Chapter 5 Conclusions & Recommendations

5.1 Summary

The coastal condition assessment was completed to investigate the main coastal hazards, and to provide setback distances and design flood elevations for the design of the 'Escape To Barbuda' development. The coastal development is located along the southwest coast of the island of Barbuda, and naturally protected from easterly swell waves. The project area is relatively flat with mild sloping sandy beaches (with rocky limestone and karst formations) and densely vegetated backshore areas.

Historical satellite images indicate limited shoreline change in the last couple of decades. The shoreline change at the site is mainly driven by extreme events like hurricanes. The normal daily wave conditions (i.e. calm conditions) have limited sediment transport capacity and are therefore not considered the main sources of coastal erosion.

Sea level is expected to rise 0.84 m (RCP8.5) by 2100, this will inevitably increase the risk of flooding and potentially coastal erosion. Natural coastal adaptation like sustaining or improving existing coral reef coverage and enhancing natural beach stability may be possible, but will depend on multiple factors, like water quality (for healthy coral growth), sediment availability (to allow for natural beach buildup), and broader impacts from climate change.

The most significant coastal hazard for the project site are hurricane events, leading to extreme surge, wave run-up and erosion. Barbuda has experienced the devastation of hurricanes in recent history, first with hurricane Luis in 1995 and more recently hurricane Irma in 2017. An analysis of hurricane frequency was completed using all hurricanes on record (170 years of hurricane tracks dating back to 1851), which provided representative storm conditions that were used as input for the numerical modelling component of this project.

The numerical modelling included calculation of wave propagation, wave run-up and beach erosion. The nearshore wave conditions were derived using Delft3D-WAVE and served as input for the run-up and beach erosion simulations that were performed using XBeach. Setback distances and design flood elevations were defined based on the numerical modelling results for non-hurricane wave conditions and three different hurricanes Categories (1, 3 and 5). The impacts of a Category 4 or 5 hurricane are likely too severe and catastrophic to accommodate in a reasonable setback design allowance, and are therefore not practical for land planning purposes. Major redevelopment actions are expected after these extreme events make landfall. Therefore, for the scale of the 'Escape To Barbuda' development we recommend the use of results from the Category 3 hurricane as the minimum setback distance and design flood elevation for infrastructure prone to damage caused by temporary flooding or erosion. Ultimately the level of risk tolerated at the site should be selected by the developer, considering the likelihood of a certain event occurring, the impacts it will have, and the resources available to manage that risk during the design stage of the project or in the future once it occurs.

Summary of Design Flood Elevation and Setback Distance

Extreme Event	Design Flood Elevation (MSL)	Design Flood Elevation Including	Erosion Setback Distance from the
Extreme non-Hurricane Wave Conditions	1.0 m (3.3 ft)	1.8 m (5.9 ft)	7 m (23 ft)
Hurricane – Category 1	2.3 m (7.5 ft)	3.1 m (10.2 ft)	15 m (49 ft)
Hurricane – Category 3	3.8 m (12.5 ft)	4.6 m (15.1 ft)	35 m (115 ft)
Hurricane – Category 5	5.8 m (19 ft)	6.6 m (21.7 ft)	80 m (262 ft)

The proposed risk mitigation measures proposed by CBCL include:

- Elevating the ground floor of critical infrastructure to at least 3.8 m (12.5 ft).
- Maintaining a healthy beach environment, including maintaining the beach well-nourished and protecting the coral reefs and vegetation.
- Avoid any type of infrastructure near the high water line.
- Disturb the natural beach profile as little as possible
- No cabanas or other temporary structures should be placed on the dune or the beach.
- Developing post-storm contingency beach nourishment plans, including the regular monitoring of beach profiles.
- Maintain or enhance local vegetation on the dune, and further inland, as it both stabilizes the dune and acts as a natural wave energy dissipation mechanism during storm surge events.
- Monitor and protect the existing coral reef system near the property.

5.2 Recommendations

Subsequent design of the proposed elements of the 'Escape To Barbuda' coastal development should be informed with the outcome and recommendations from this study. Long-term plans for the area must account for the ever-growing risks of coastal flooding due to accelerating sea level rise, combined with storm surge and wave run-up. Finally, it is recommended to further develop long-term coastal monitoring tools. Monitoring will provide a record of coastal processes, future long-term changes and impacts from extreme

[30] Based on the average beach slope derived from the topo-bathymetric transect measurements and DTM.

future storm events. Recommended information to formally document includes monitoring and surveying of pre-determined beach profiles, flood level measurements, limits of wave run-up, and reports of wave damage. The information would serve as a validation of assumptions and models used for this study, and for future update of plans and models for mitigation of local coastal risks.

5.3 Limitations

The results presented in this report are indicative of the information that was made available to CBCL at the time of the study. Should additional information become available, CBCL requests that this information be brought to our attention so that we may re-assess the conclusions presented herein. While most of the information came from carefully documented and reliable sources (e.g. beach transect surveys, offshore wave climate), other types of available information were more anecdotal in nature (e.g., flood levels, local wave impacts) which did not allow for a detailed quantification of model error range. Due to the very dynamic aspect of the area and the complex nature of wave processes examined (sea state with important swell and hurricane dominated storms), results should be interpreted with caution.

We very much look forward to your comments and feedback on the contents of this report. Please do not hesitate to contact the undersigned with any questions or comments you may have.

