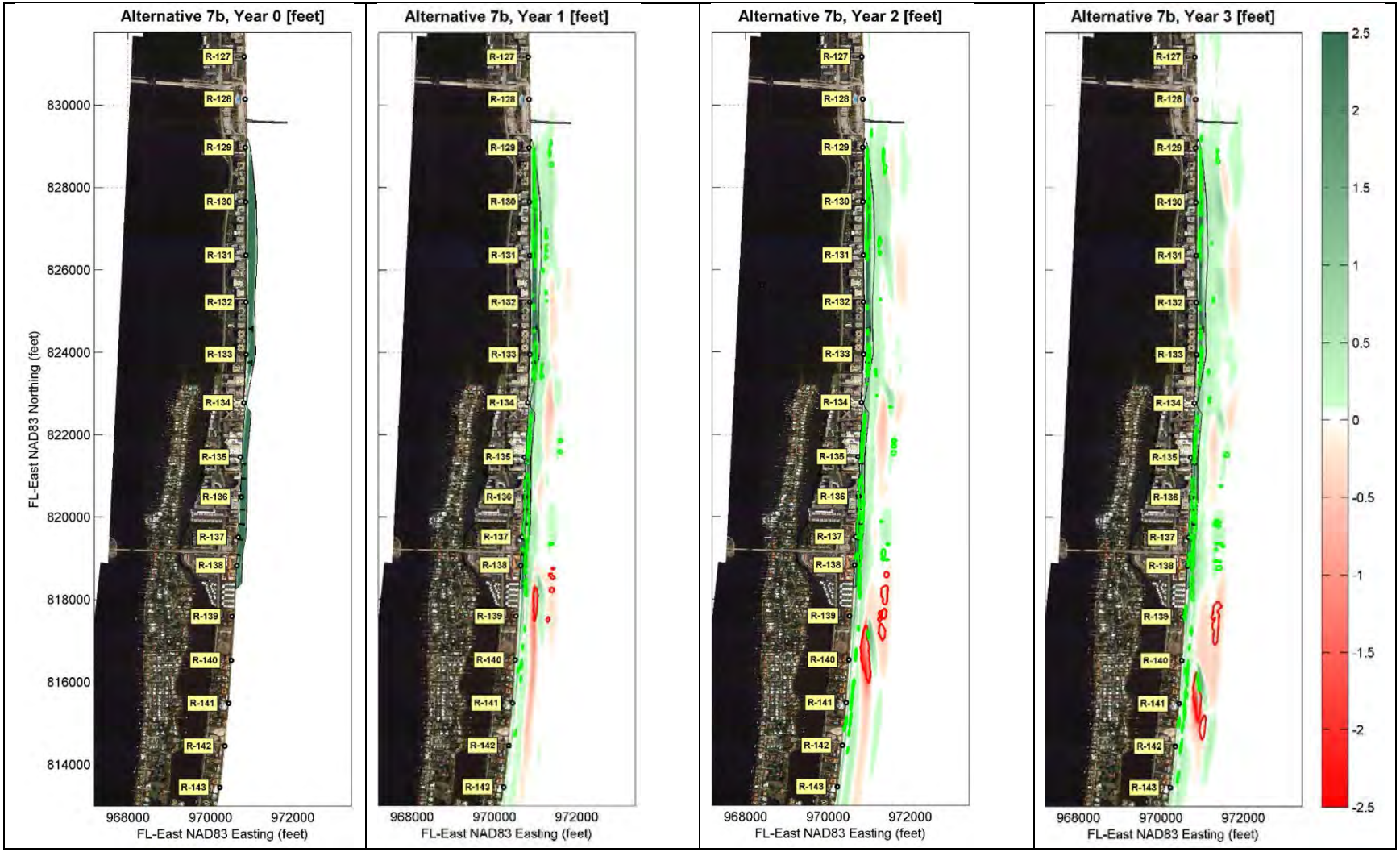

Figure 3-85. Temporal evolution of beach nourishment for Alternative 7b, compared to No Action scenario - fill grain size 0.60 mm.

