SOUTH WEST COASTAL MONITORING

making space for sand



Making Space for Sand – Lelant Towans Beach Report

Topographic and LiDAR Data Analysis

SWCM | TBR16 | 17/05/2024

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Taken by: Joseff Saunders

Summary

This report utilises Light Detection and Ranging (LiDAR, topography and aerial imagery data collected by the South West Coastal Monitoring (SWCM) Programme to analyse beach and dune volume at Lelant Towans. The aim is to highlight coastal change at Lelant Towans using SWCM data since 2007, focusing on beach and dune areas categorised into four zones: Beach, Mobile, Fixed, and Developed. Lelant Towans, situated within Hayle Estuary, a north-northwest facing large sandy beach backed by a dune system. Topographic data collected bi-annually along fixed cross-shore profile lines are presented to indicate change of the intertidal beach area over time. LiDAR data is compared from each available flight to show difference models of the intertidal area, to compare volumetric data over time and to show change in Mean Seal Level and Dune Toe contours over time.

Since 2007, 45 topographic surveys were conducted at Lelant Towans, including 9 repeat full surveys (from 2013) and 36 interim surveys. Analysis of topographic data suggests the survey unit has progressively lost volume between 2007 and 2024. Notable fluctuations were observed in survey results, with data suggesting periods of beach recovery, however despite this, multiple drops in volume are seen throughout. Profile 700775 has observed the lowest area on record, whilst the remaining profiles have suggested to be subtlety lowering over time. It is important to note the changing river path can heavily influence the data.

Beach volume is extracted from the Mobile and Beach Zone for 10 LiDAR flights between 2007 and 2023. The Mobile Zone shows a strong erosive trend, losing 67% of volume between 2008 and 2023. Similarly, the Beach Zone has also shown a positive trend of erosion, losing 4% of total volume between the same survey dates, however, greater fluctuation is expected within the Beach Zone due to the influence of the Hayle River. The Dune Toe contours have shown dune retreat, by up to 14 m, to the western extent of the beach.

Overall, Lelant Towans beach has a negative trend, progressively losing volume on the dunes, more prominent loss is seen to the west. The dunes to the east have appeared to accrete and build-up, whilst to the north the dunes have experienced a significant loss. The intertidal zone, on the eastern end of the beach, can significantly differ with each survey, likely due to the changing river path.

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1.0 Introduction

The aim of this report is to highlight beach and dune change at Lelant Towans Beach using data collected as part of the South West Coastal Monitoring (SWCM) Programme since 2007. Four zones have been identified to define the beach/dune area and are defined as:

- **Beach Zone** – The wet beach area has been defined using Mean Low Water Spring (MLWS) and Mean High Water Spring (MHWS) contours extracted from all LiDAR data captured by SWCM. The Beach Zone will therefore encompass the area between the MHWS and MLWS contours, with volumes for this area extracted from each LiDAR surface.
- **Mobile Zone** – This area is defined as the active dune face and embryo dune[1] from MHWS +1 m to the back of the mobile area, often distinguished by vegetation depth or urban development. The Mobile Zone has been defined using aerial imagery from 2007 to 2021 and historic OS maps and has been verified through site visits.
- **Fixed Zone** – This area is defined by permanent dune vegetation that may also include scrub or invasive species, effectively denoting vegetation atop sandy soil.
- **Developed Zone** – This is defined as urban development areas (i.e., car parks, unnatural grassy areas, roads, houses etc.) which have been built atop previously present dune systems.

1.1 Study Site

Lelant Towans, situated within Hayle Estuary, is a north-northwest facing large sandy beach backed by a dune system, and a golf course (Fig.1). The River Hayle runs along the western side of the beach which causes considerable geomorphology changes as a result of fluvial influence. The beach has a cross-shore section of ~400 m and longshore distance of ~1.2 km with an average spring tidal range of 5.8 m.

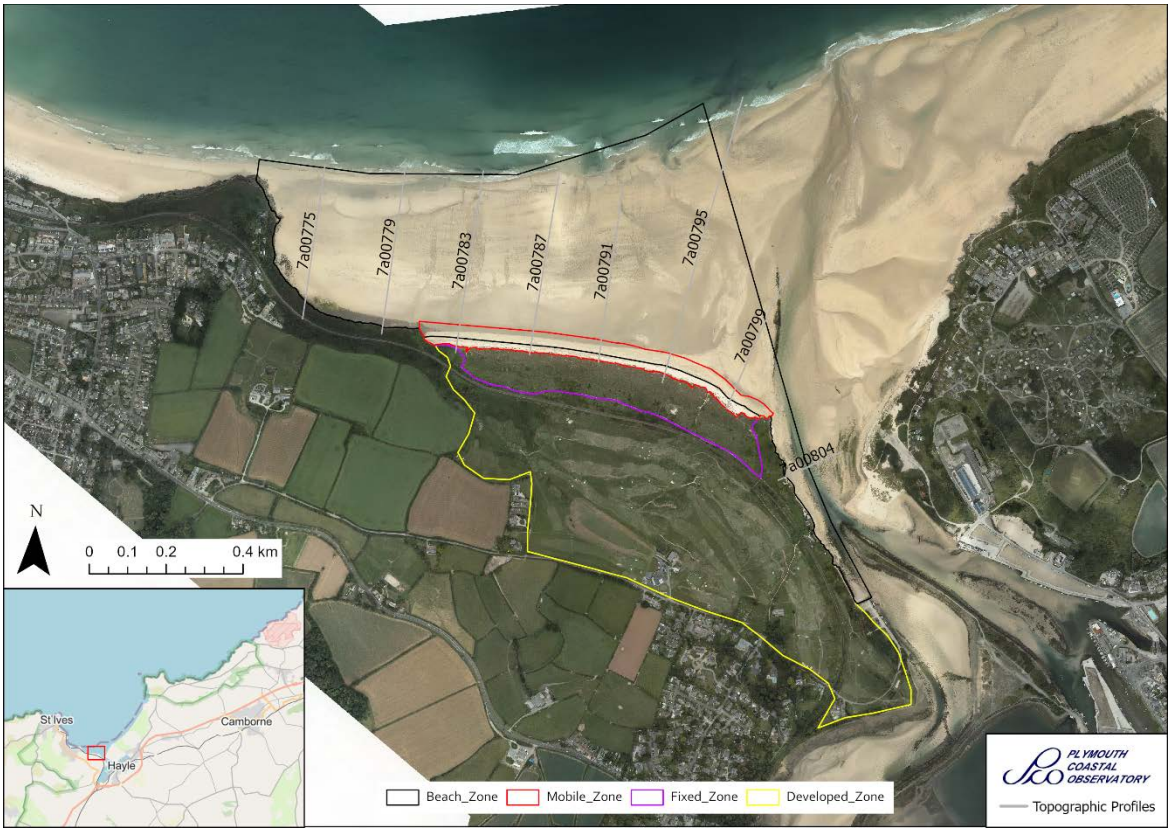


Figure 1 - Location Map of Lelant Towans Beach and Dune System, indicating the four defined zones outlined in section 1.0. Interim topographic profiles are also overlain to show their location, as detailed in section 2.1

[1] An embryo dune, or yellow dune, is the earliest stage of dune growth, usually found along the seaward extent of a dune system or newly formed dune.

2.0 Methods

Data utilised in this report was collected by SWCM between 2007 and 2024. Information on topographic and LiDAR data collection and specifications can be found on the Website for the National Network of Coastal Monitoring Programmes.

2.1 Topographic Data

SWCM have undertaken routine topographic beach surveys at 34 of the 40 MS4S sites since 2006. All surveys are conducted from the MLWS contour to the backshore. On average, each surveyed beach receives two interim surveys a year and one full coverage survey every 5 years:

- Interim - Conducted twice a year in the spring (conducted between January and April), and autumn (conducted between September and December). An interim survey consists of collecting data points at 5m intervals along pre-defined profiles; these are outlined in Figure 1.
- Full coverage – Conducted once per phase (6 years), or annually at more vulnerable sites (conducted between May and September). Full coverage surveys include a full profile survey at 50 m intervals and continuous spot height data collected across a 5 m grid covering the whole beach.

Analysis of the Cross-Sectional Area (CSA) change is conducted for each individual profile between each separate survey. Changes in CSA are measured relative to the fixed master profile which is defined by a pre-determined stable landward position and the MLWS level in reference to Ordnance Datum.

2.1.1 Topographic Data Analysis

Topographic data is presented as the following, where applicable:

Trend Analysis Plot - The combined profile trend in CSA is presented for each survey unit (example shown in Fig.2). The sum of all interim profile CSA is combined for each survey conducted to date to provide a survey unit with a single 'beach area' value, known hence-forth as the Combined Profile Area (CPA). CPA is compared using linear trend analysis over a temporal scale (Fig.2).

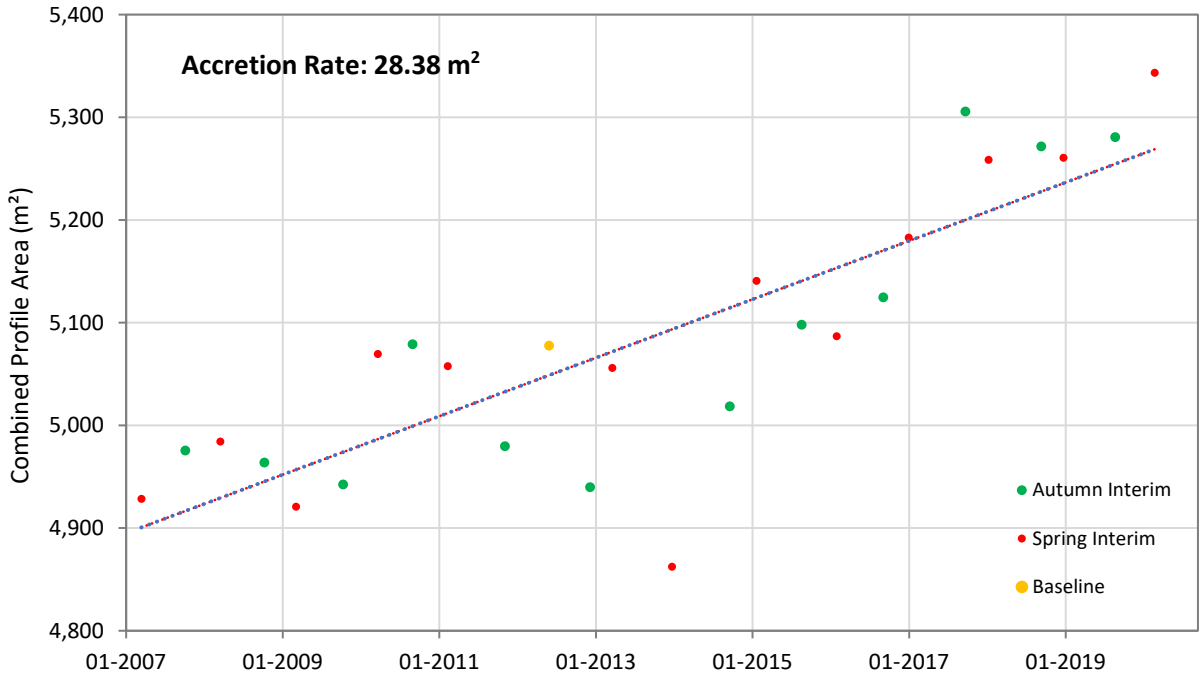


Figure 2 - Example of trend analysis for CPA for each survey with a linear trend rate highlighted at 28.4 m^2 y^{-1} equating to the increase of 0.56% of the average CPA per year.

If a profile has been omitted from a particular survey, for reasons of obstruction or similar, the average CSA of that profile from all available surveys is taken to ensure a consistent 'beach area'; if fewer than 75% of surveys have been conducted for a particular profile, the profile is omitted.

Profile Extremes Analysis - This plot displays the range of CSA values recorded throughout the duration of data collection (2006-2024) for each individual interim profile; the most recent survey is represented as a green dot. An example is given in figure 3. This plot provides the reader with information on how the CSA for each interim profile from the most recent survey corresponds to the entire dataset range.

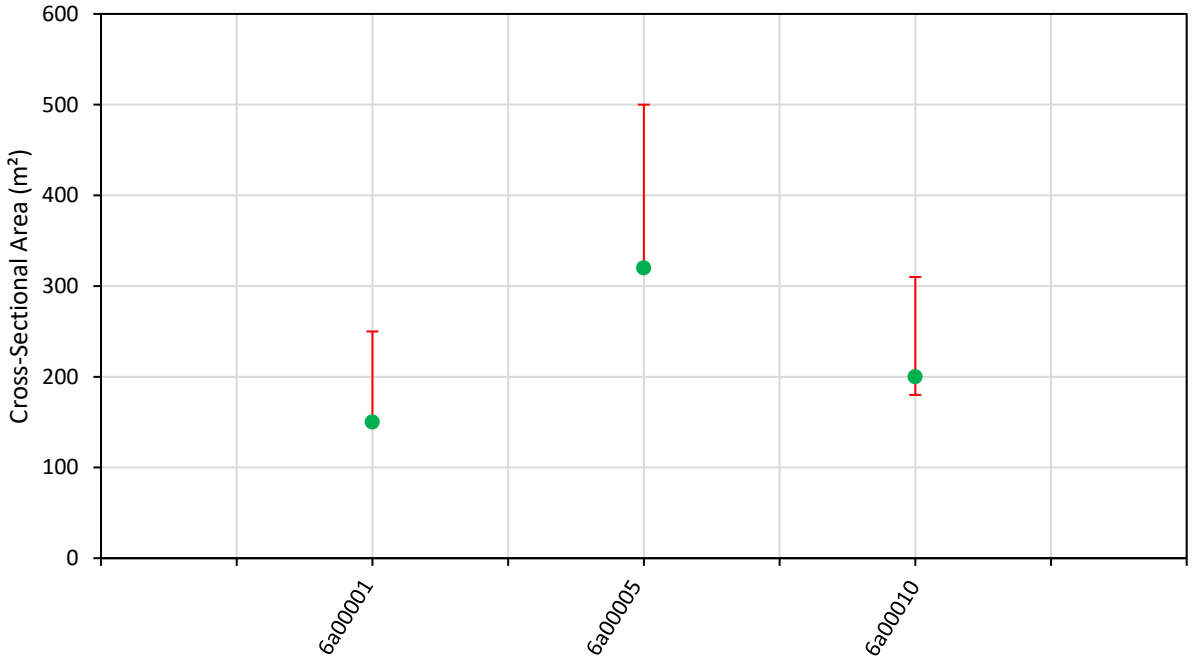


Figure 3 - Example plot showing the most recent CSA value recorded for three separate profile lines (green dots). The error bars represent the range of CSA recorded by each profile throughout the topographic dataset.

CSA Time Series Plot - CSA measurements for each interim profile are displayed on a separate plot representing values from each interim and full coverage survey conducted to date (example shown in Fig.4). This provides the reader with information on each interim profile's CSA evolution through time.

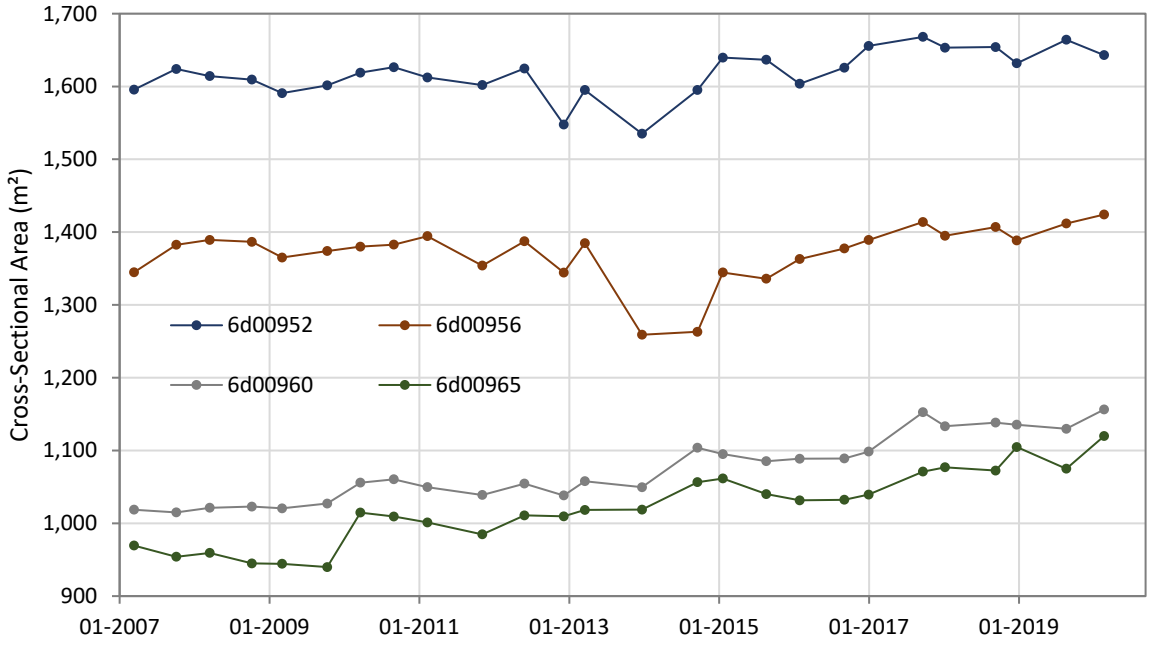


Figure 4 - Example of a cross-sectional area plot showing each of the interim profiles recorded for every survey since the 2007 baseline.