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Xbeach User Manual https://xbeach.readthedocs.io/en/latest/user_manual.html

APPENDIX A

Aerial Images

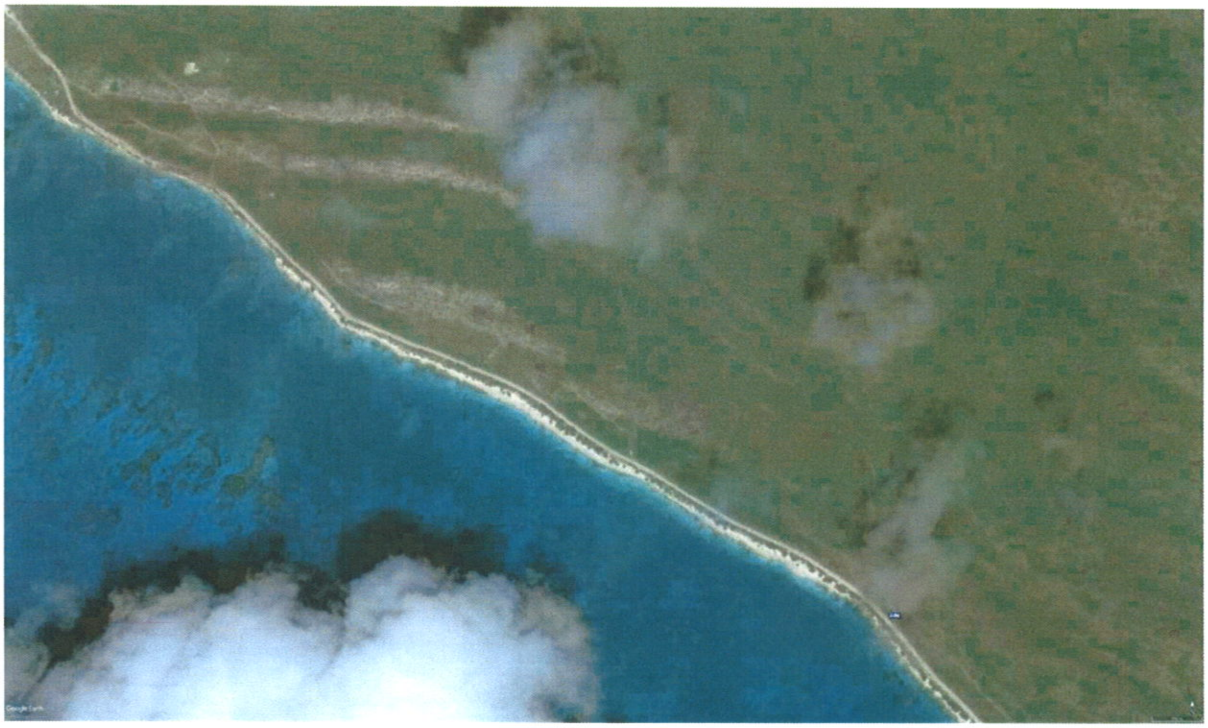

Figure A.1: Aerial image September 2005

Figure A.2: Aerial image April 2014

Figure A.3: Aerial image June 2016