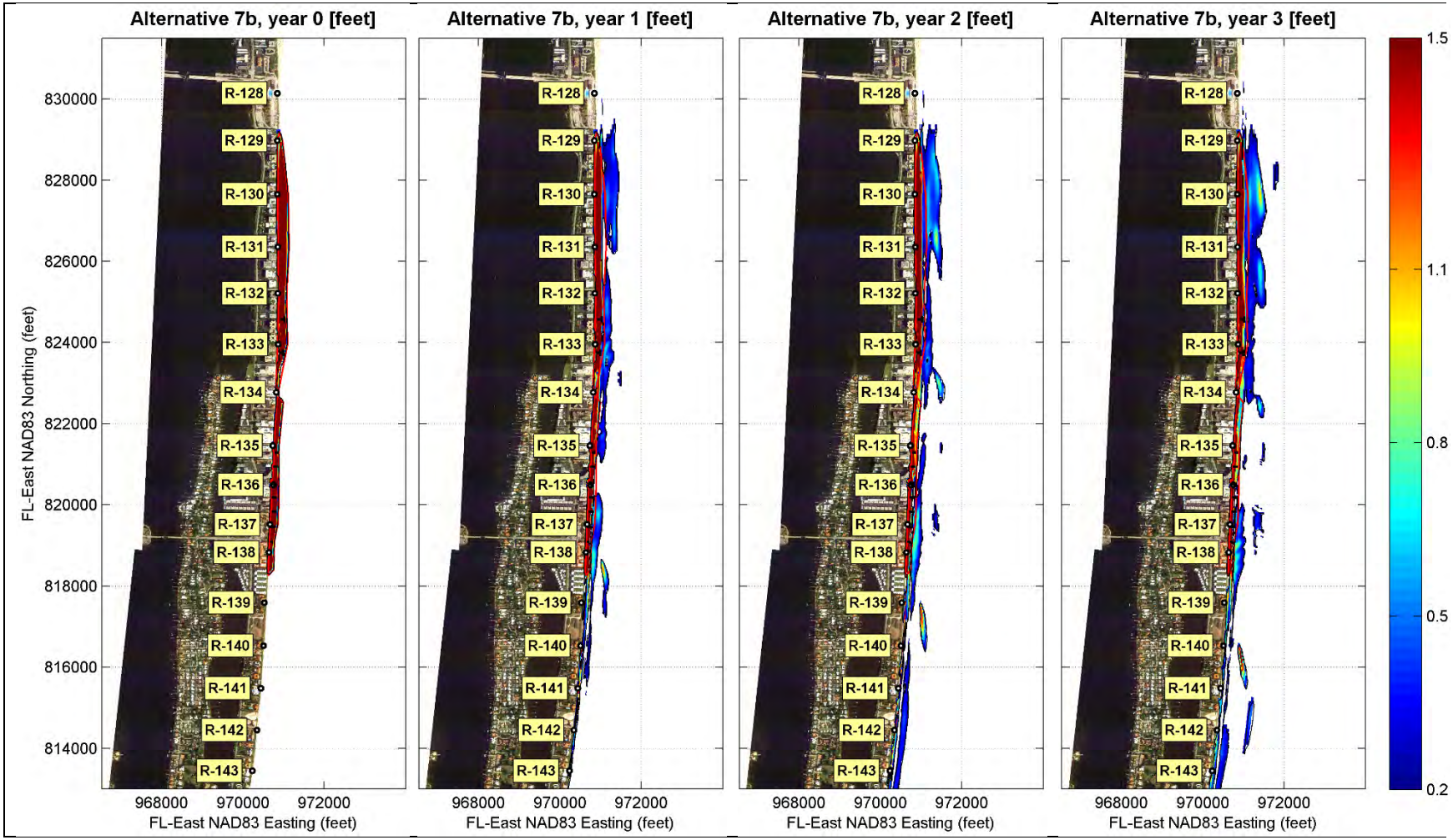

Figure 3-86. Sediment Accumulation greater than 0.2 ft for Alternative 7b - fill grain size 0.60 mm.