Individual Profile Charts - Each interim profile is portrayed as a cross-sectional profile comparing the most recent spring interim (blue), the previous spring interim (green) and the original full coverage survey (red). Profiles are displayed against the master profile (dotted red line) and are presented in the Appendices.

The 2013/2014 Storms – The winter period between September 2013 and April 2014 was, for many beaches in Cornwall, the most destructive period since SWCM records began in 2007. An abnormal number of significant storms, occurring in quick succession, heavily impacted many beaches, causing the loss of sediment from the intertidal area and dune face. This period is extensively discussed throughout this report and will hereinafter be referred to as the 2013/2014 winter period.

2.2 LiDAR Data

Airborne Light Detection and Ranging (LiDAR) data have been captured as part of the SWCM since 2007. Products include a point clouds, from which filtered and unfiltered 1 m^2 gridded surface models are derived:

- Unfiltered (Digital Elevation Model) representing the earth's surface including natural and artificial features such as trees and buildings.
- Filtered (Digital Terrain Model) representing the bare earth surface, with trees, buildings, cars etc. removed.

LiDAR is captured between September and March to minimise vegetation capture. Data is captured between MLWS and up to approximately 500 m inland. This report utilises "filtered" LiDAR data.

2.2.1 LiDAR Data Analysis

LiDAR data analysis is presented as the following:

Difference Modelling – Separate LiDAR surfaces are compared to produce a difference model of change based on gridded spot height elevations. The raw spot height data is processed into a gridded digital terrain model (DTM) and successive models are subtracted from one another to produce a difference model for the survey unit. Change in elevation is shown for values +/- 0.25 m and is represented by a colour scale bar.

Volume Extraction - Net sediment volume (m^3) is extracted for each LiDAR surface from the Beach Zone above MLWS and Mobile Zone above MHWS for trend comparison over time.

Contour Analysis – Contours are mapped from four LiDAR epochs spanning from 2007 to 2023, representing Mean Sea Level (MSL) and dune toe (calculated using the Stockdon equation by UoP, 2023[2]).

2.3 Accuracy Statement

Topographic Data – All survey points recorded along profiles have a measurement accuracy of +/- 0.03 m RMSE[3] in the horizontal and +/-0.03 m RMSE in the vertical.

LiDAR Data – Each LiDAR point cloud dataset has an average point density of 1.5 points per square metre. The digital terrain surfaces provide a minimum accuracy in elevation data of +/- 0.10 m RMSE with a minimum horizontal standard deviation as < 0.05 m. Please note that while every endeavour has been made to capture LiDAR as far seaward as MLWS, tidal and weather restrictions may in some instances have precluded this and coverage may be slightly reduced.

[2] Please refer to the following for Dune Toe elevation calculation: UoP, 2023. MS4S: Contemporary Dune Evolution and Future Predictions, Report, University of Plymouth, 33 pp.

[3] RMSE – Root-Mean-Square Error

3.0 Results

3.1 Topographic Data Analysis

There has been a total of 45 topographic surveys at Lelant Towans since 2007. Exact dates of each survey for Lelant Towans are available to view on our survey record. Analysis of the CPA indicates the survey unit has been eroding at 71.2 m^2 y^{-1} equating to 0.68% of the average beach area per year (Fig.5). The lowest recorded combined area was during the 2023 autumn interim (9,875 m^2); however, the beach had indicated some beach recovery the following spring. The highest recorded combined area was during the spring interim of 2008 (11,400 m^2).

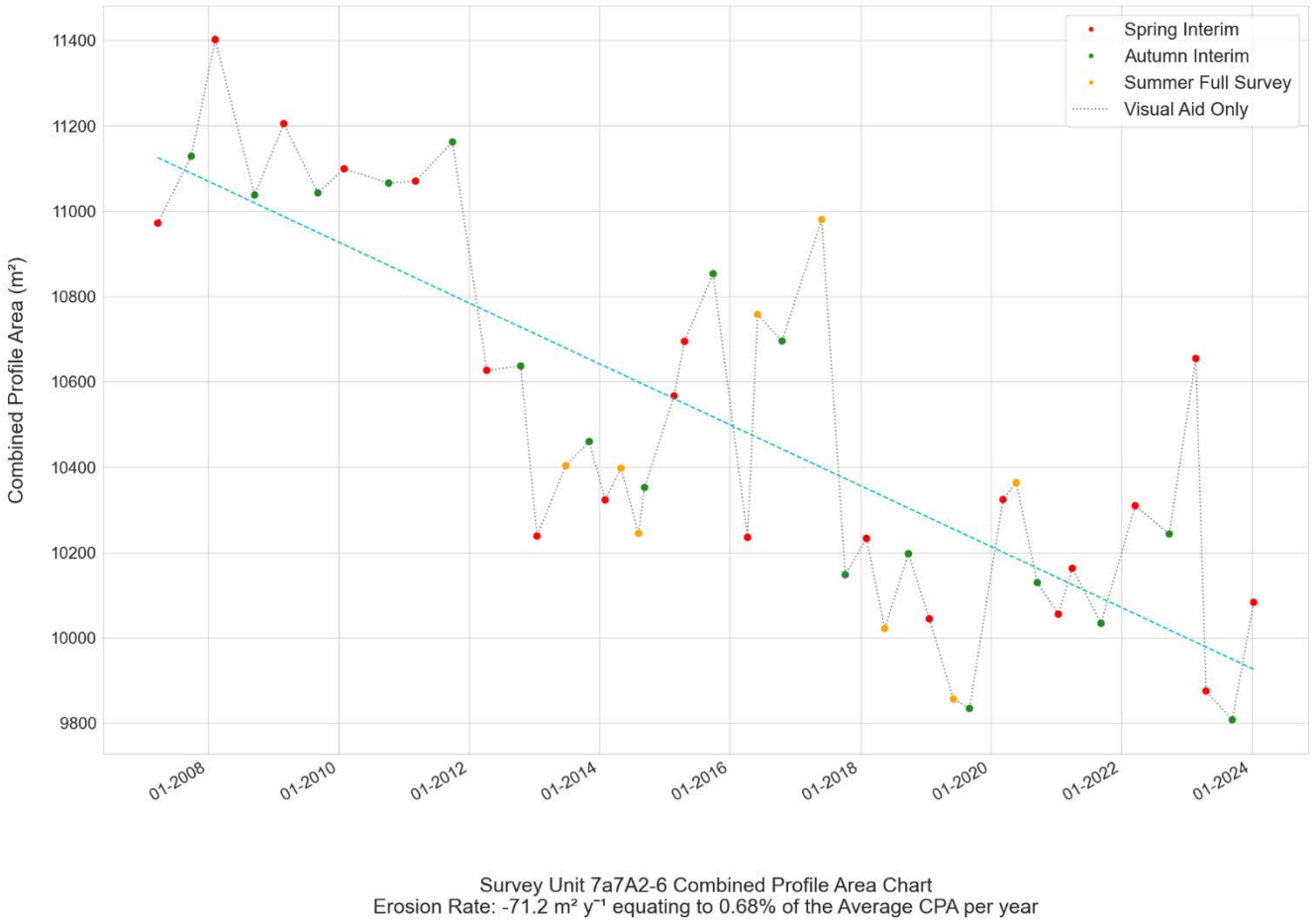


Figure 5 - The Combined Profile Area (CPA) for Lelant Towans, including every spring (red), summer (yellow) and autumn (green) survey completed between 2007 and 2024.

When comparing to the entire dataset (Fig.6), during the 2024 spring interim the majority of Lelant Towans profiles were average or below the average cross-sectional area. Profile 700775 has observed the lowest area on record.

When comparing profile cross-sectional areas to the entire time series (Fig.7), all profiles have minimal seasonal variation apparent. Profile 7a00799 has shown the most variance, displaying a distinct drop between 2012, 2017, and 2023, whereas the remaining profiles are relatively consistent in area change, but subtlety look to be lowering in area.

Profile Charts for Lelant Towans can be found in Appendix 1, these display the cross-sections of each profile for the initial baseline survey conducted in 2007 along with the two most recent interim surveys. Profiles 7a00787, 7a00791, 7a00795 and 7a00799 have seen the dune face to retreat by up to 14 m.

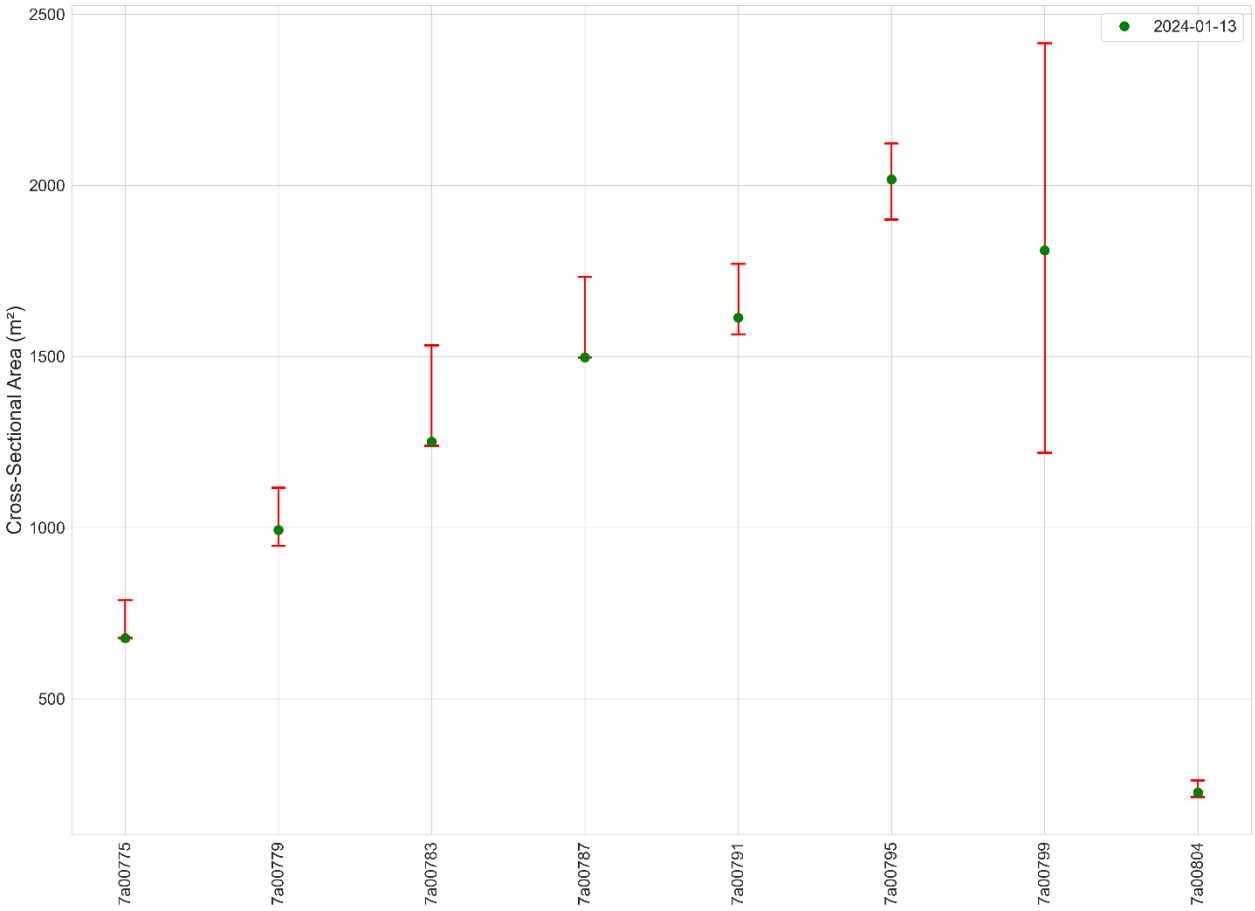


Figure 6 - Cross-sectional area of each interim profile, comparing the current area of the profile (green dot), with the maximum and minimum values (red error bar) recorded between 2007 and 2024.

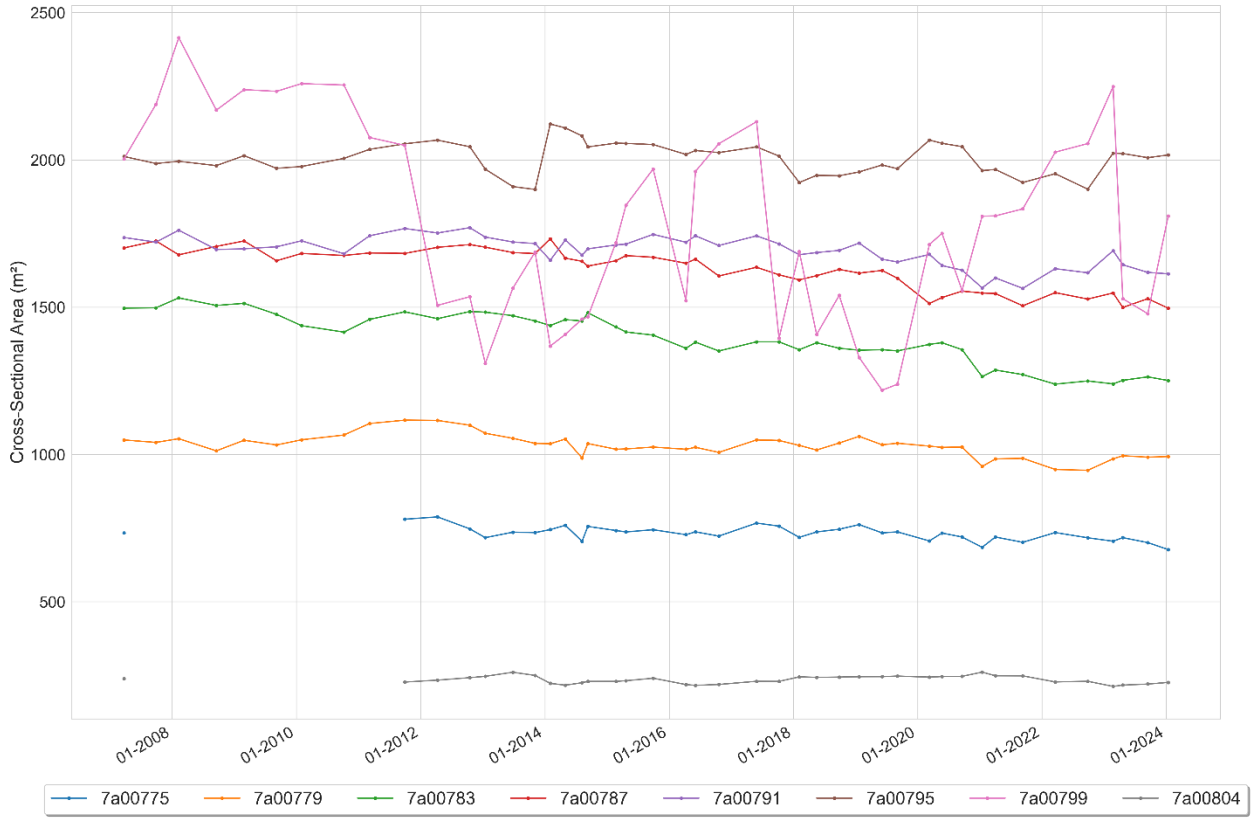


Figure 7 - Cross-sectional area of each interim profile, comparing the values recorded during each interim and baseline survey between 2007 and 2024.

3.2 LiDAR Data Analysis

There has been a total of 10 LiDAR flights captured at Lelant Towans since 2007, by the SWCM Programme.