Figure A.4: Aerial image October 2019

Figure A.5: Aerial image March 2020

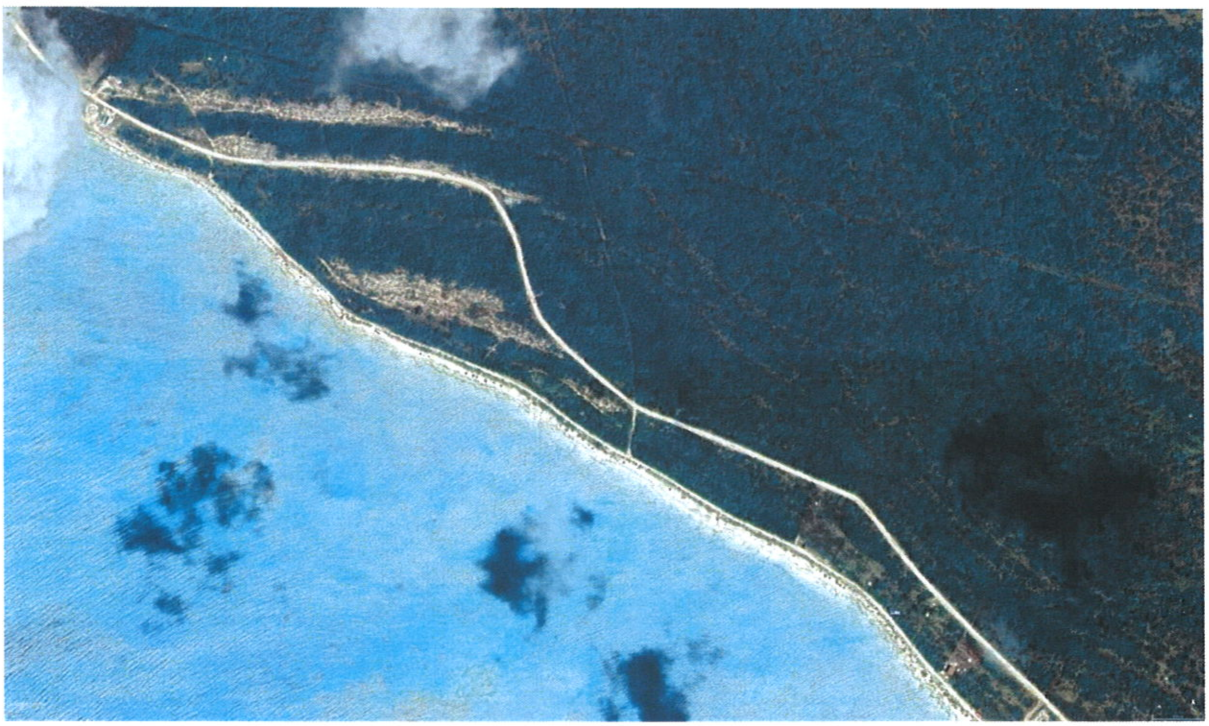

Figure A.6: Aerial image October 2020

APPENDIX B

Wave Propagation

Results Delft3D-WAVE

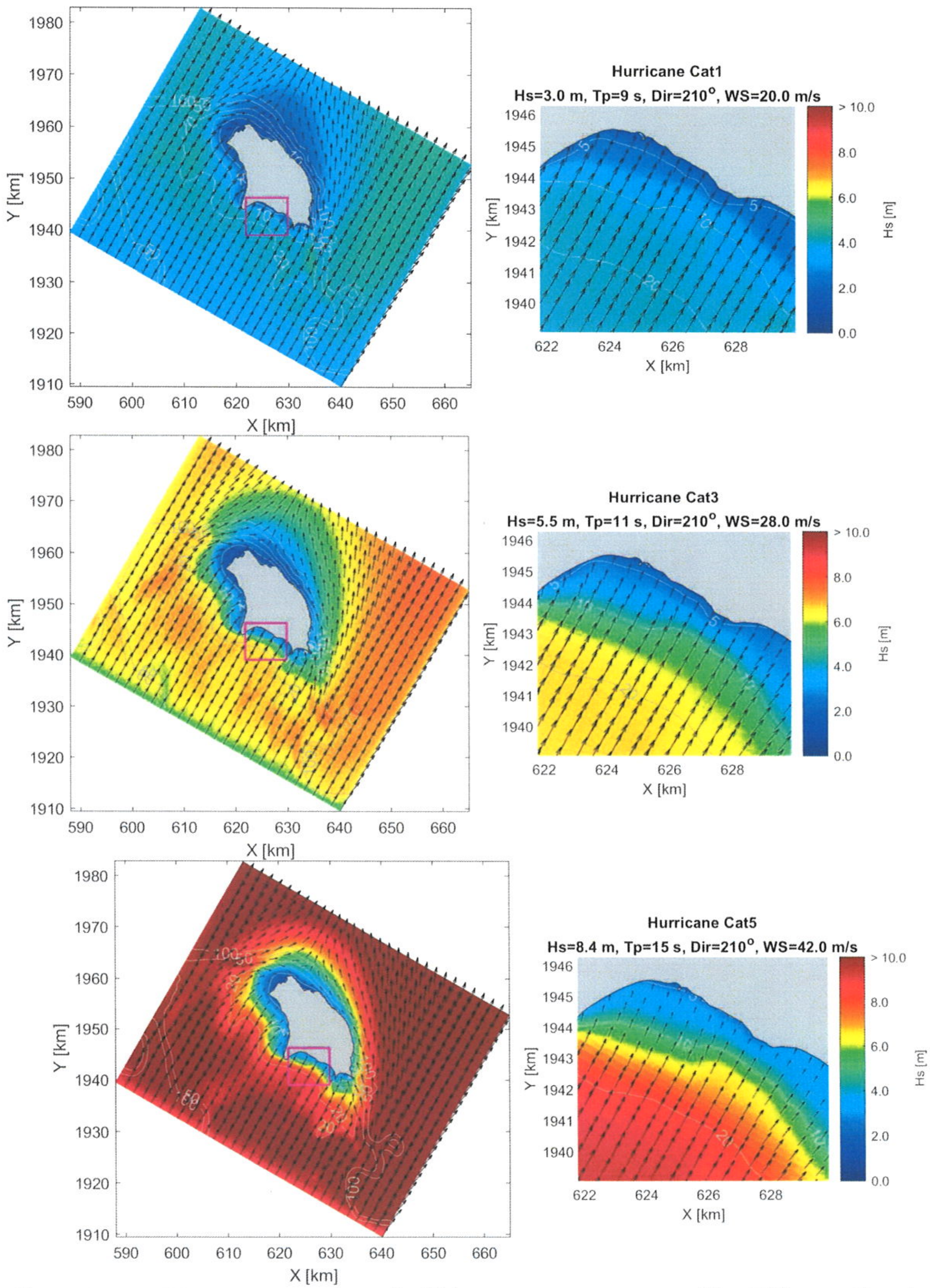

Figure B.1: Wave Propagation of Offshore Waves Generated by Different Hurricane Categories