Separated Action – Alternative 7bT (Town of Palm Beach portion of alternative)

Model results for Alternative 7bT simulated with fill sediment grain size of 0.60 mm in the Town of Palm Beach's portion of the template appear in Figure 3-87 through Figure 3-90.

Within the areas of sand movement, hardbottom coverage in excess of the No Action Alternative is delineated by the green outlines, while hardbottom exposure is delineated by the red outlines (Figure 3-89). At the end of the 3 year simulation period, there was an estimated coverage of 7.28 acres of hardbottom and an exposure of 2.10 acres attributed to the alternative as depicted in Figure 3-89. The net change in hardbottom at the end of the simulation period (exposure minus coverage) as a result of the project is estimated to be -5.18 acres. The net change is 1.09 acres greater (more coverage) than the net change observed for the same alternative with a fill grain size of 0.36 mm.

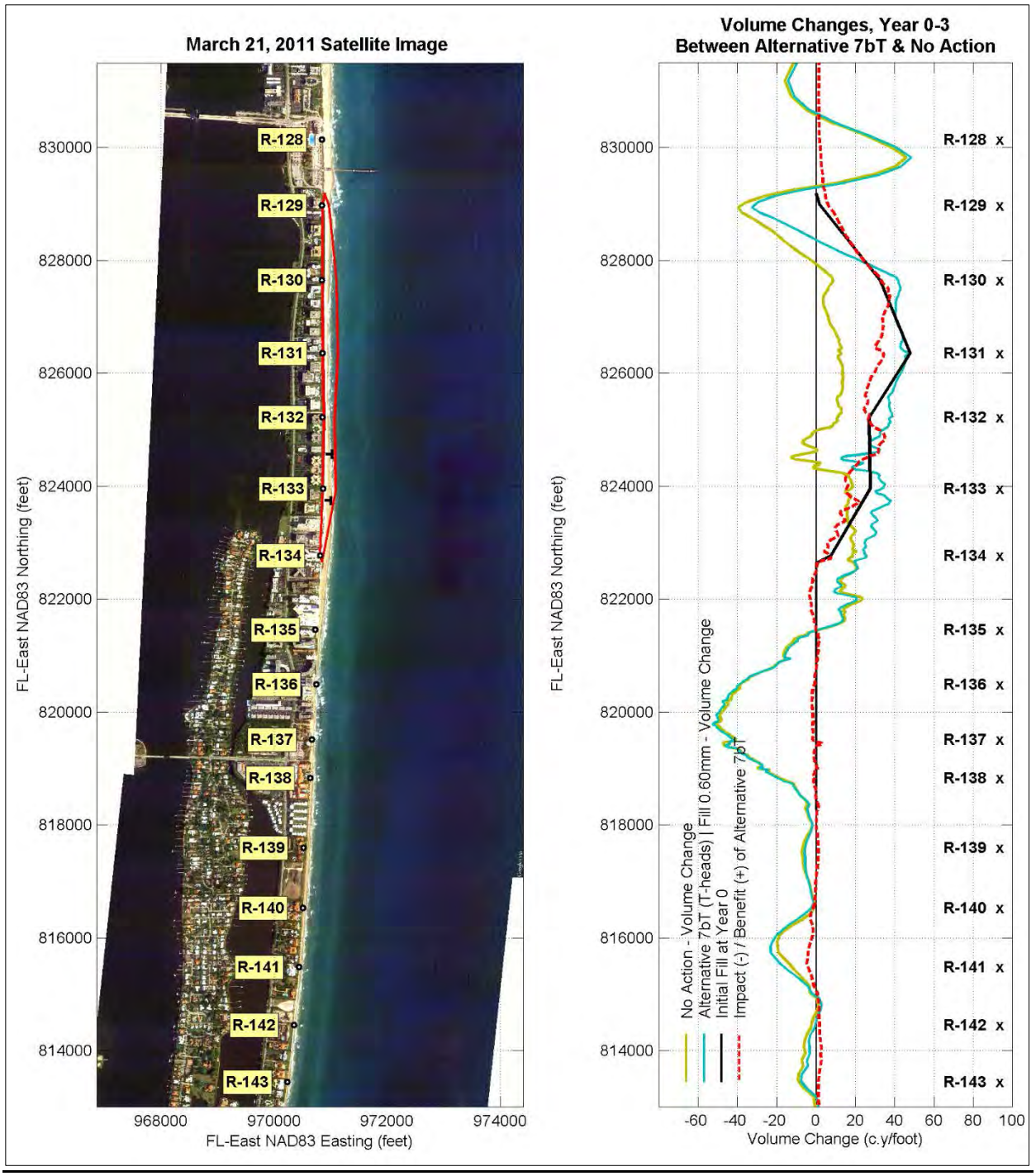

Figure 3-87. Volume changes for Alternative 7T – fill grain size 0.60 mm.