3.2.1 Difference Models

Difference models between each epoch of LiDAR data are presented here. Accretion and erosion values observed behind the dune system can be attributable to noise in the filtered LiDAR data or man-made changes in elevation and should be dismissed as such.

Figure 8 shows the difference in elevation between the first filtered LiDAR data from March 2008 compared to the most recent, captured in January 2023. The overall change here suggests the dune system has experienced acute erosion (>3 m), progressively receding the further west travelled along the beach. Acute erosion can also be seen on the dunes to the east, followed by accretion on the beach face. A mixture of erosion and accretion has been observed along the intertidal zone, whilst the western bank along the river suggests low-level erosion.

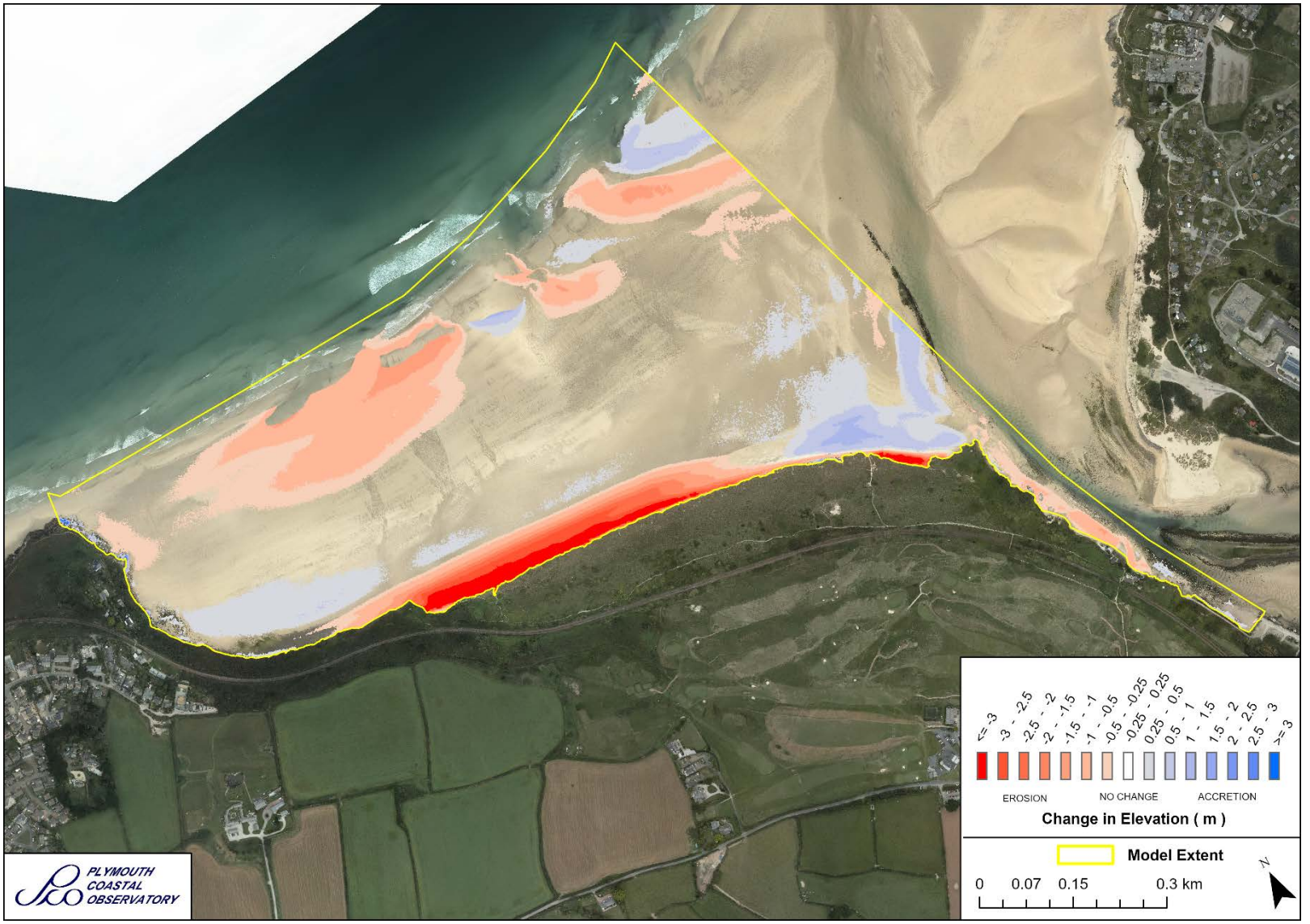


Figure 8 – Difference model indicating the changes in elevation observed between March 2008 and January 2023 filtered LiDAR datasets within the yellow model extent.

Figure 9 shows differences in elevation between filtered LiDAR data from March 2008 compared to March 2009. In contrast to that seen in Figure 8, low-level accretion can be observed along the dune face, followed by ~1 m of elevation loss along the beach face. Whereas the dune face to the east has experienced low-level erosion but accretion along the beach face. The majority of the intertidal zone has remained stable with some movement of sediment suggested towards the seaward extent.

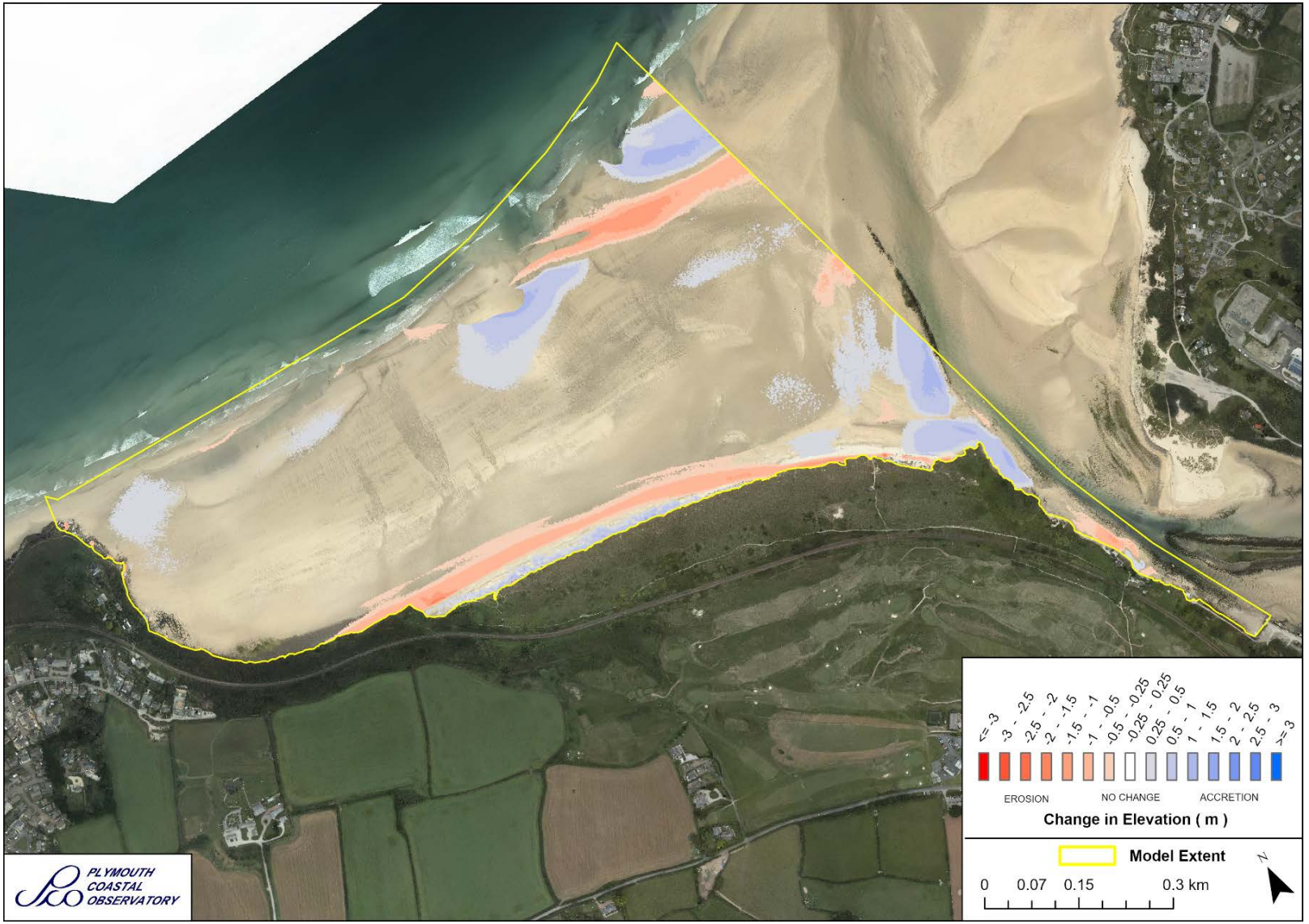


Figure 9 - Difference model indicating the changes in elevation observed between March 2008 and March 2009 filtered LiDAR datasets within the yellow model extent.

Figure 10 shows differences in elevation between filtered LiDAR data from March 2009 compared to September 2009. Even in a small epoch, a lot of change has occurred at Lelant Towans. Patches of accretion can be observed along the dune face, followed by a band of erosion along the beach face across most of the beach, whilst to the east the beach face has be seen to accrete. A mixture of erosion and accretion can be seen across the intertidal zone, likely due to the dynamic nature of the river.

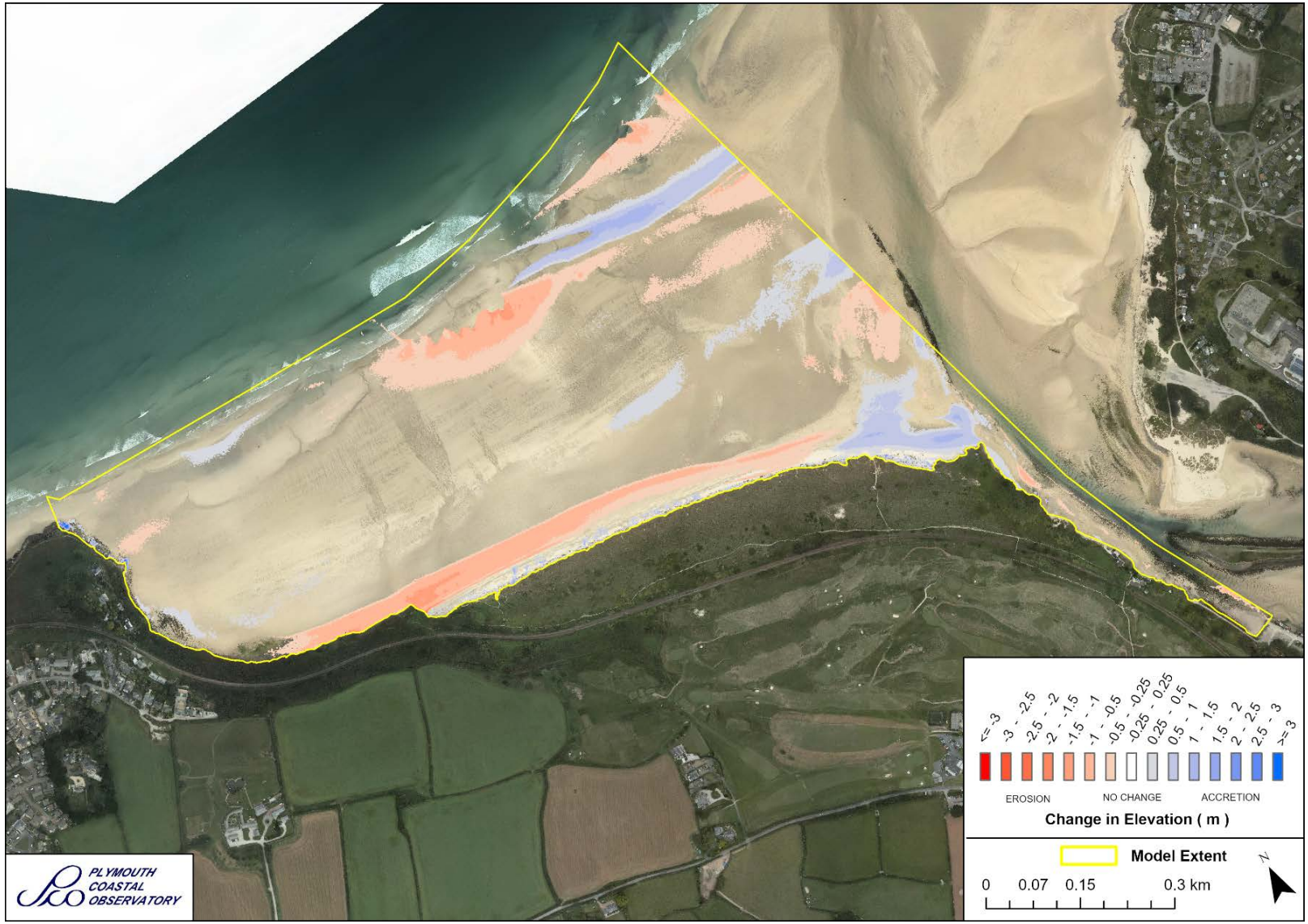


Figure 10 - Difference model indicating the changes in elevation observed between the March 2009 and September 2009 filtered LiDAR datasets within the yellow model extent.

Figure 11 shows differences in elevation between filtered LiDAR data from September 2009 compared to March 2011. In contrast to that observed in Figure 10, acute (>3 m) erosion is present along most of the dune and beach face whereas the eastern half of the dune system has experienced patches of accretion. A wide strip of accretion, increasing elevation by up to 1.5 m, has been observed across the width of the beach. This was followed by a trough-bar-trough feature across the eastern half of the unit, whilst the western half remained stable.

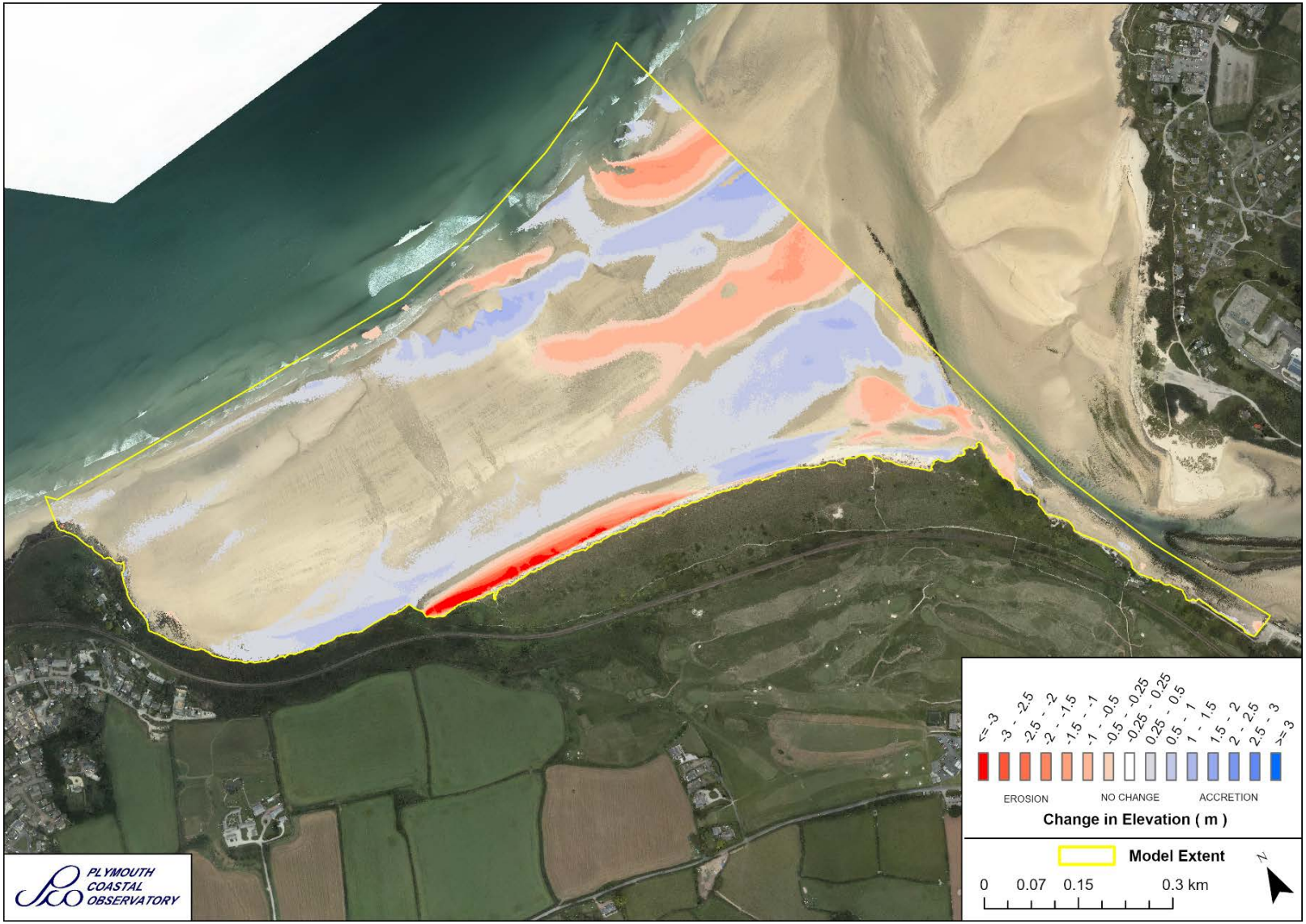


Figure 11 – Difference model indicating the changes in elevation observed between the September 2009 and March 2011 filtered LiDAR datasets within the yellow model extent.