APPENDIX C

Wave Run-up and Erosion

Results XBeach

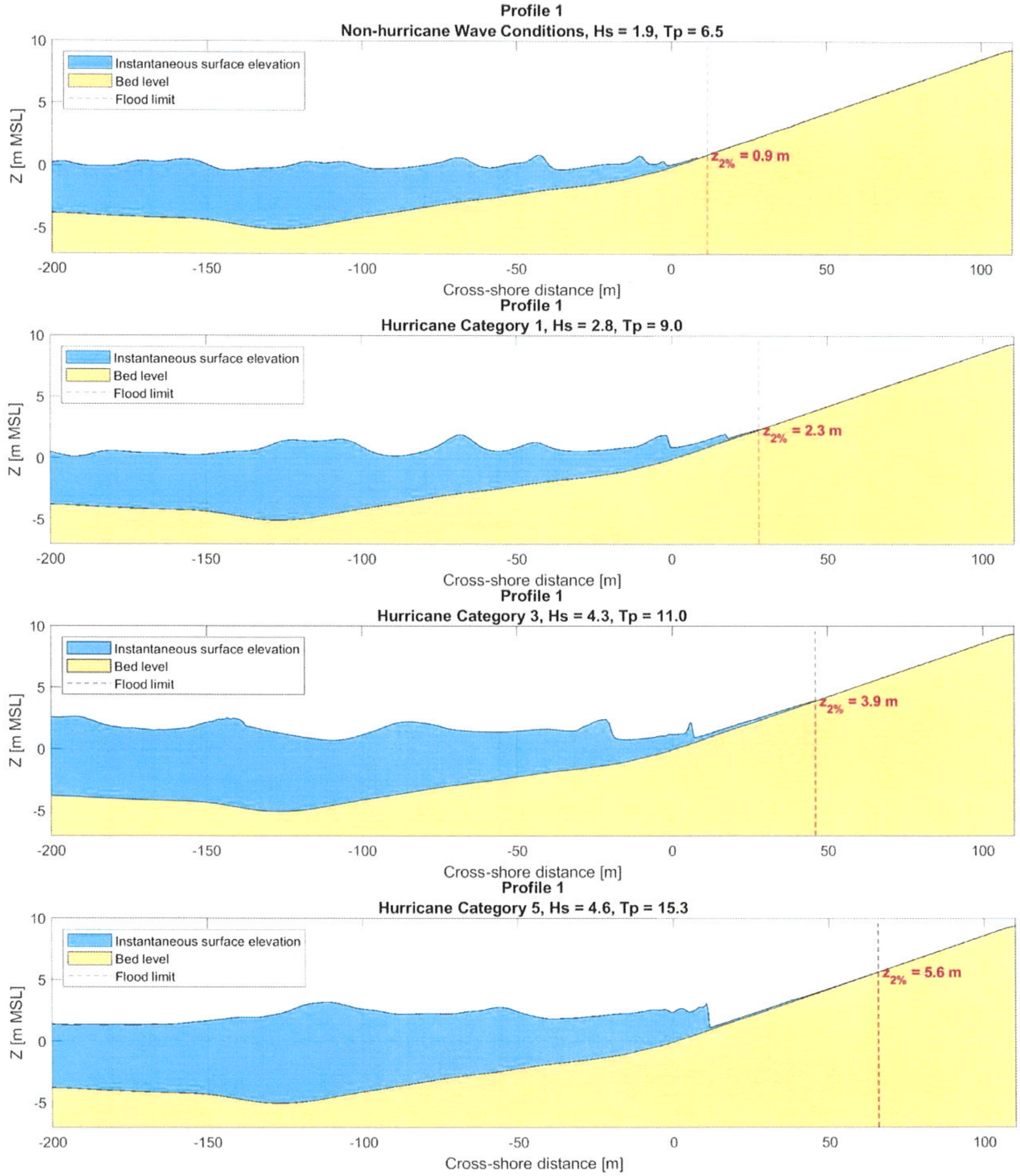

Figure C.1: Instantaneous Surface Elevations at the Peak of the Storm and Wave Run-up for Profile 1 for Different Scenarios

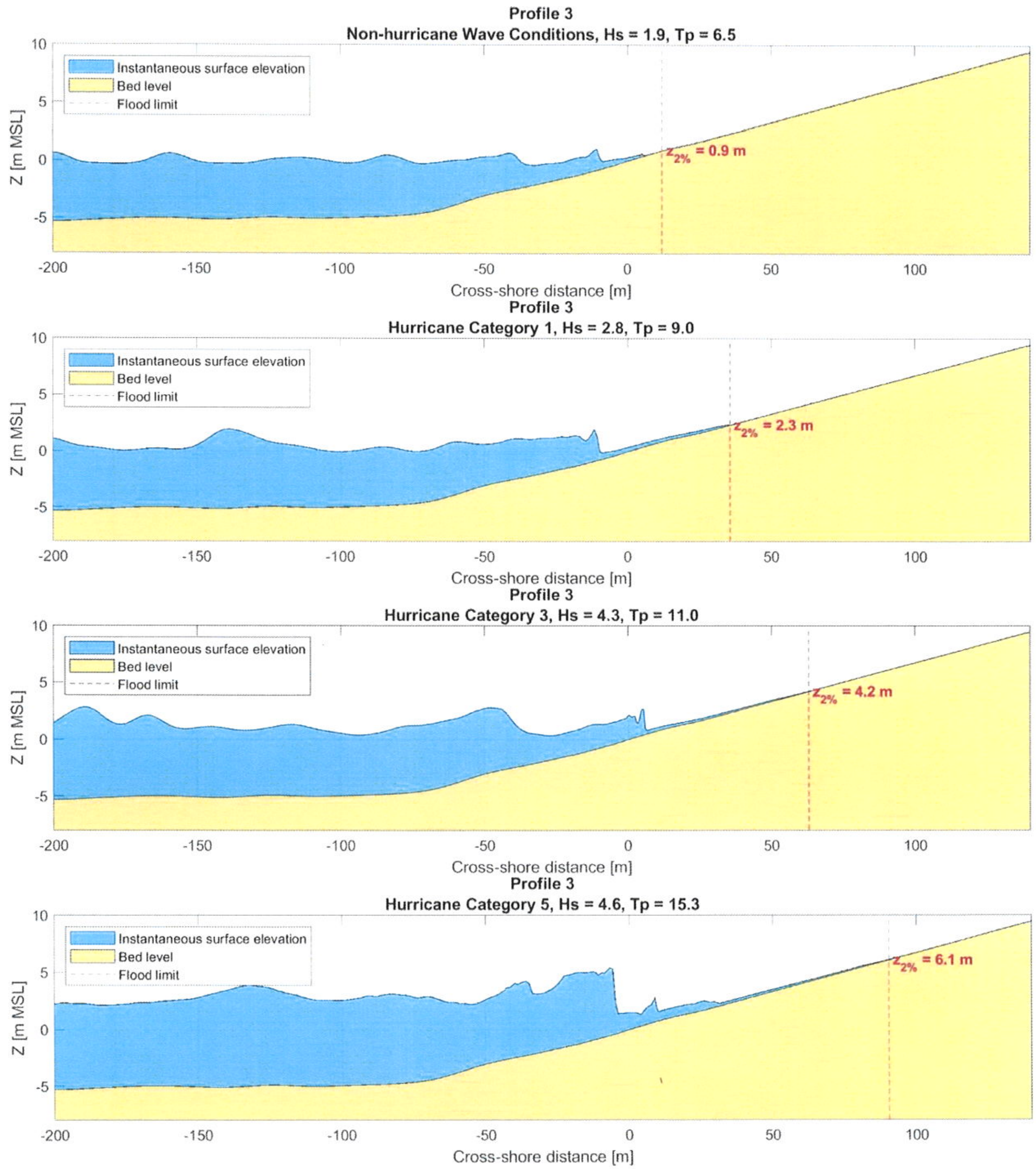

Figure C.2: Instantaneous Surface Elevations at the Peak of the Storm and Wave Run-up for Profile 3 for Different Scenarios