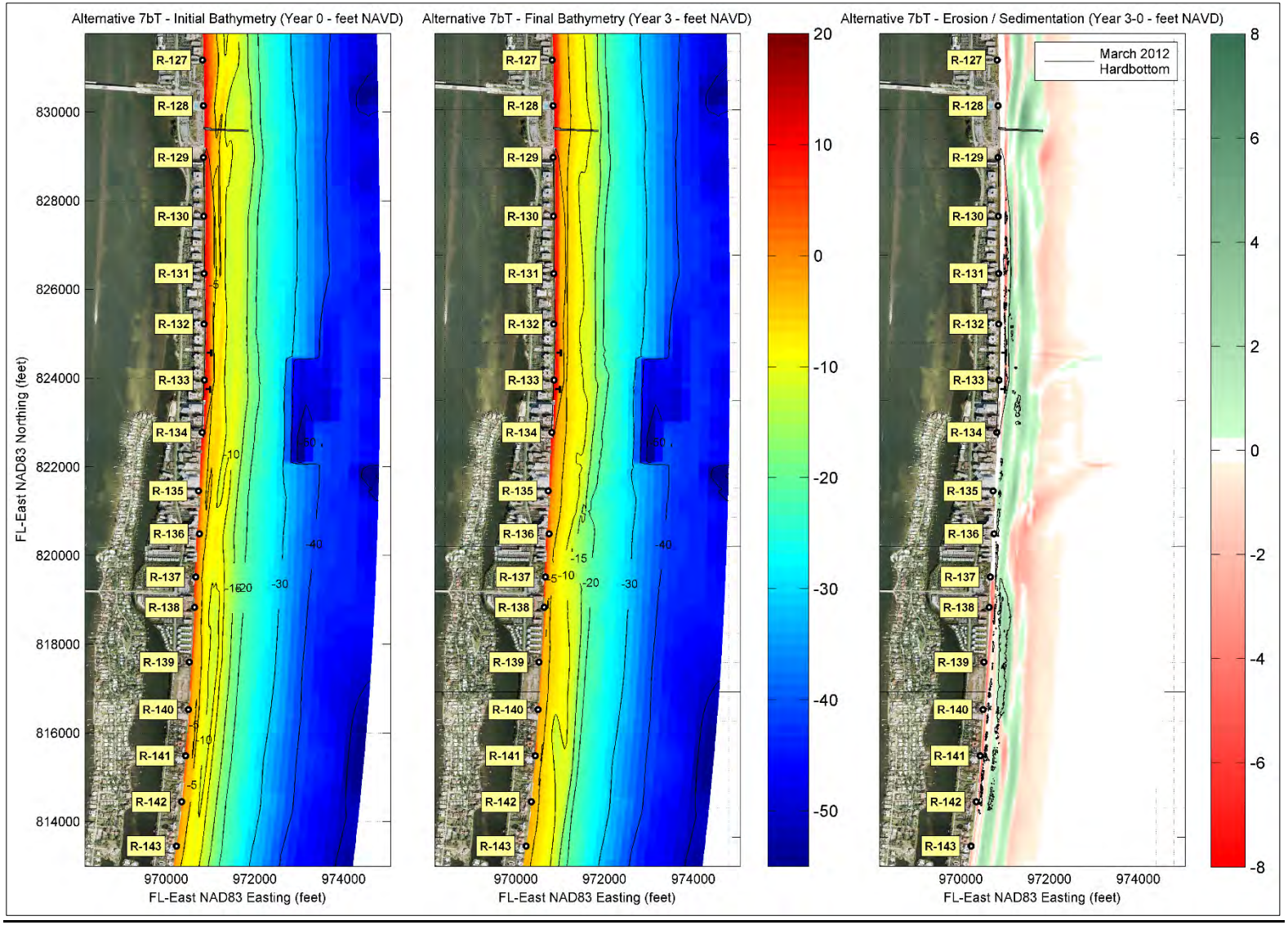

Figure 3-88. Erosion/sedimentation after 3 years of simulation, Alternative 7T - fill grain size 0.60 mm.