Figure 12 shows differences in elevation between filtered LiDAR data from March 2011 compared to April 2012. The eastern half of the beach has seen the most change, likely due to the river system, causing sediment to move around the system. This has resulted in two intertidal bars towards the east. Some patches of erosion can be observed along the dune face, whilst the beach face has experienced an increase in elevation of up to 1.5 m.

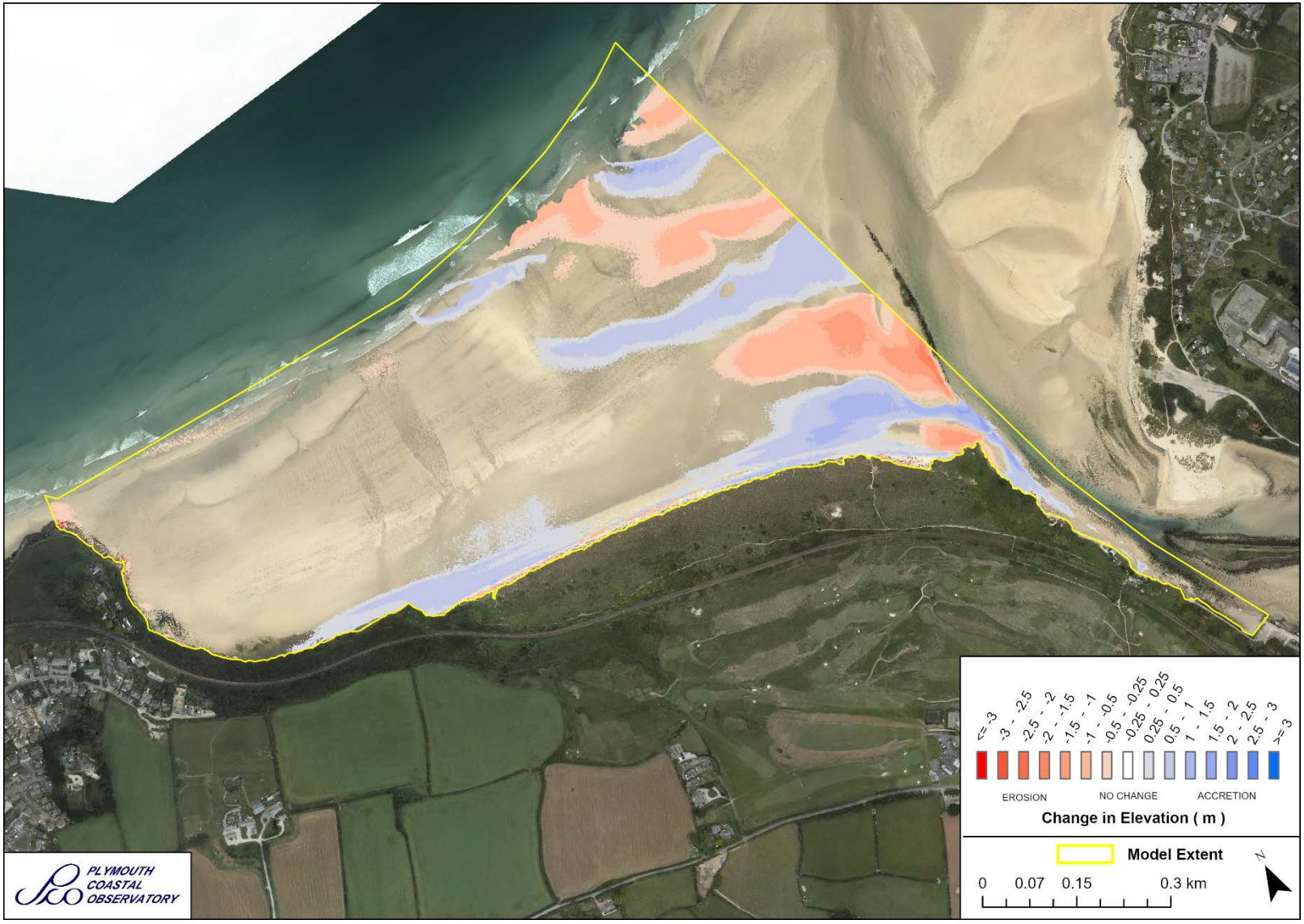


Figure 12 - Difference model indicating the changes in elevation observed between the March 2011 and April 2012 filtered LiDAR datasets within the yellow model extent.

Figure 13 shows differences in elevation between filtered LiDAR data from April 2012 compared to April 2014. Despite the impact of the 2013/14 winter storms, the majority of the dune and beach face suggested accretion, with up to 1.5 m gains observed along the entire width of the beach. However, acute erosion is seen to the east of the beach, losing >3 m of elevation on the dune face, continuing down to the beach and along the low tide terrace for the entire beach width. Most of the intertidal zone has remained stable, with patches of erosion and accretion seen along the eastern boundary.

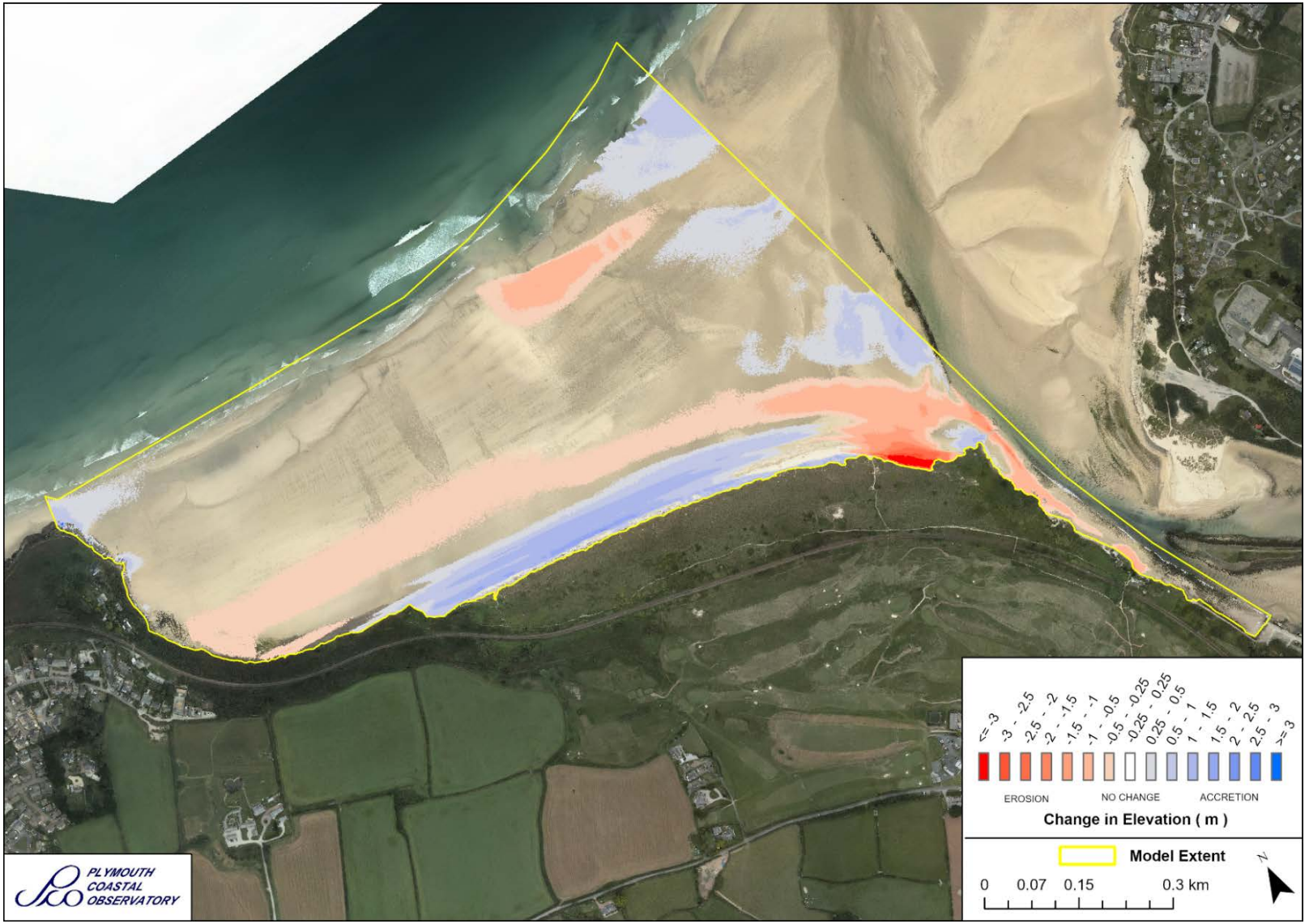


Figure 13 - Difference model indicating the changes in elevation observed between the April 2012 and April 2014 filtered LiDAR datasets within the yellow model extent.

Figure 14 shows differences in elevation between filtered LiDAR data from April 2014 compared to March 2016. Widespread erosion is observed along the beach face and low tide terrace, losing up to 2.5 m towards the west, whilst the dune has seen a build-up of material along the entire face. To the east of the beach accretion continues from the dune onto the beach face, whilst the rest of the intertidal zone has remained relatively stable, apart from some low-level erosion seen towards the seaward extent and a small sandbar, gaining ~1 m of material.

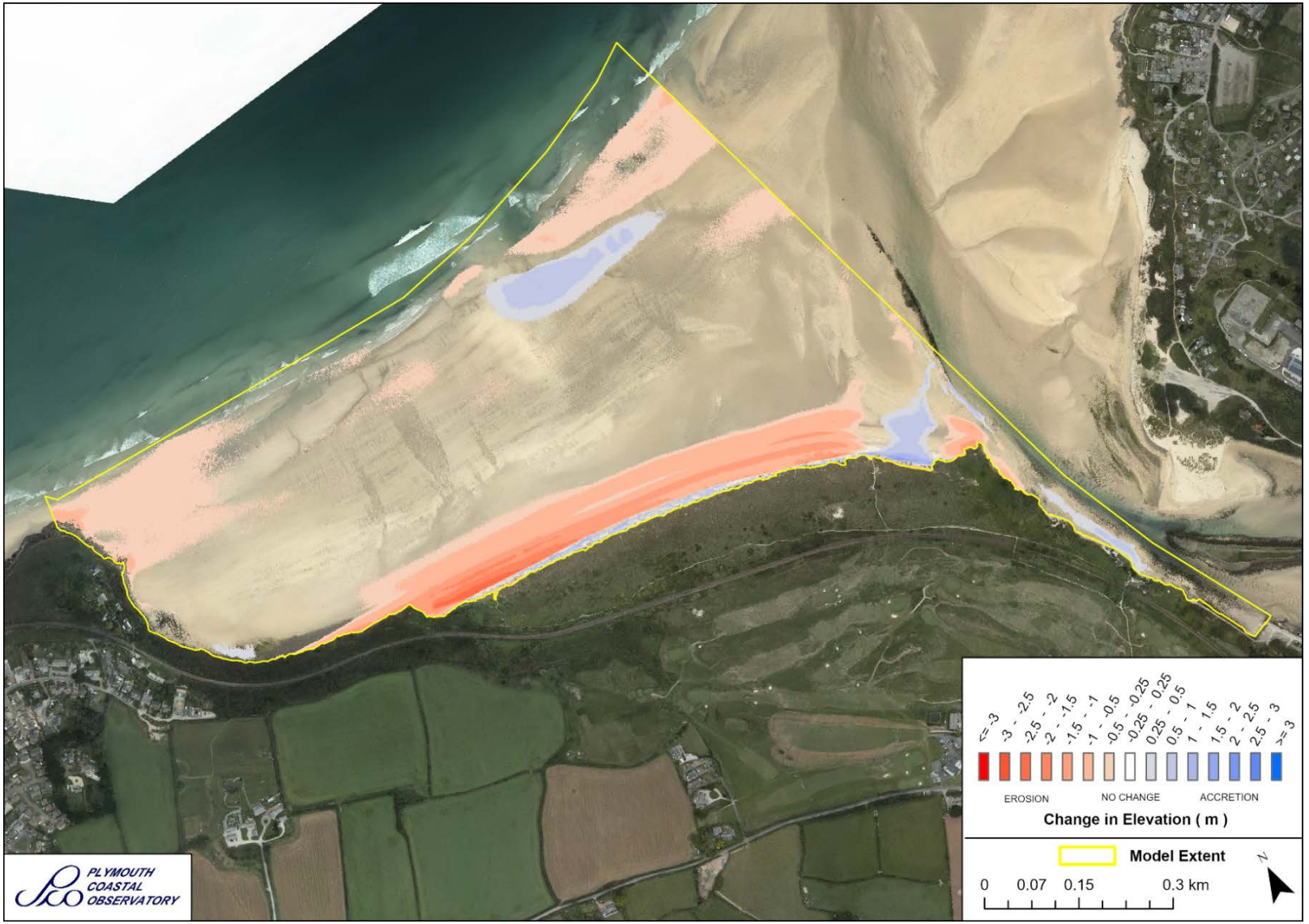


Figure 14 - Difference model indicating the changes in elevation observed between April 2014 and March 2016 filtered LiDAR datasets within the yellow model extent.

Figure 15 shows differences in elevation between filtered LiDAR data from February 2016 compared to April 2017. A band of acute erosion is measured along most of the dune face, and a continued lowering on the beach face, whereas to the east the dunes and beach face have experienced up to 1.5 m of accretion. The majority of the intertidal zone has remained stable, with the exception of the eastern section of the beach resulting in some movement of material, likely due to the dynamic movement of the river.