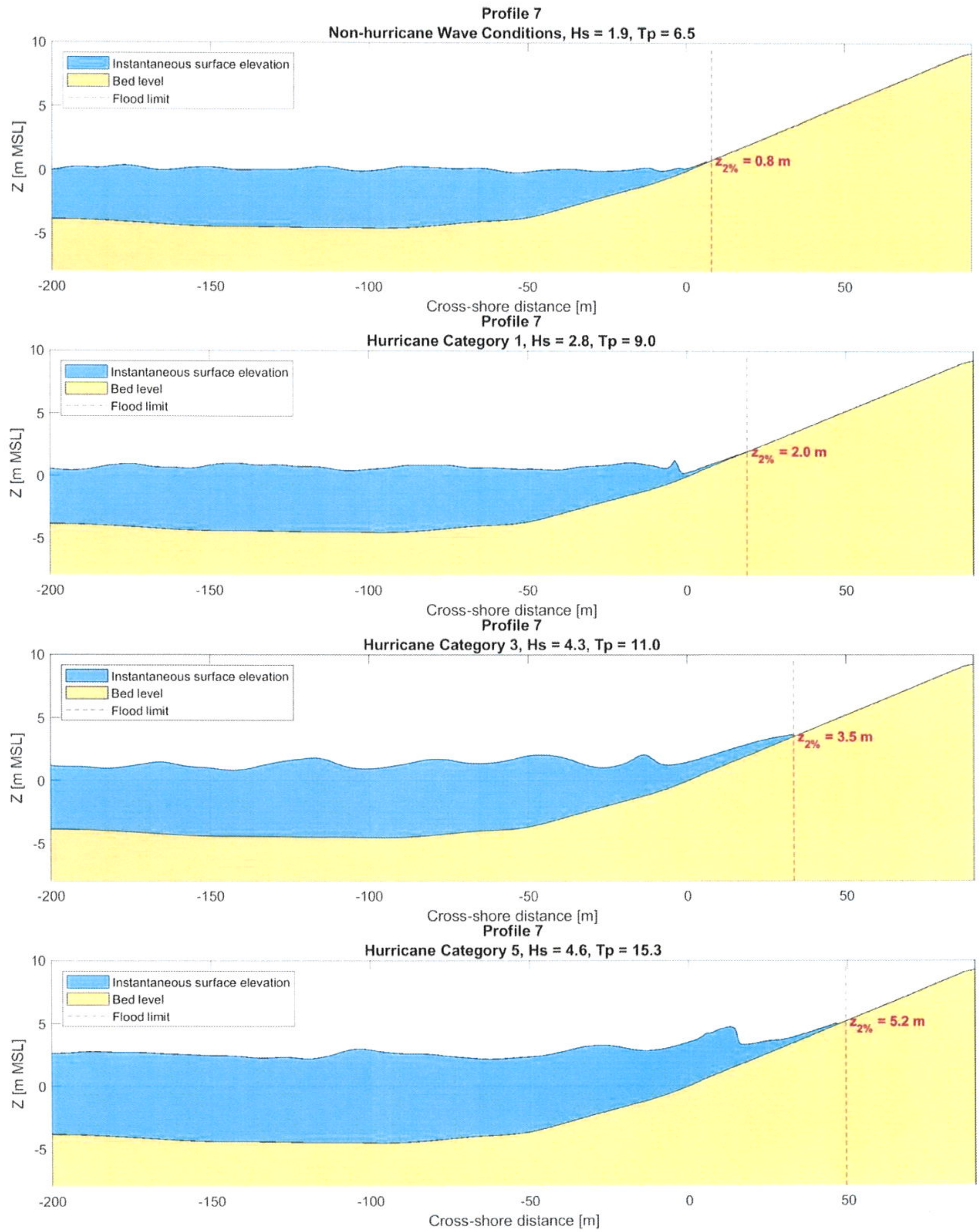

Figure C.3: Instantaneous Surface Elevations at the Peak of the Storm and Wave Run-up for Profile 7 for Different Scenarios