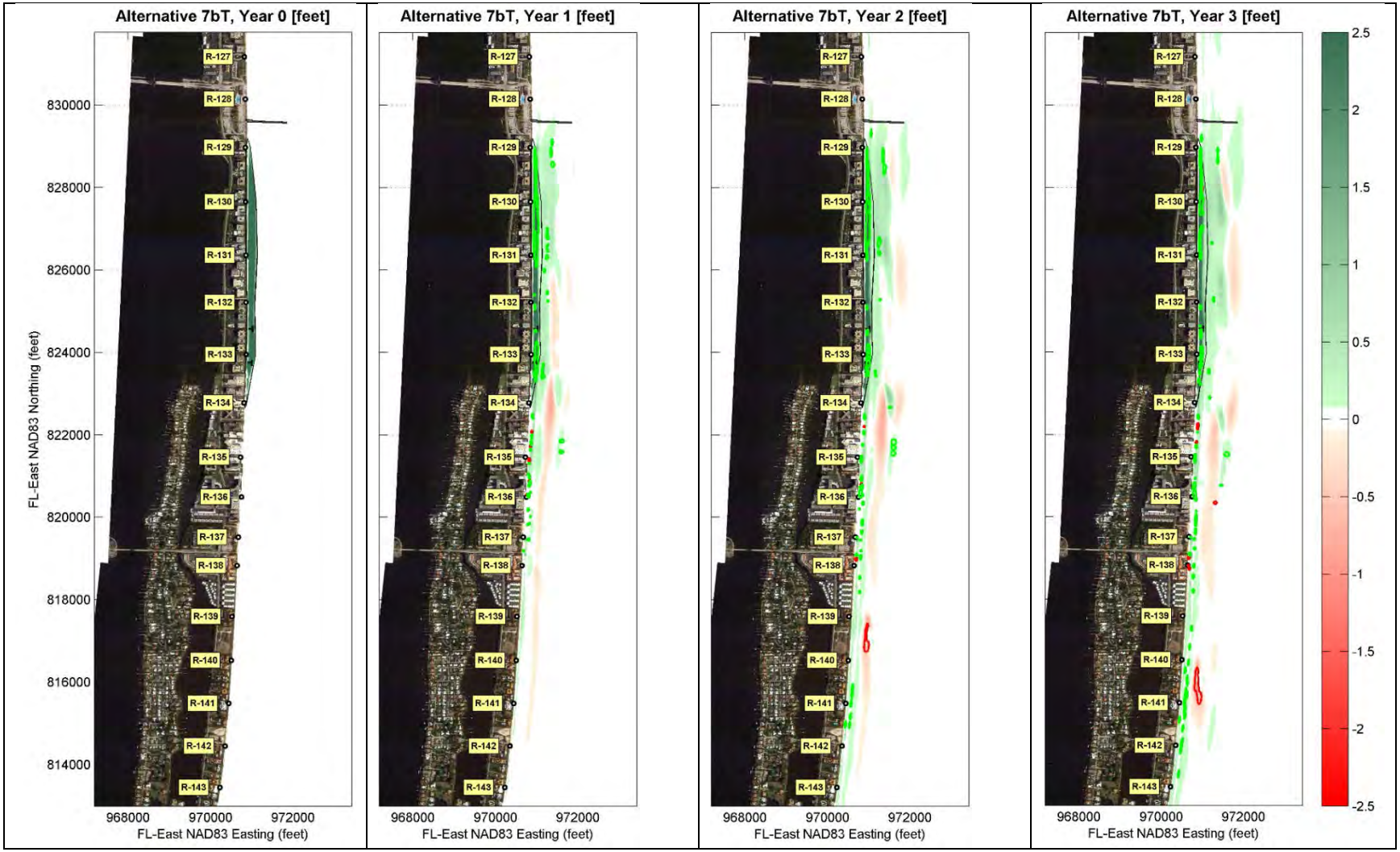

Figure 3-89. Temporal evolution of beach nourishment for Alternative 7T, compared to No Action scenario - fill grain size 0.60 mm.