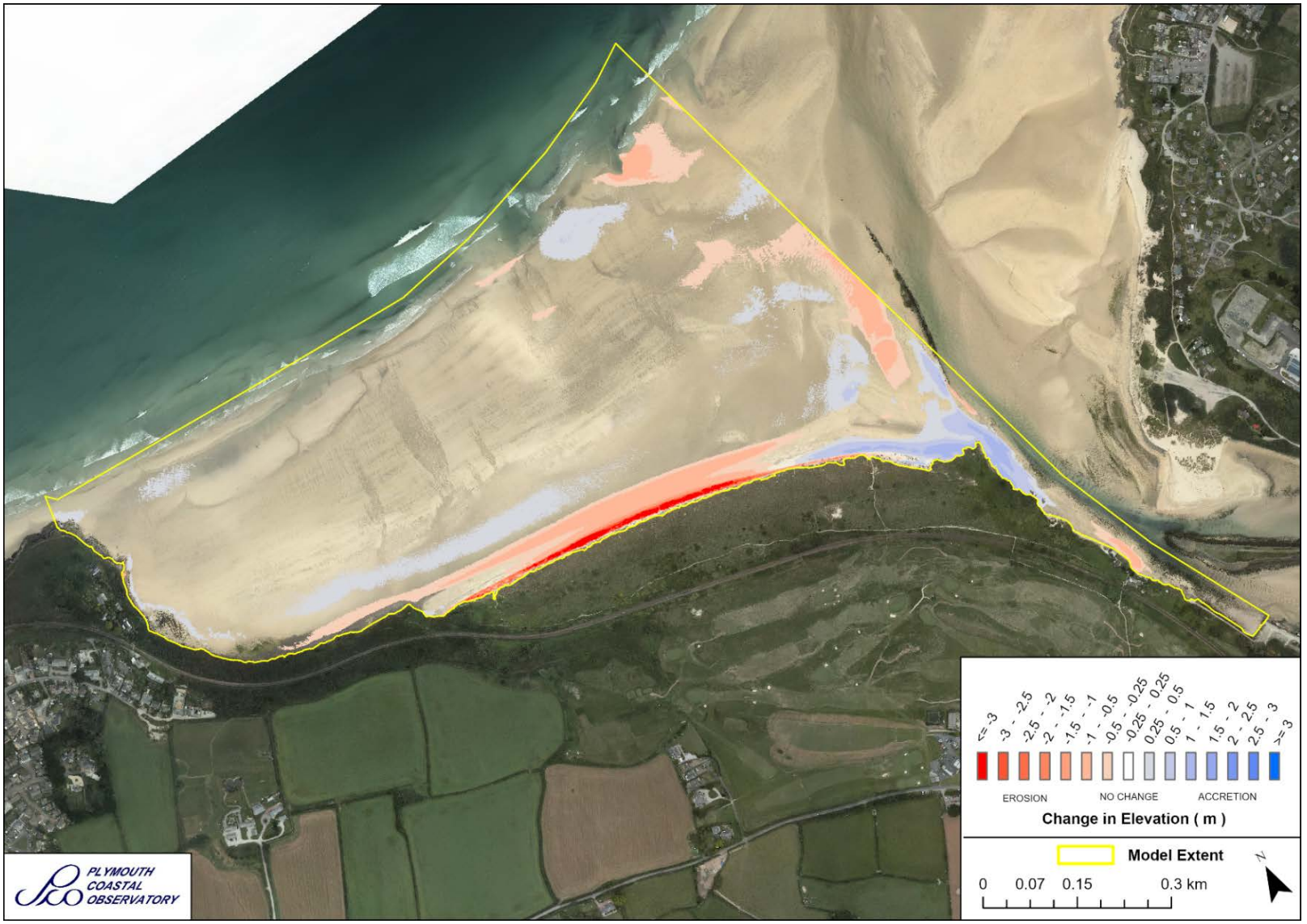


Figure 15 - Difference model indicating the changes in elevation observed between the February 2016 and April 2017 filtered LiDAR datasets within the yellow model extent.

Figure 16 shows differences in elevation between filtered LiDAR data from April 2017 compared to April 2019. High-level erosion (>3 m) is experienced along the dune face, whereas the beach face has observed up to 1.5 m gain in elevation, more so to the eastern half of the beach. A significant build-up of material can be seen along the western bank of the river, suggesting a sharp increase in elevation, whereas the eastern intertidal zone has seen a trend for erosion.

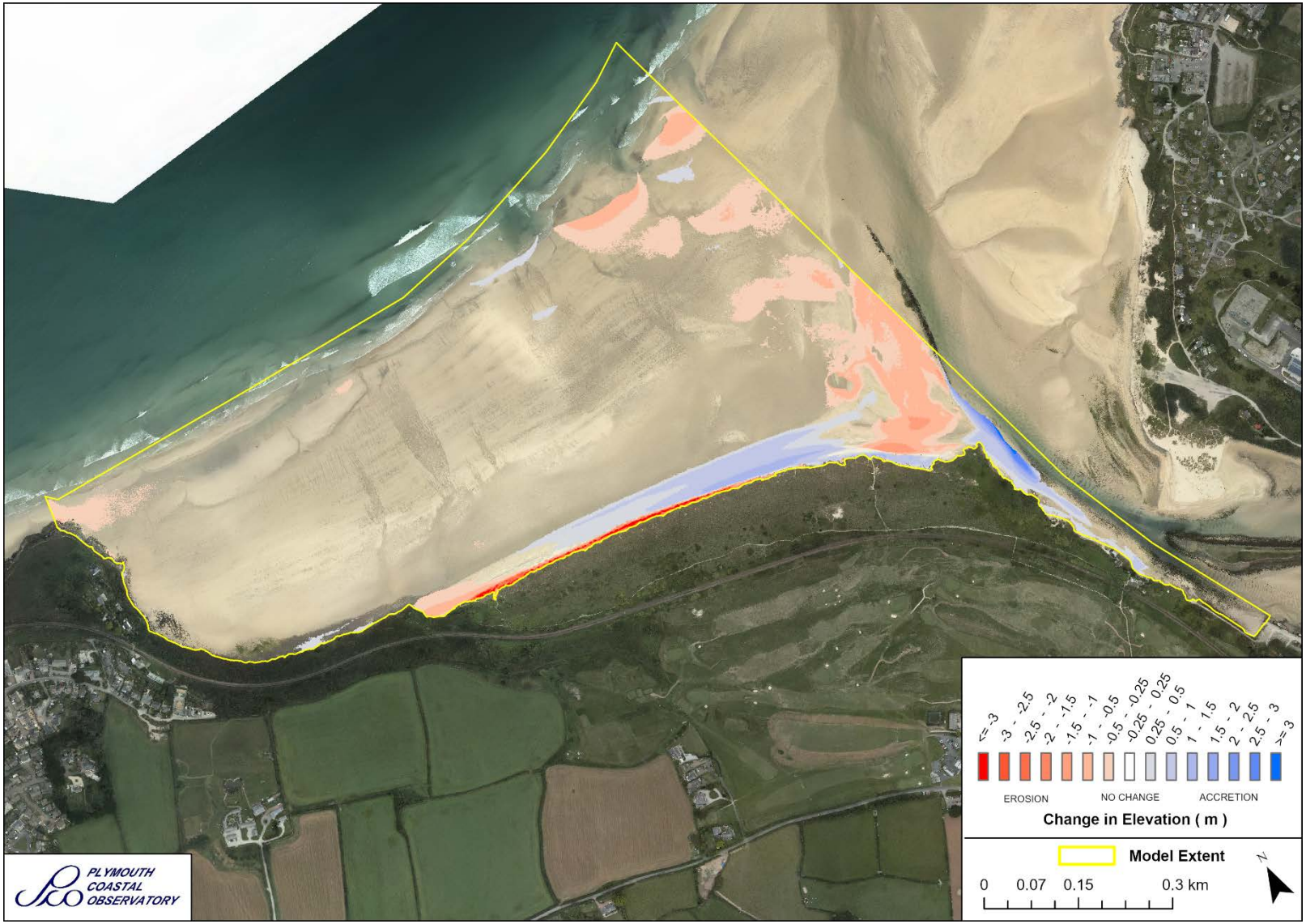


Figure 16 - Difference model indicating the changes in elevation observed between the April 2017 and April 2019 filtered LiDAR datasets within the yellow model extent.

Figure 17 shows differences in elevation between filtered LiDAR data from April 2019 compared to September 2020. A movement of material is suggested to have gone from east to west, along the beach face, whereas the dune face has experienced a loss of material across the entire length of the beach. A higher trend for erosion can be seen to the eastern end of the dunes, as well as the western bank of the river. Large patches of low-level accretion are observed on the eastern half of the unit, whilst the rest of the intertidal zone has remained relatively stable.

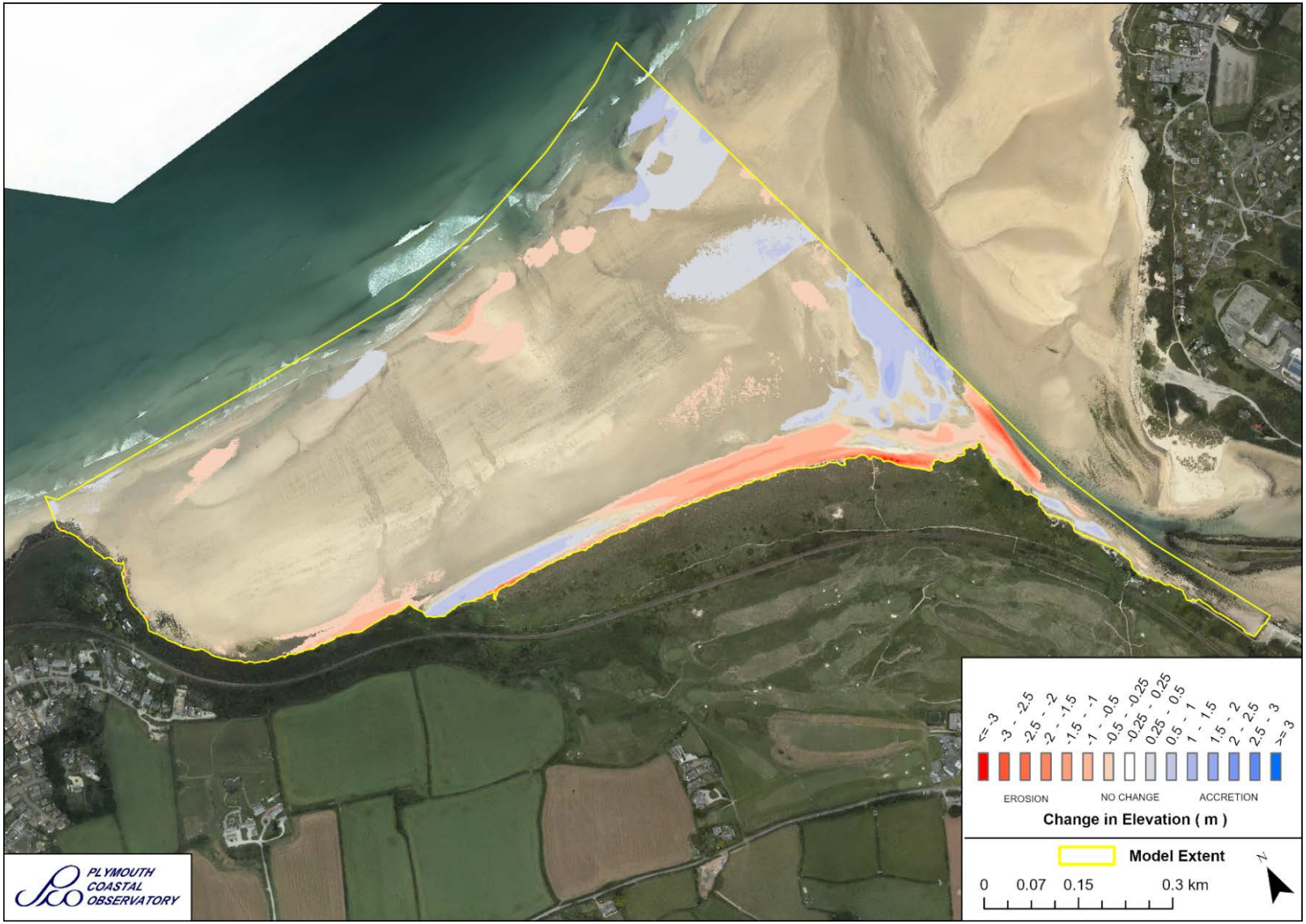


Figure 17 - Difference model indicating the changes in elevation observed between the April 2019 and September 2020 filtered LiDAR datasets within the yellow model extent.

Figure 18 shows differences in elevation between filtered LiDAR data from September 2020 compared to January 2023. In contrast to that seen in Figure 17, the data suggests a movement of material from west to east along the beach face. However, the dune face has still experienced a trend for erosion, except for the dunes to the very eastern end of the beach where it is suggested they have built-up. The western bank has experienced a relatively large area of erosion, losing up to 3 m in some areas. In the intertidal zone, a large patch of erosion can be seen in the western half of the unit, whereas to the east, a mixture of erosion and accretion can be seen which is likely a result of the dynamic movement of the river.

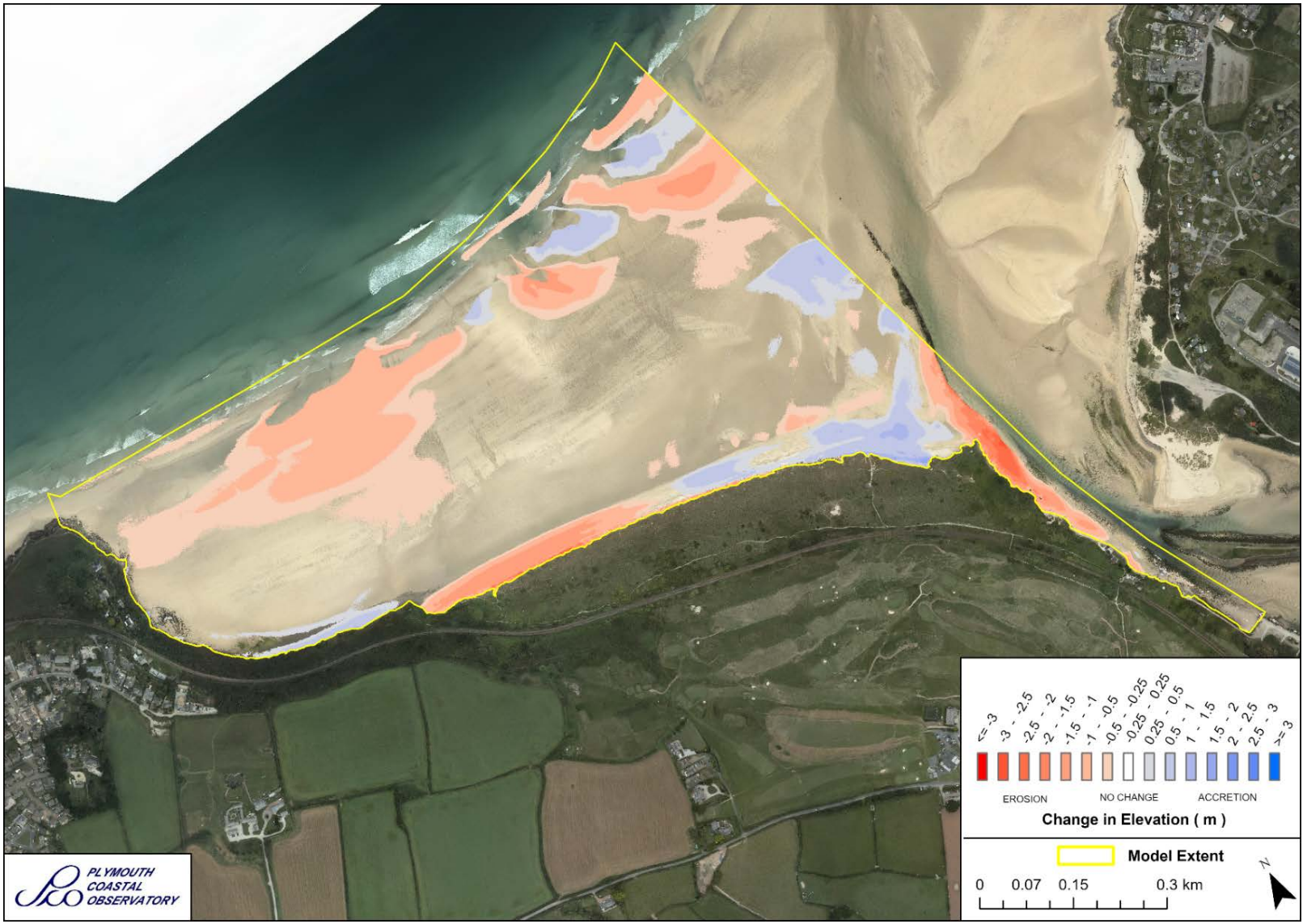


Figure 18 - Difference model indicating the changes in elevation observed between September 2020 and January 2023 filtered LiDAR datasets within the yellow model extent.

3.2.2 Beach and Dune Volume Extraction

Surface volume extracted from each available LiDAR dataset from the Mobile Zone above the MHWS contour (3.20 m OD) are shown in Table 1 and Figure 19. The data shows a considerable negative trend with the highest recorded volume during the first survey in March 2008 and the lowest recorded volume in January 2023, with a 67% loss in volume overall. Analysis suggests the Mobile Zone has been actively eroding and retreating between 2008 and 2023.

Surface volume extracted from each LiDAR dataset from the Beach Zone above the MLWS contour (-2.60 m OD) are shown in Table 1 and Figure 20. Similarly, to the Mobile Zone, the overall trend for the Beach Zone is progressive erosion between 2008 and 2023, losing 4% in total volume (Fig.20). As the Beach Zone is considerably influenced by the Mouth of the River Hayle, fluctuations in volume are expected.

Table 1 – Surface volume values (m^3) extracted from all available filtered LiDAR datasets for the Mobile Zone above MHWS (3.20 m OD) and for the Beach Zone above MLWS (-2.60 m OD).