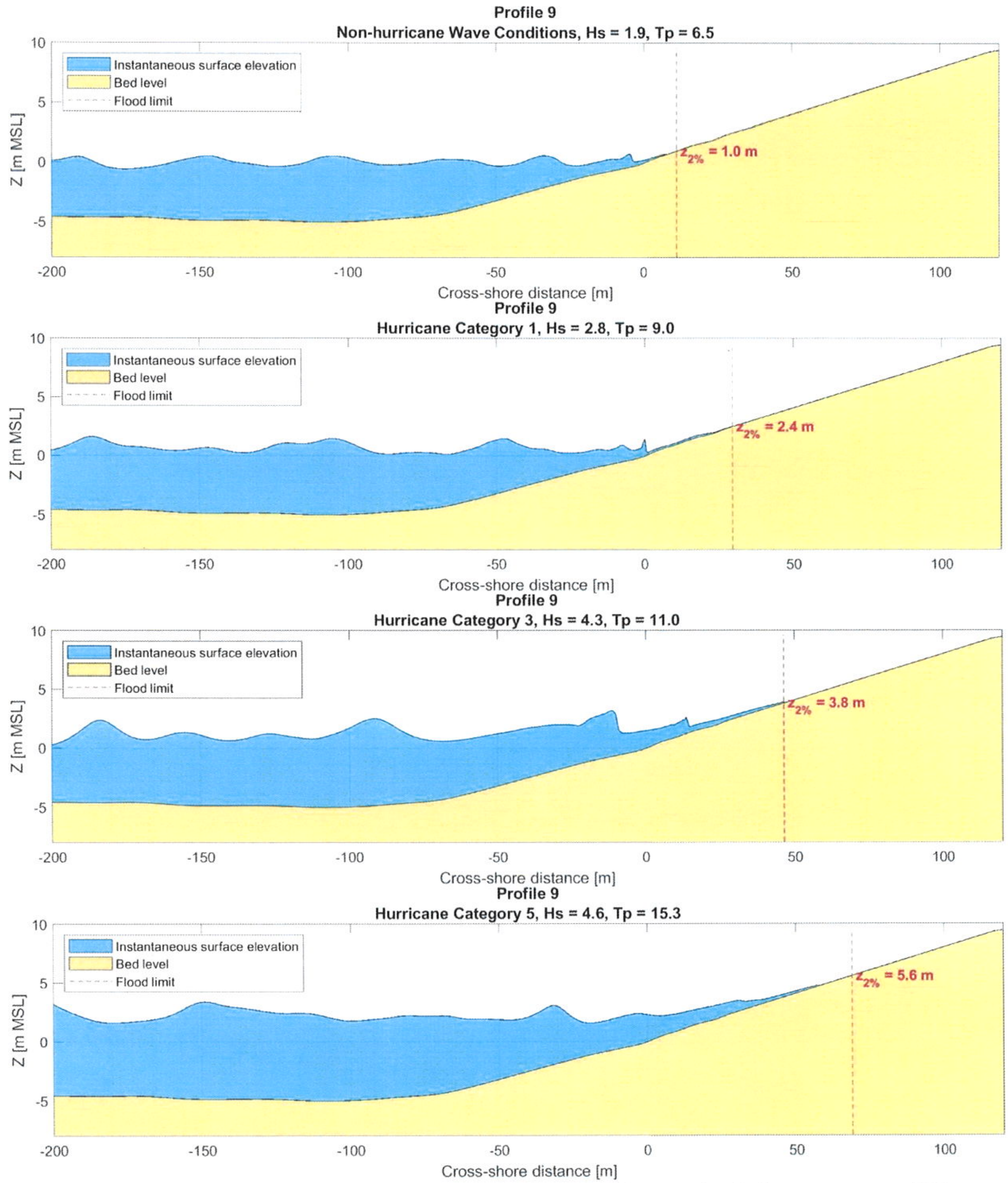

Figure C.4: Instantaneous Surface Elevations at the Peak of the Storm and Wave Run-up for Profile 9 for Different Scenarios