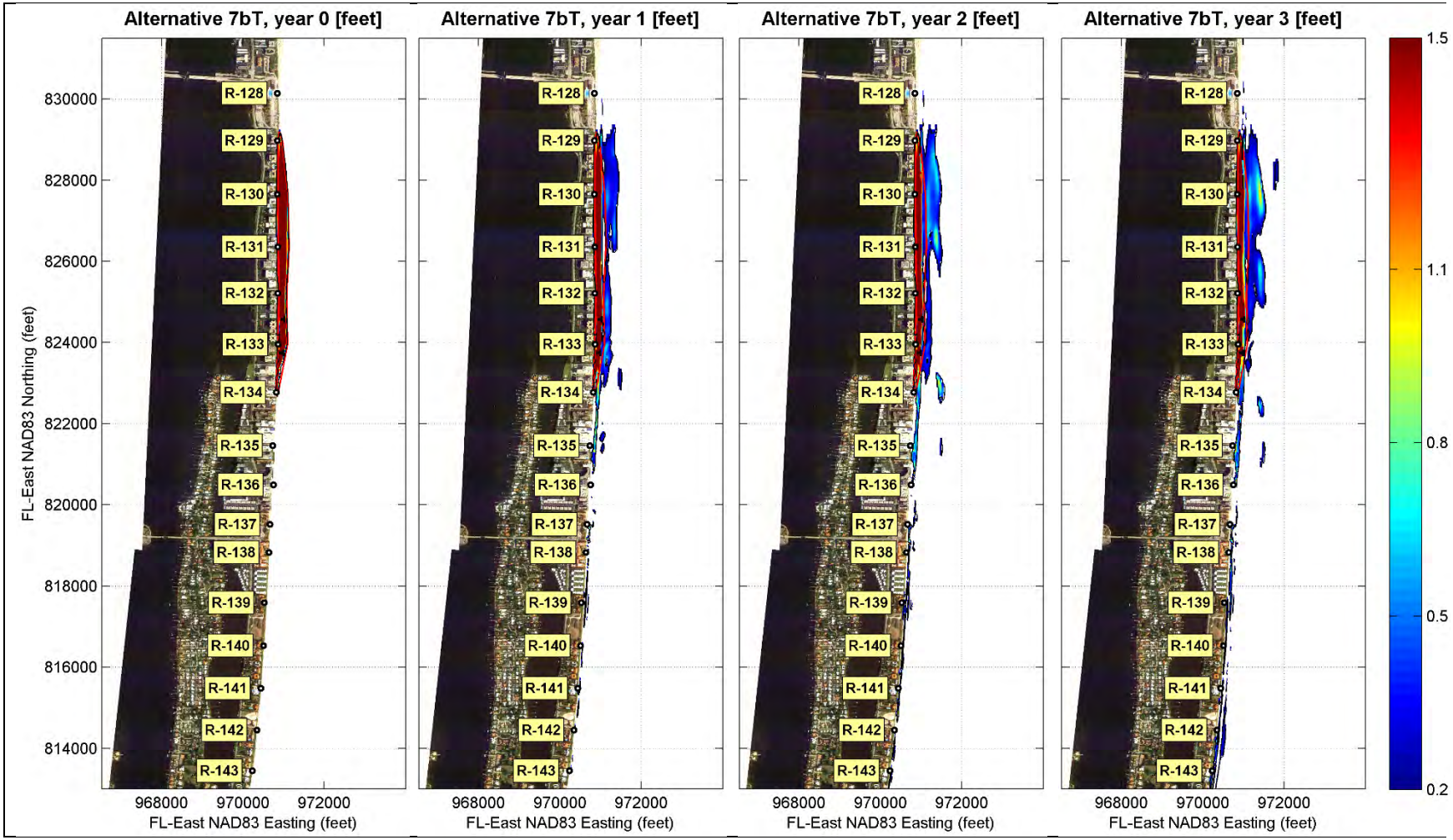

Figure 3-90. Sediment Accumulation greater than 0.2 ft for Alternative 7T - fill grain size 0.60 mm.

4.0 RESULTS SUMMARY

The net hardbottom change in hardbottom of each alternative at the end of the 3 year simulation period presented in the previous sections was summarized in Table 4-1. Negative values denote a net coverage (reduction in exposure) of hardbottom when compared to the No Action Alternative. The trends in hardbottom changes between alternatives simulated during the previous modeling study for a uniform grain size of 0.36 mm were similar to the trends simulated for the range of grains sizes. The absolute magnitude of the changes varied when comparing the range of grain sizes for a particular alternative. There was greater coverage for the simulations that included grain sizes of 0.25 mm and 0.60 mm as compared to the simulations with a uniform grain size of 0.36 mm.

Table 4-1. Net Change in Hardbottom.

Alternative	Net Change in Hardbottom (acres)		
	Grain Size 0.25 mm	Grain Size 0.36 mm	Grain Size 0.60 mm
2	-5.45	-4.78	-5.55
2T	-1.11	-1.04	-1.22
3	-7.25	-7.29	-7.58
4	-11.51	-11.48	-11.94
5	-7.75	-6.64	-7.35
6	-12.98	-12.99	-13.45
6T	-2.63	-2.21	-2.32
7a	-12.24	-10.64	-9.65
7aT	-6.57	-5.54	-5.37
7b	-10.85	-11.12	-7.25
7bT	-4.32	-4.09	-5.18

Hardbottom coverage and exposure discussed in this report were quantified based on the sediment thickness mapping developed as part of the model calibration. Impacts to hardbottom attributable to the project alternatives were assessed based the areas of sediment accumulation greater than 0.2 feet and are presented in the Chapter 4, Section 4.4 of the main text.

5.0 DOWNDRIFT IMPACT ANALYSIS

Downdrift impacts were evaluated by analyzing the volumetric changes within the area extending 4,000 feet south from the south end of the fill templates of each alternative and offshore to the closure depth (-21.5 feet, NAVD88). Erosion and accretion volumes within the defined area were estimated to determine the net volume change (accretion minus erosion). The net changes are presented in Table 5-1. Negative values represent net erosion/loss of sand downdrift and positive values represent net accretion/gain of sand when compared to the No Action Alternative.

Alternative 2 and Alternative 5, which are the alternatives with the groins between R-135+160 and R-137+422, resulted in net erosion downdrift for all the sediment grain size combinations simulated.