Date	Mobile Zone Volume (m^3)	Beach Zone Volume (m^3)
03/2008	87,368	1,892,290
03/2009	81,429	1,907,782
09/2009	83,323	1,884,949
03/2011	61,429	1,937,367
04/2012	69,862	1,965,879
04/2014	83,253	1,911,610
02/2016	58,957	1,854,943
04/2017	44,935	1,887,946
04/2019	41,607	1,851,343
09/2020	32,519	1,881,098
01/2023	29,109	1,815,078

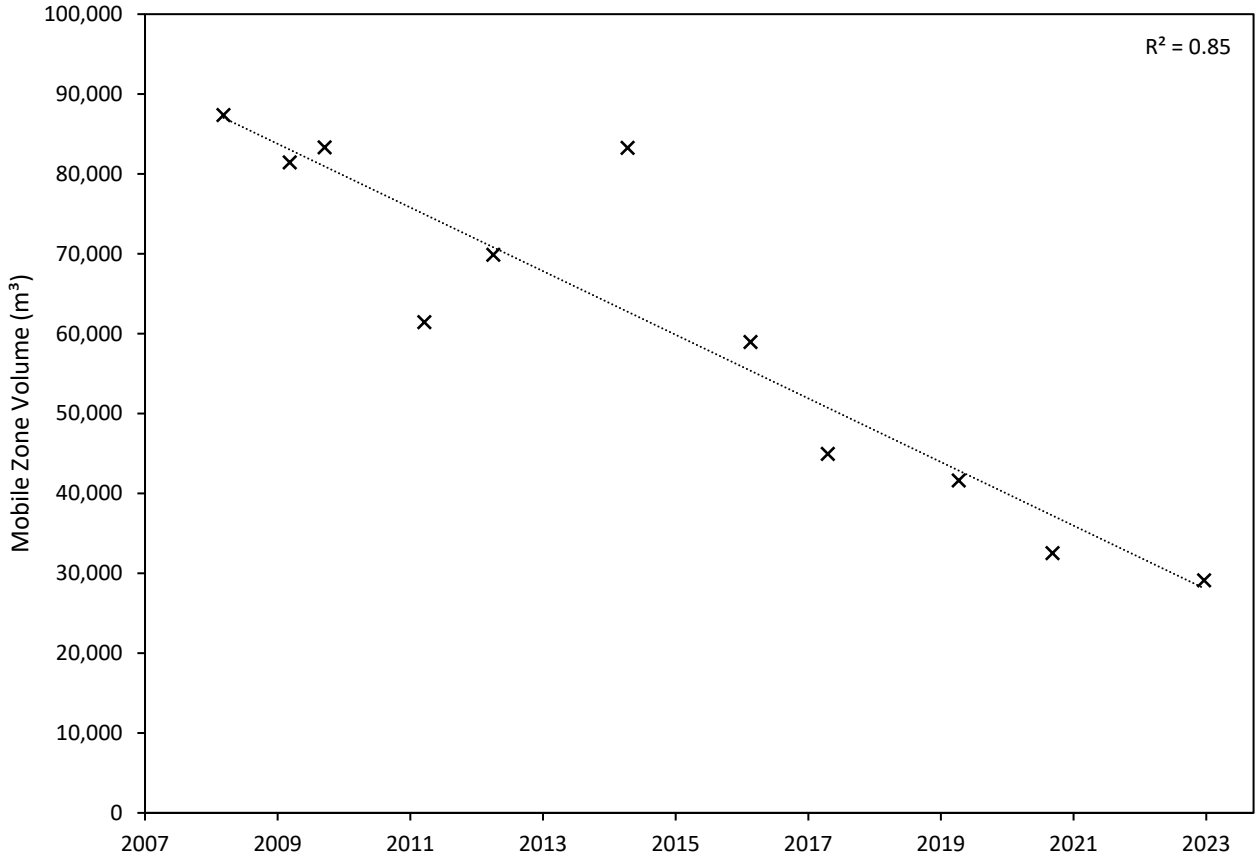


Figure 19 – Plot indicating beach volume (m^3) recorded in the Mobile Zone above MHWS (3.20 m OD) for each filtered LiDAR datasets between 2008 and 2023.

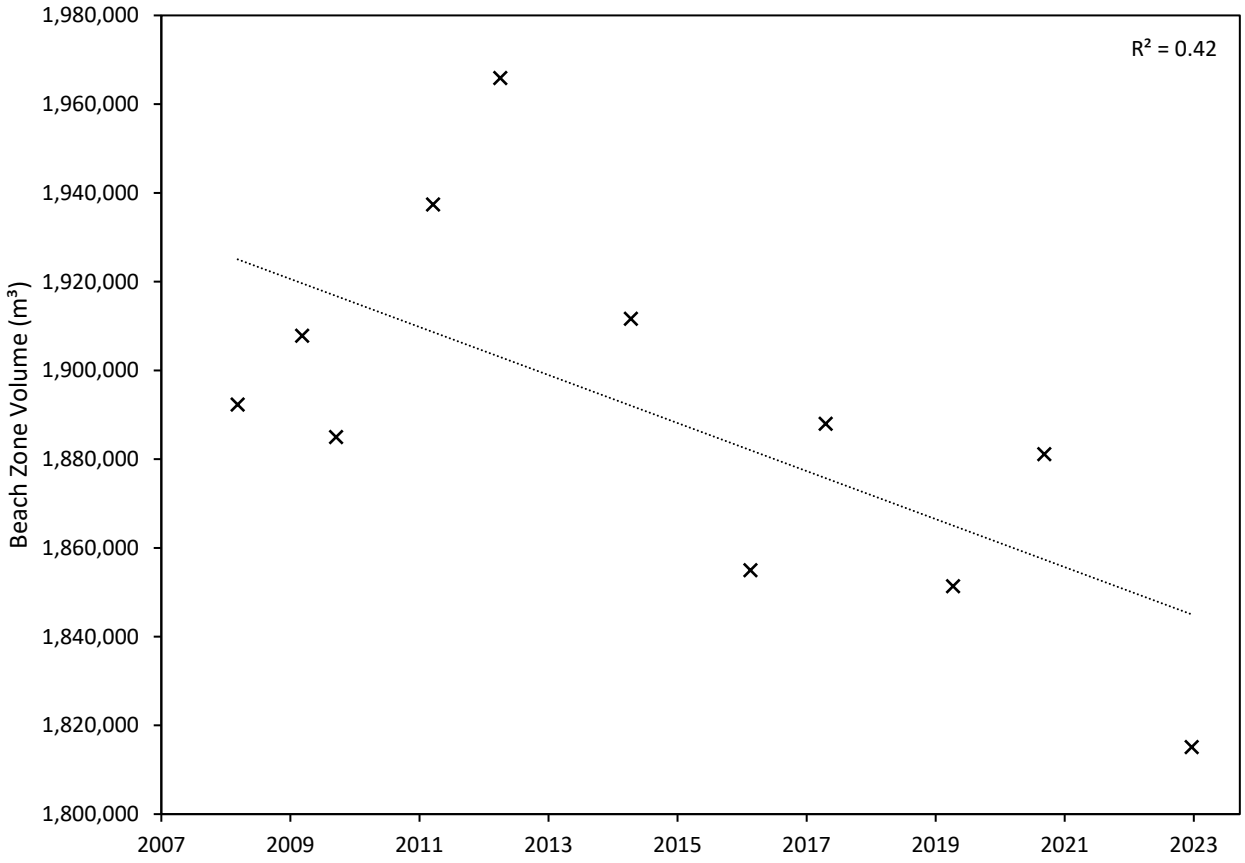


Figure 20 - Plot indicating beach volume (m^3) recorded in the Beach Zone above MLWS (-2.60 m OD) for each filtered LiDAR datasets between 2008 and 2023.

3.2.3 Contour Comparison

Figure 21 indicates the Mean Sea Level (MSL), and Dune Toe contours indicate have remained relatively consistent between 2008 and 2023, only ranging by approximately 10 m. However, the river end of the beach has seen a lot of change, due to the river changing course. The Dune Toe contours have shown dune retreat by up to 14 m to the western extent of the beach.

3.3 Historic Aerial Maps

Historic aerial photography captured in 1947 by the RAF, in 2001 by the Environment Agency (Figs. 22 and 23) and from 2006 onwards by the SWCM (Figs 24- 27) are presented here.

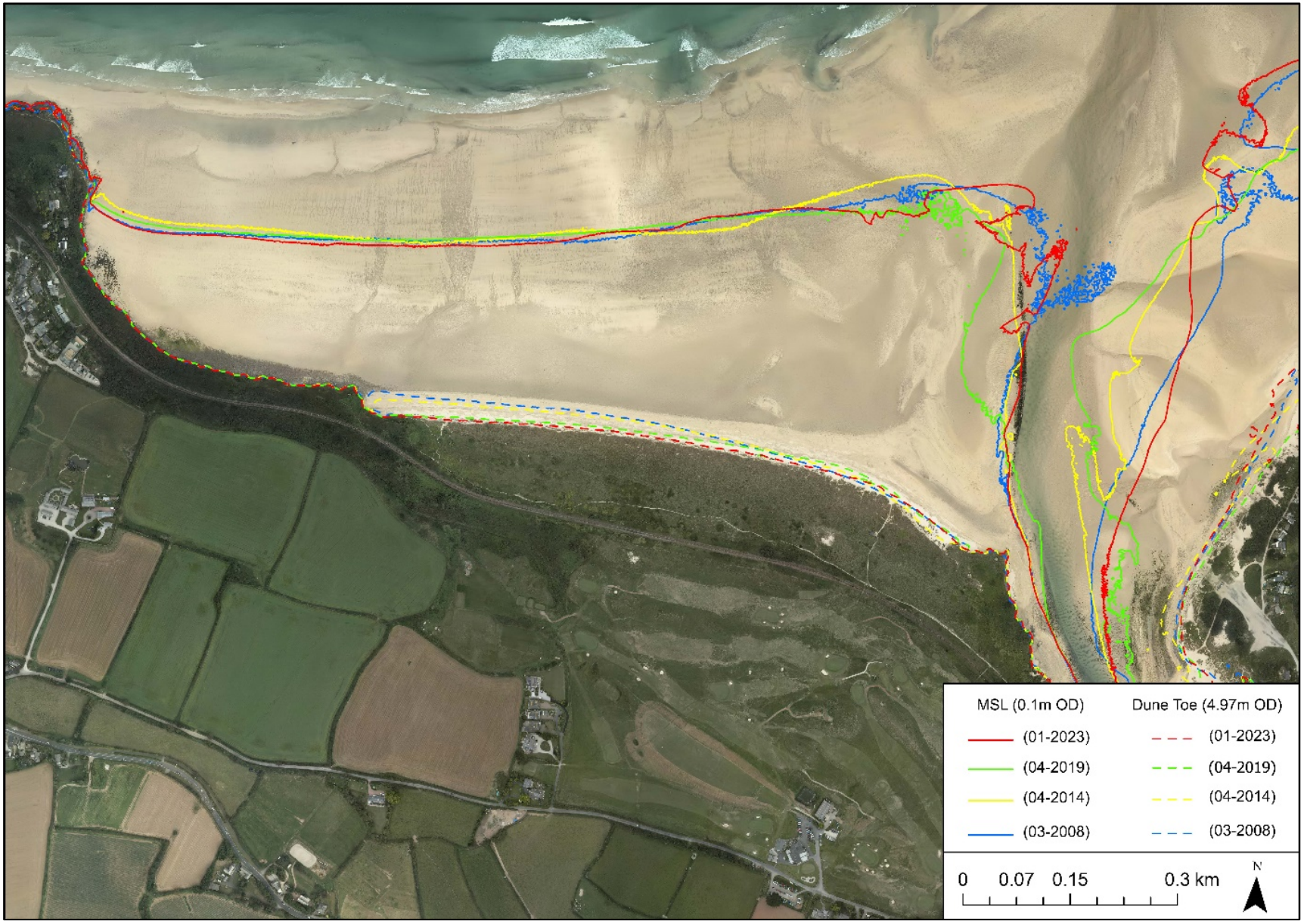


Figure 21 – Contour map indicating Mean Sea Level (solid line) and Dune Toe (dashed line) extracted from 2008, 2014, 2019 and 2023 LiDAR datasets.

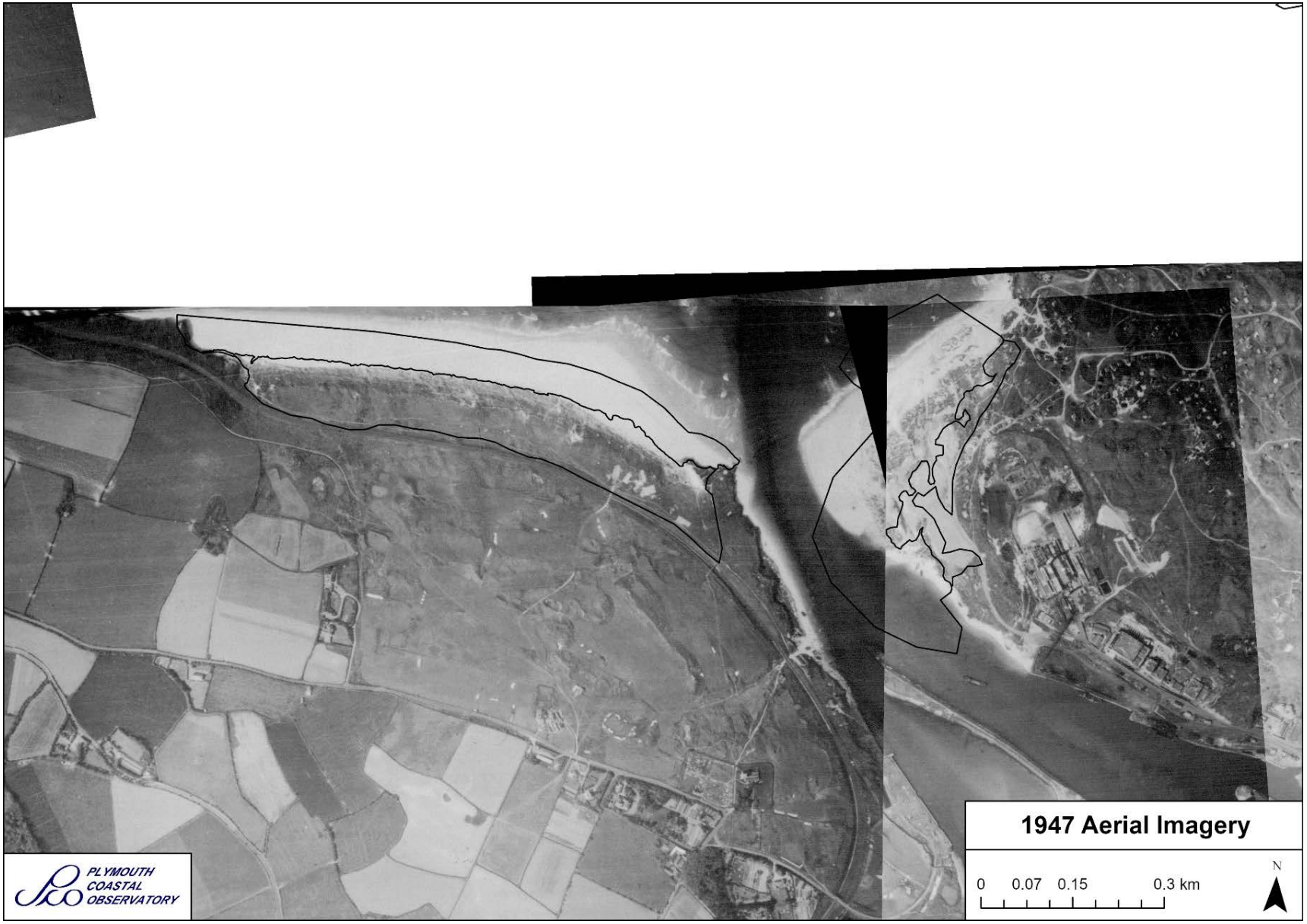


Figure 22 – Aerial imagery from 1947.