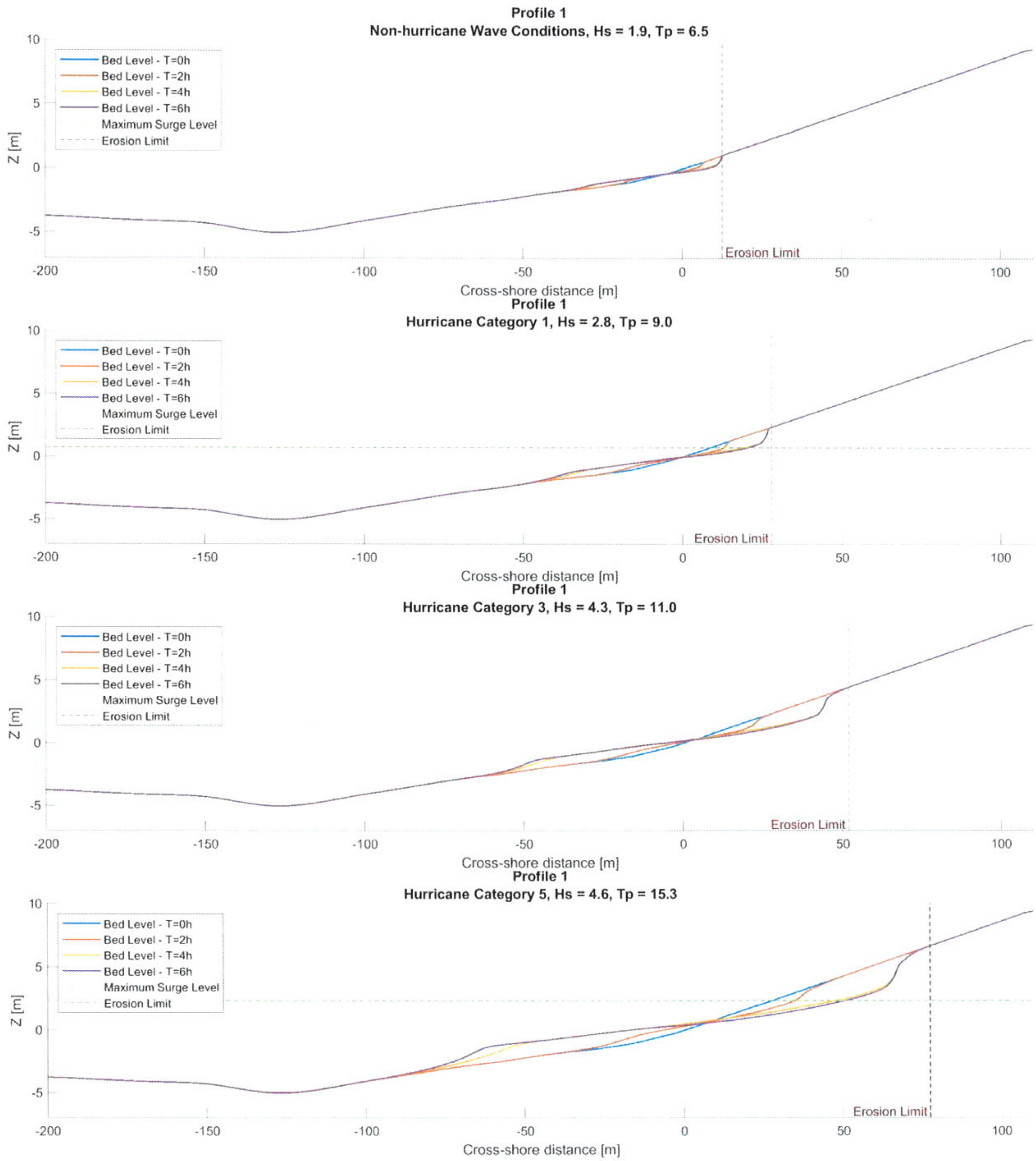

Figure C.5: Beach Morphological Development for Profile 1

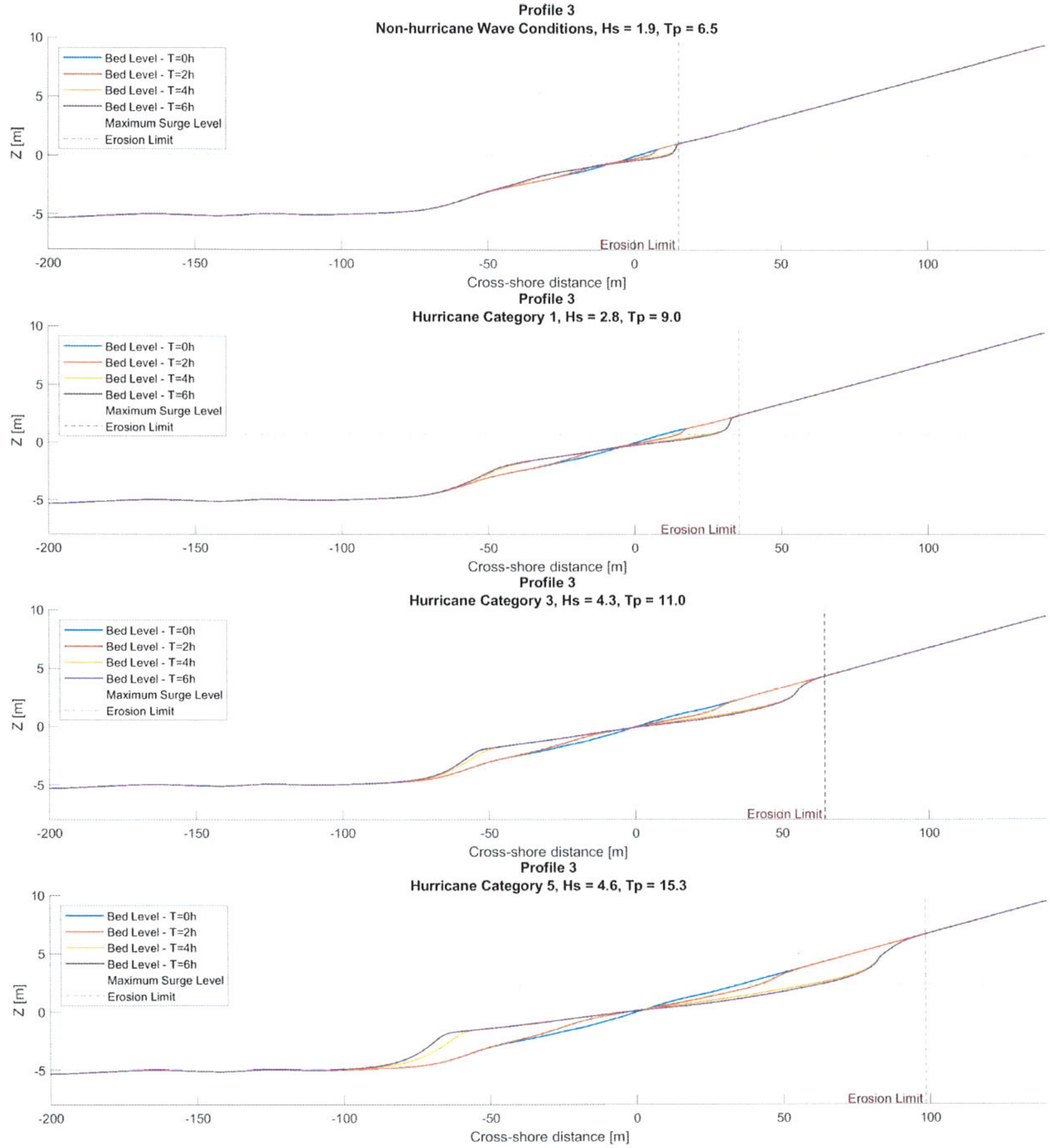

Figure C.6: Beach Morphological Development for Profile 3

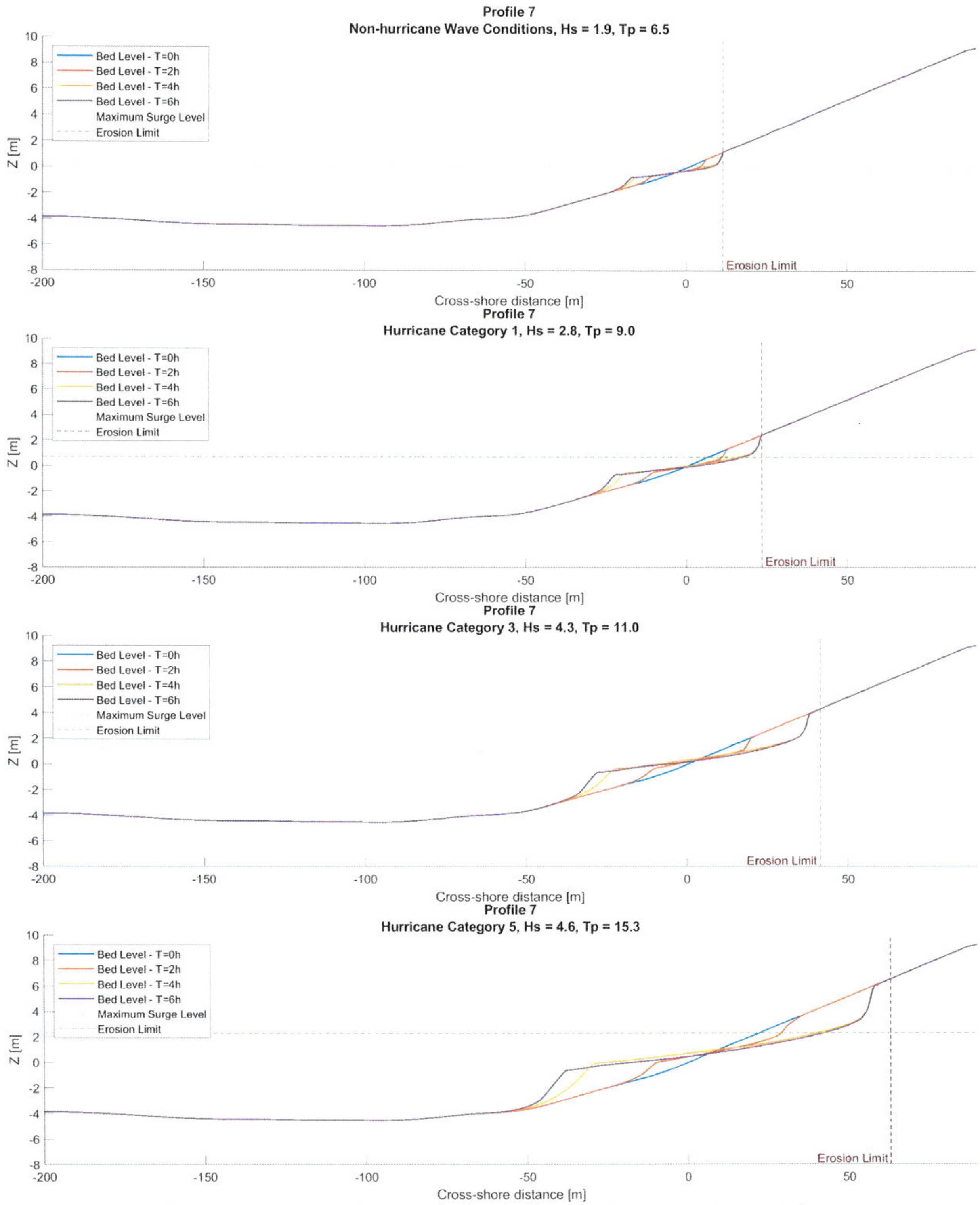