Alternative 3, Alternative 4, and Alternative 6 resulted in net accretion downdrift for all the sediment grain size combinations simulated. The accretion volumes for each alternative were higher for the finer grain size (0.25 mm) than for the coarser grain size (0.60 mm).

Alternative 7a resulted in net accretion downdrift for the simulation with a fill grain size of 0.25 mm, and net erosion downdrift for fill grain sizes of 0.36 and 0.60 mm.

Alternative 7b and Alternative 7bT resulted in net accretion downdrift for the simulation with a fill grain size of 0.36 mm, and net erosion downdrift for fill grain sizes of 0.25 and 0.60 mm.

Regarding the remaining Town of Palm Beach only alternatives, Alternative 2T and Alternative 7aT resulted in net accretion downdrift for all the sediment grain size combinations simulated, while Alternative 6T resulted in net erosion.

Table 5-1. Downdrift Net Volume Impact.

Alternative	Downdrift Net Volume Impact After 3 years (cy)		
	Grain Size 0.25 mm	Grain Size 0.36 mm	Grain Size 0.60 mm
2	-6,077	-6,764	-7,993
2T	976	1,115	1,185
3	9,317	8,924	9,029
4	16,815	16,284	15,855
5	-5,406	-6,673	-8,703
6	18,513	17,393	15,848
6T	-1,512	-1,598	-2,261
7a	1,240	-3,649	-6,566
7aT	13,283	16,545	6,513
7b	-2,190	919	-12,600
7bT	-169	1,178	-2,362

6.0 CONCLUSION

The additional Delft3D numerical modeling study was conducted to assess seven "combined" and the four Town of Palm Beach's "separated" alternatives for fill with sediment grain sizes of 0.25 mm and 0.60 mm within the Town of Palm Beach's portion of the project area. Model calibration setup described in Sub-Appendix G-3 was used to assess the performance of the alternatives for the range of grain sizes.

Hardbottom coverage and exposure discussed in this report were quantified based on the sediment thickness mapping developed as part of the model calibration. Impacts to hardbottom attributable to the project alternatives were assessed based the areas of sediment accumulation greater than 0.2 feet and are presented in the Chapter 4, Section 4.4 of the main text.

The following are the primary findings of the study:

- Sediment grain size has an influence on the cross-shore redistribution and the downdrift migration of the fill placed to construct the alternatives. The model results indicated that finer fill material (i.e. sediment grain size of 0.25 mm) was redistributed further offshore and downdrift during the 3 year simulation periods as compared to coarse fill material (i.e. sediment grain size of 0.60 mm). The

influence of grain size on the movement of fill material within the coastal system becomes more apparent as the volume of fill increases and more sand is placed within the water. Alternatives 2 and 3 included the smallest fill volumes and the influence of grain size was not as readily apparent. Alternative 7 contained the greatest fill volumes and the influence of grain size was most apparent.

- While finer fill material tends to be redistributed further offshore and downdrift, this may not result in a direct correlation to increased hardbottom impacts. Hardbottom within the project area are highly ephemeral and the impacts attributed to the project's fill material are highly dependent upon the spatial relationship between the areas of the sedimentation and exposed hardbottom.

- The downdrift impact analysis indicated that two factors increase the likelihood of erosion downdrift (south) of the Project Area for the alternatives considered.
    - Shoreline protection structures
    - Coarser fill material (i.e. larger sediment grain sizes)
- The downdrift impact analysis indicated that larger fill volumes increased the likelihood of accretion downdrift of the project area, but greater hardbottom coverage.

The results of this numerical modeling study should be used in conjunction with other coastal engineering assessments and prudent engineering judgment.

7.0 LITERATURE CITED

Deltares. 2011. Delft3D-FLOW Simulation of Multi-Dimensional Hydrodynamic Flows and Transport Phenomena, Including Sediments, User Manual, Part of Hydro-Morphodynamics, Deltares, Delft, the Netherlands.

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