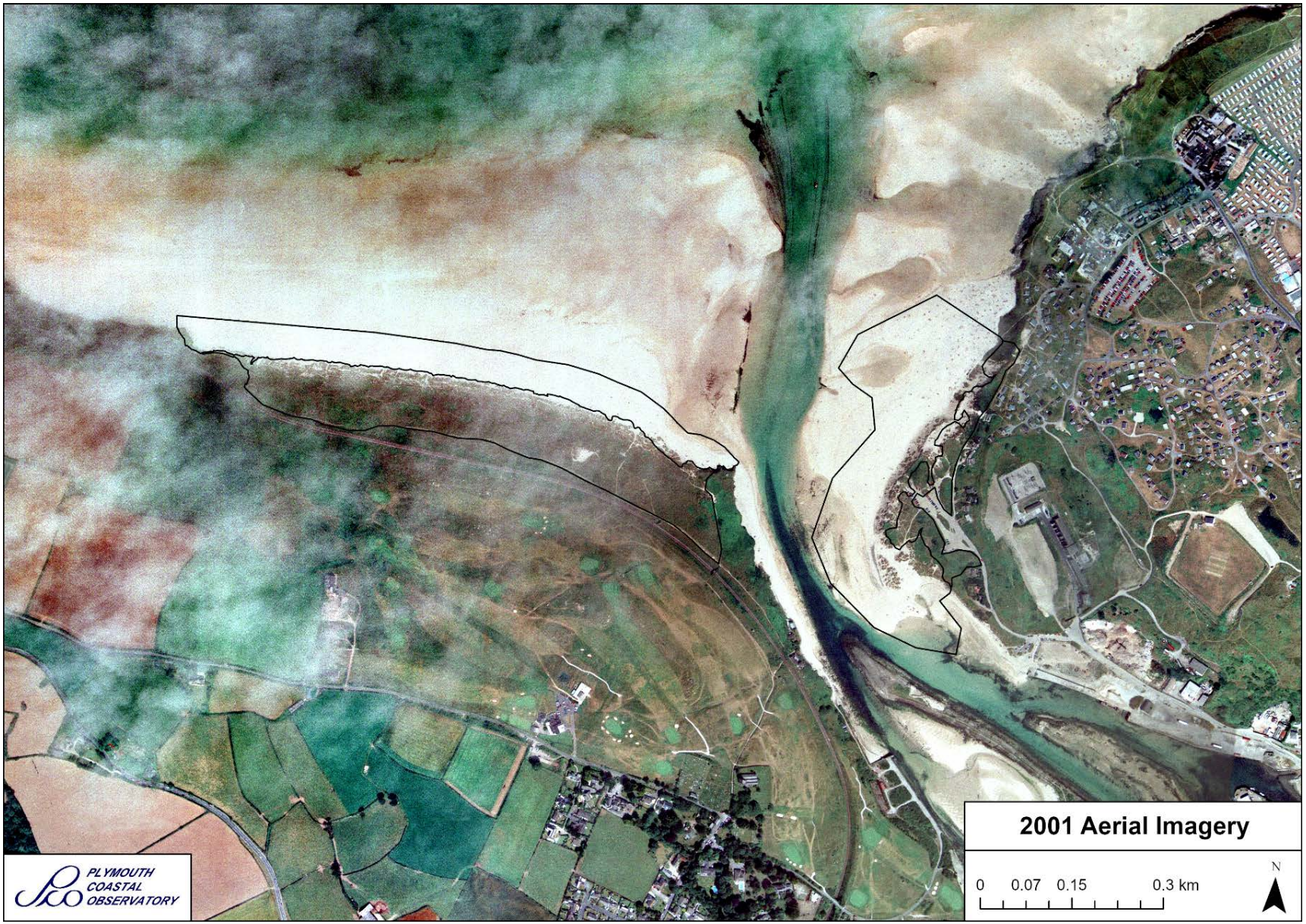


Figure 23 – Aerial imagery from 2001.



Figure 24 – Aerial imagery from 2008.



Figure 25 – Aerial imagery from 2008.



Figure 26 – Aerial imagery from 2014.



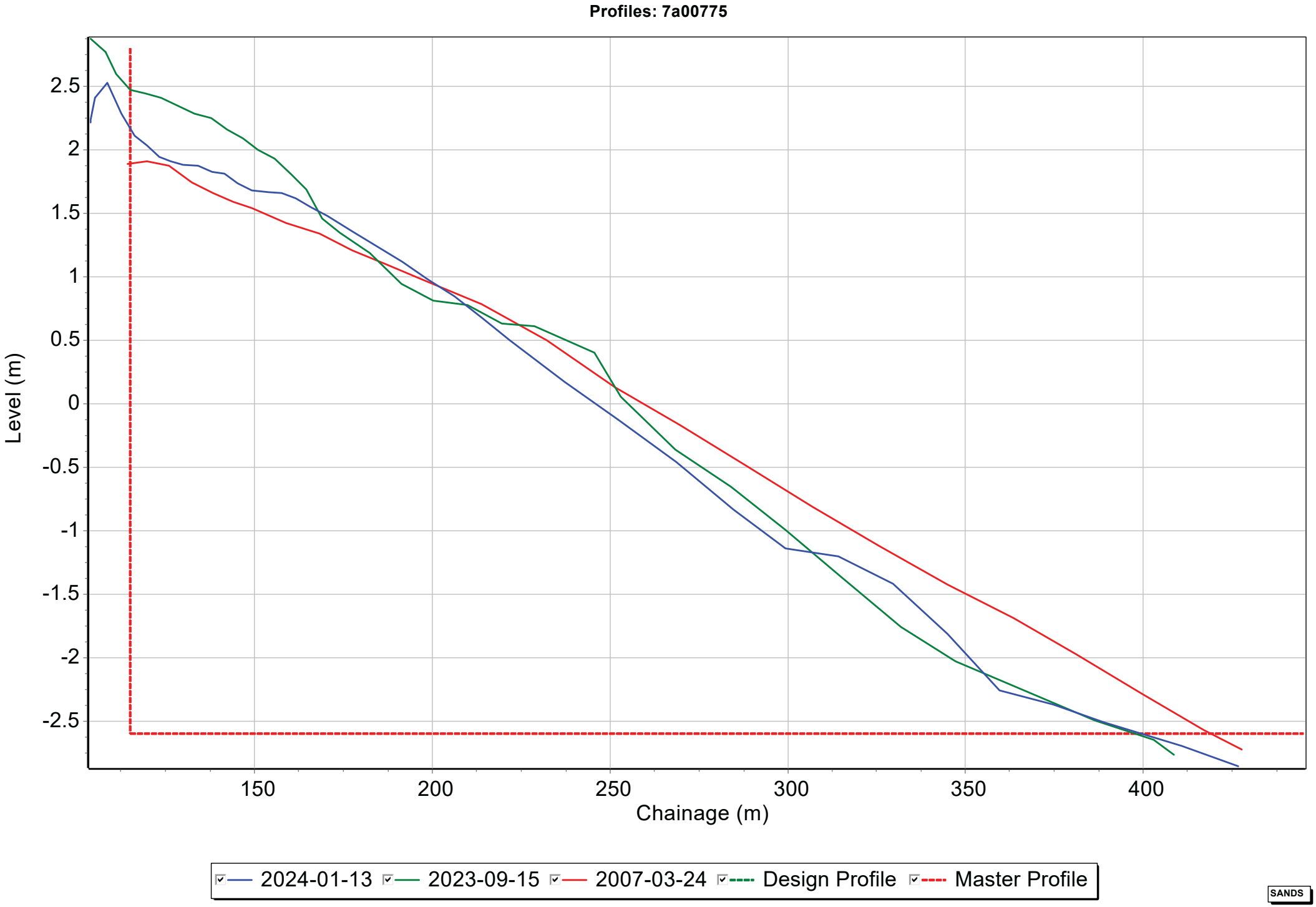
Figure 27 – Aerial imagery from 2018.

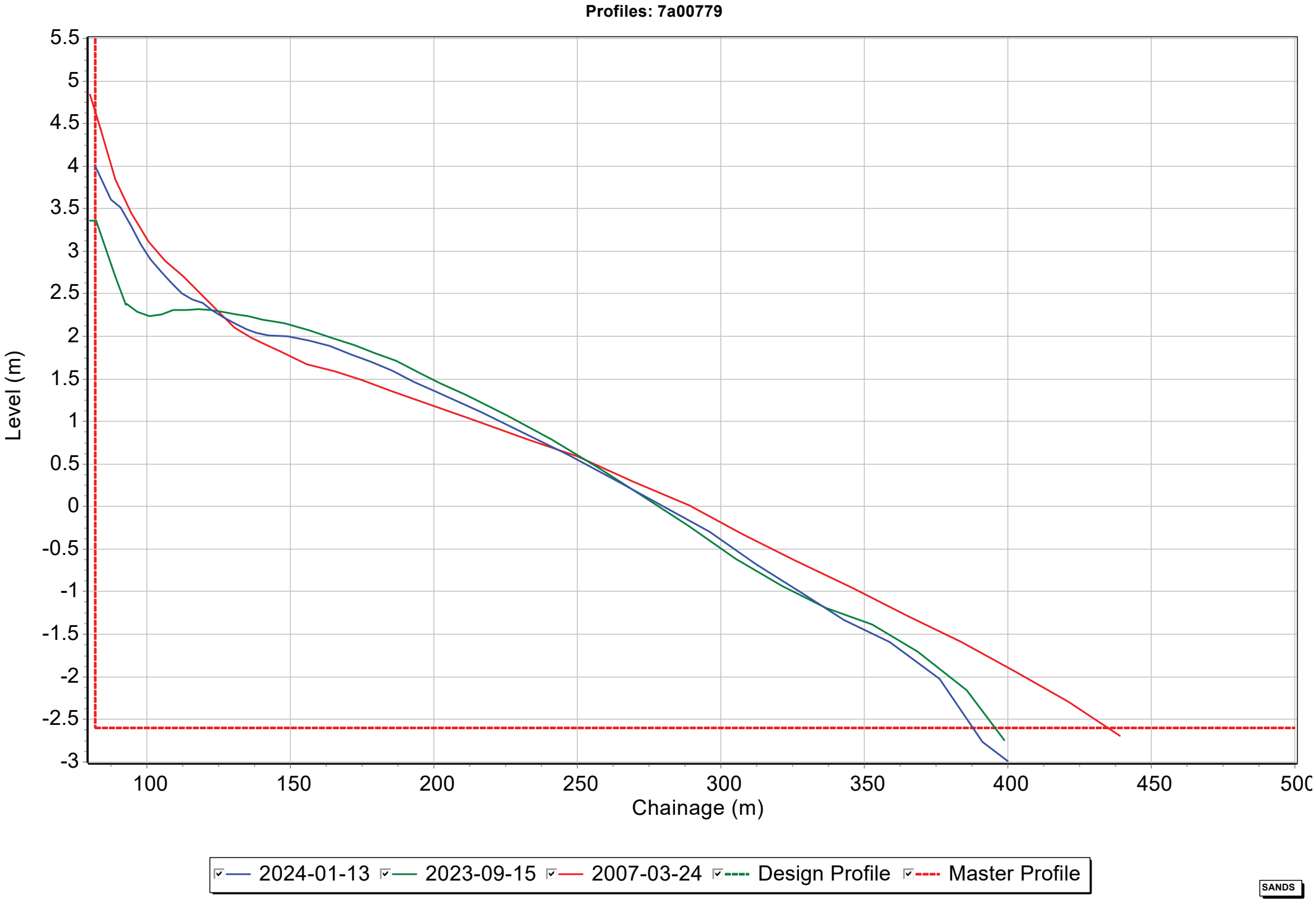
Glossary

1. Accretion: The net accumulation of deposited sediment, deposited by waves, tides or current.
2. Coastal Morphodynamics: The study of changes in coastal landforms and landscapes over time.
3. Contour Analysis: Mapping of contours from LiDAR datasets to represent Mean Sea Level (MSL) and Dune Toe elevations.
4. Cross-Sectional Area (CSA): The area of a two-dimensional cross-section of a cross-shore beach profile, running between Mean Low Water Spring and the back of the beach.
5. Developed Zone: Areas of urban development built atop previously present dune systems.
6. Difference Modelling: Comparison of separate LiDAR surfaces to produce a difference model of change based on gridded spot height elevations.
7. Digital Elevation Model (DEM) and Digital Terrain Model (DTM): DEM represents the Earth's surface with all features, while DTM represents the bare earth surface, excluding vegetation and structures.
8. Embryo Dune: The earliest stage of dune growth, typically found along the seaward extent of a dune system or newly formed dune.
9. Erosion: The process by which local sea level rise, strong wave action, and coastal flooding wear down or carry away rocks, soils, and sands along the coast.
10. Fixed Zone: Area defined by permanent dune vegetation, including scrub or invasive species, denoting vegetation atop sandy soil.
11. Intertidal Bar: A ridge or mound of sand, gravel, or other sediment deposited in the intertidal zone along a shoreline.
12. LiDAR: Light Detection and Ranging, a remote sensing method that uses light in the form of a pulsed laser to measure variable distances to the Earth.
13. Mean High Water Spring (MHWS): The height of mean high-water springs is the average throughout the year of two successive high waters during those periods of 24 hours when the range of the tide is at its greatest.
14. Mean Low Water Spring (MLWS): The height of the mean low-water springs is the average height obtained by the two successive low waters during the same period.
15. Mobile Zone: The area including the active dune face and embryo dune that is in motion due to wind action or other factors.
16. Root-Mean-Square Error (RMSE): A measure of the differences between values predicted by a model and the observed values.
17. Tidal Range: The vertical difference between high tide and low tide during a tidal cycle.

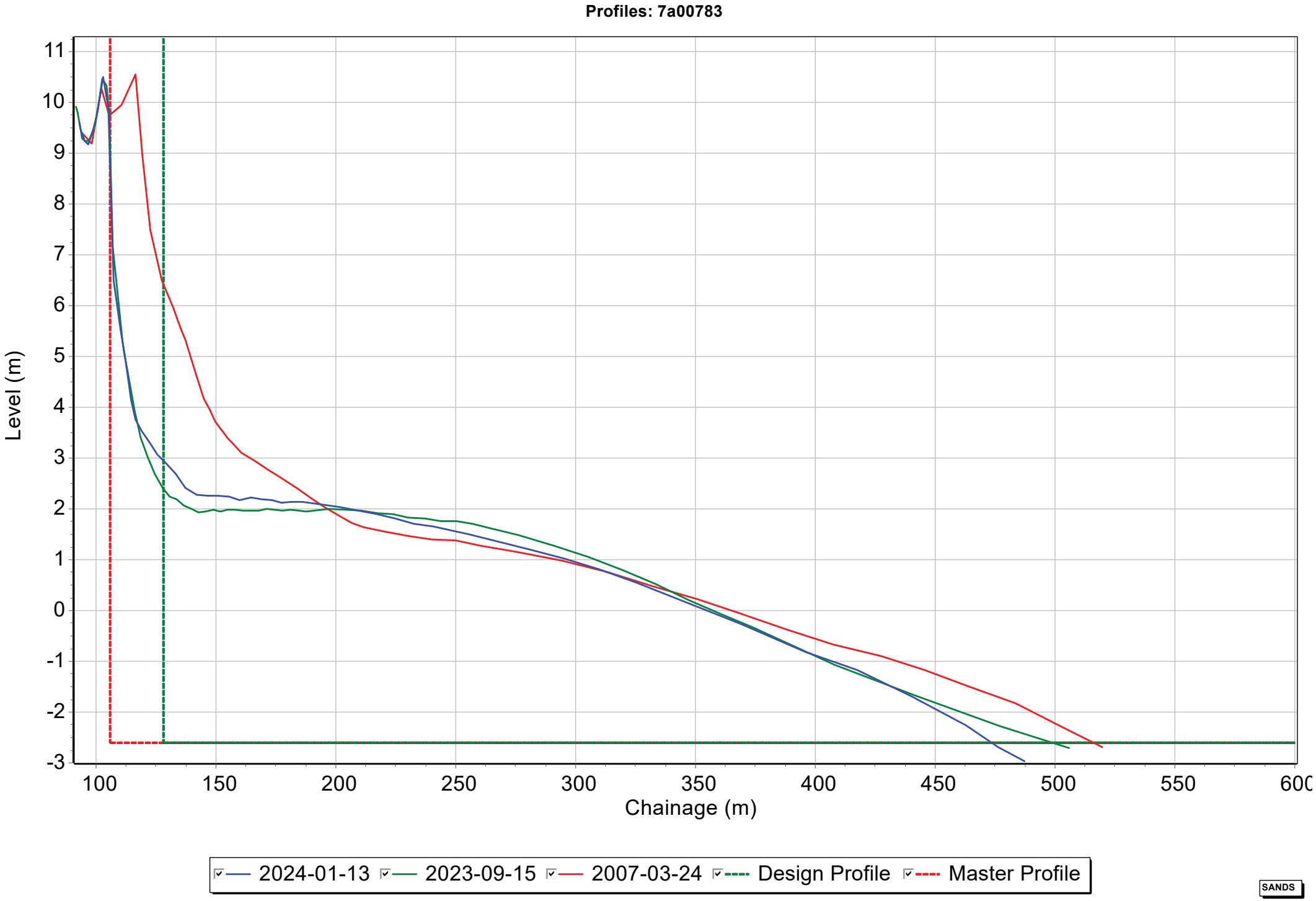
Appendices

Appendix 1 – Profile charts showing the cross-shore area of each interim profile from the most recent survey (blue), second most recent survey (green) and first survey, also known as the baseline (red) at Lelant Towans are presented below.