Figure C.7: Beach Morphological Development for Profile 7

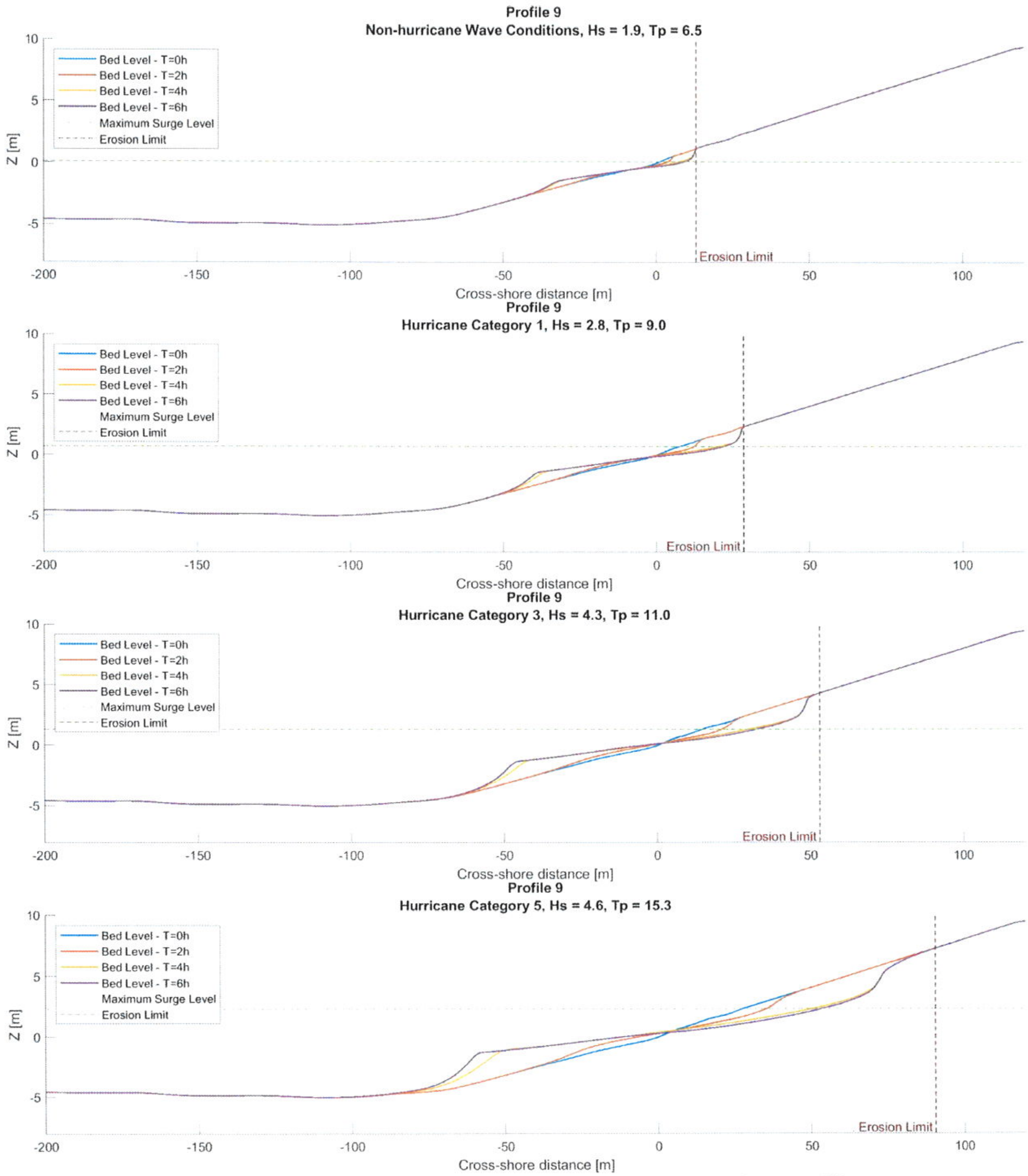

Figure C.8: Beach Morphological Development for Profile 9

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