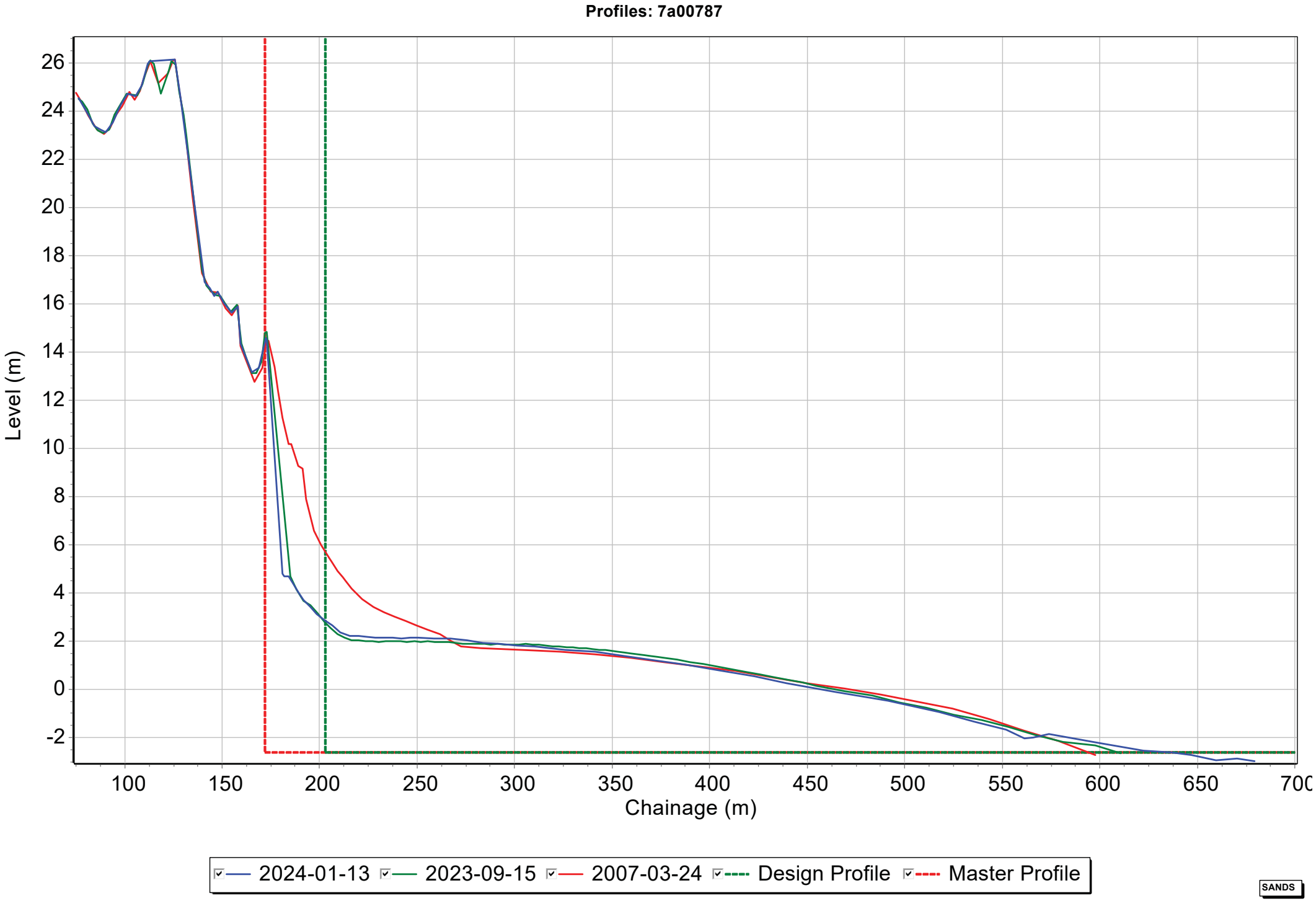

Profiles: 7a00775
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
Level (m)
150
200
250
300
350
400
Chainage (m)
2024-01-13
2023-09-15
2007-03-24
Design Profile
Master Profile


Profiles: 7a00779
Level (m)
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
100
150
200
250
300
350
400
450
500
Chainage (m)
2024-01-13
2023-09-15
2007-03-24
Design Profile
Master Profile

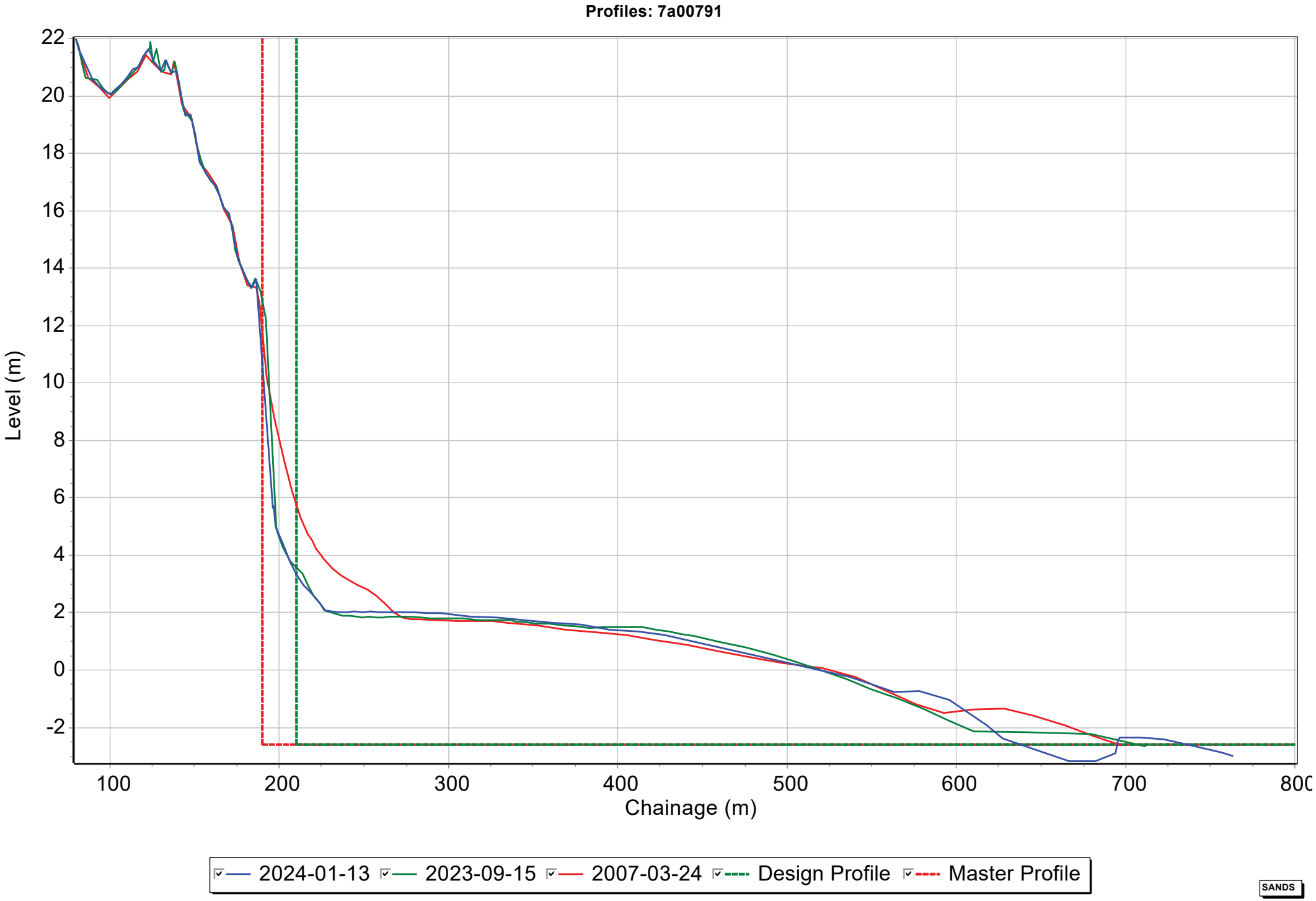
SANDS

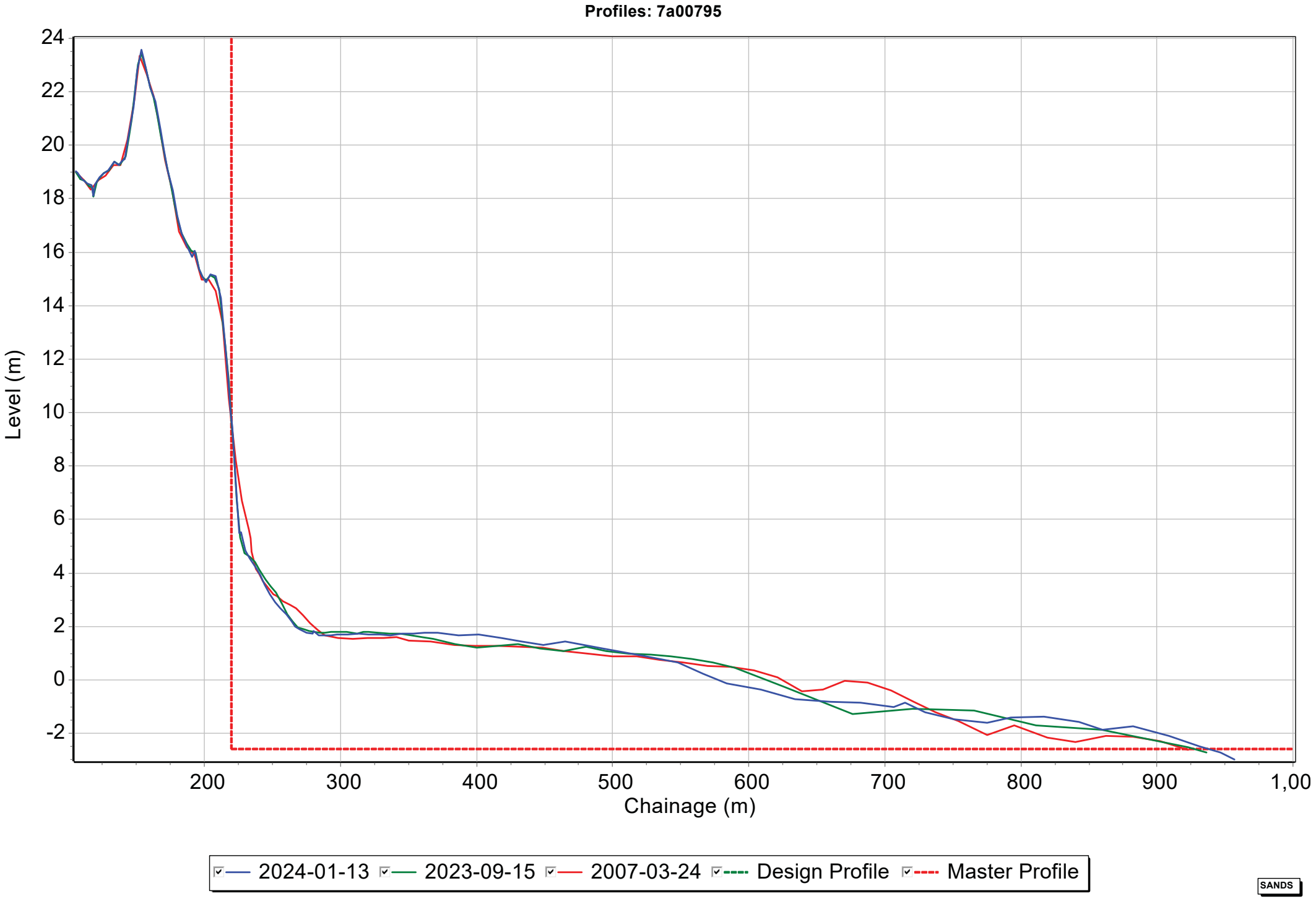

Profiles: 7a00783
Level (m)
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
100
150
200
250
300
350
400
450
500
550
600
Chainage (m)
2024-01-13
2023-09-15
2007-03-24
Design Profile
Master Profile

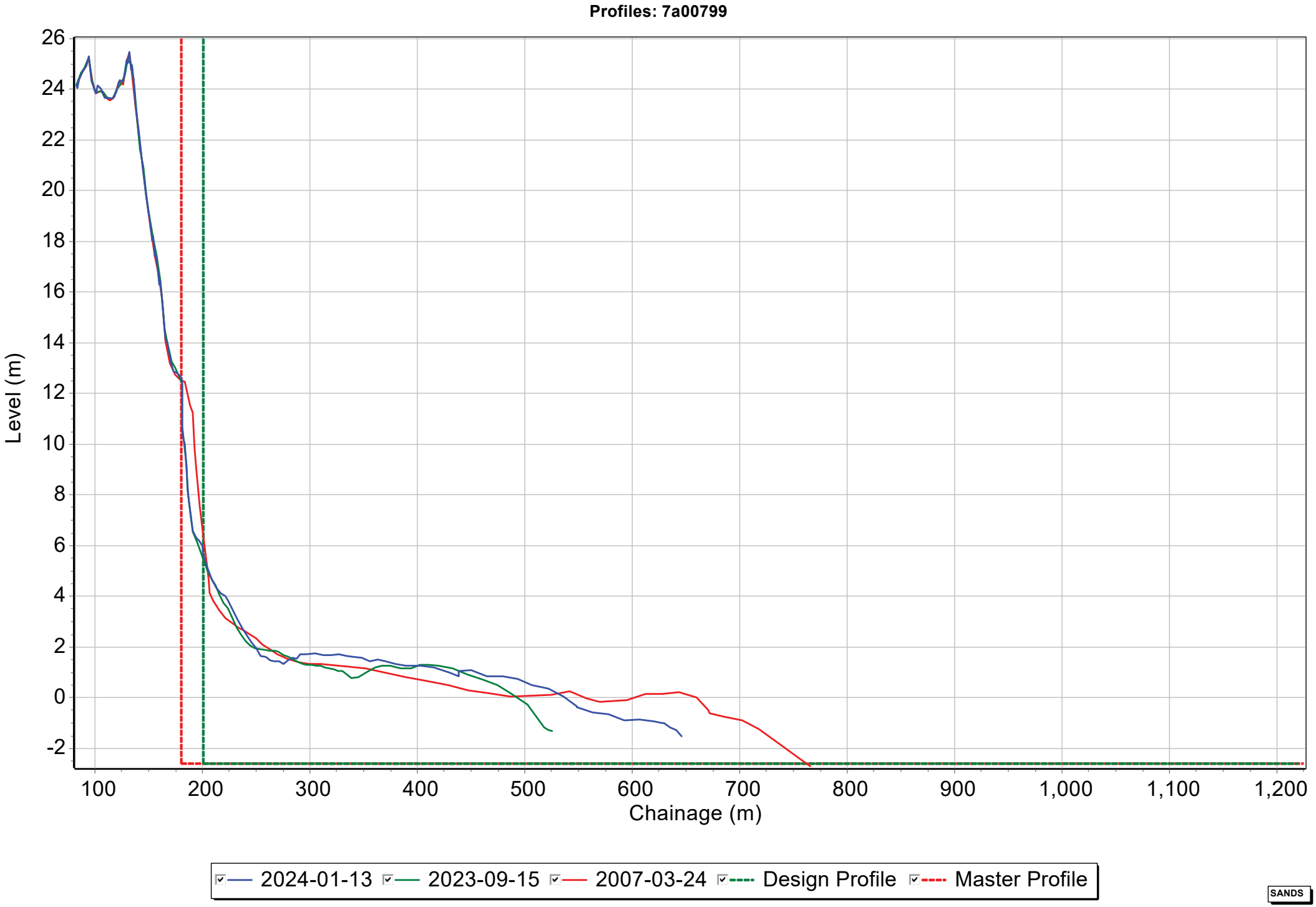
SANDS

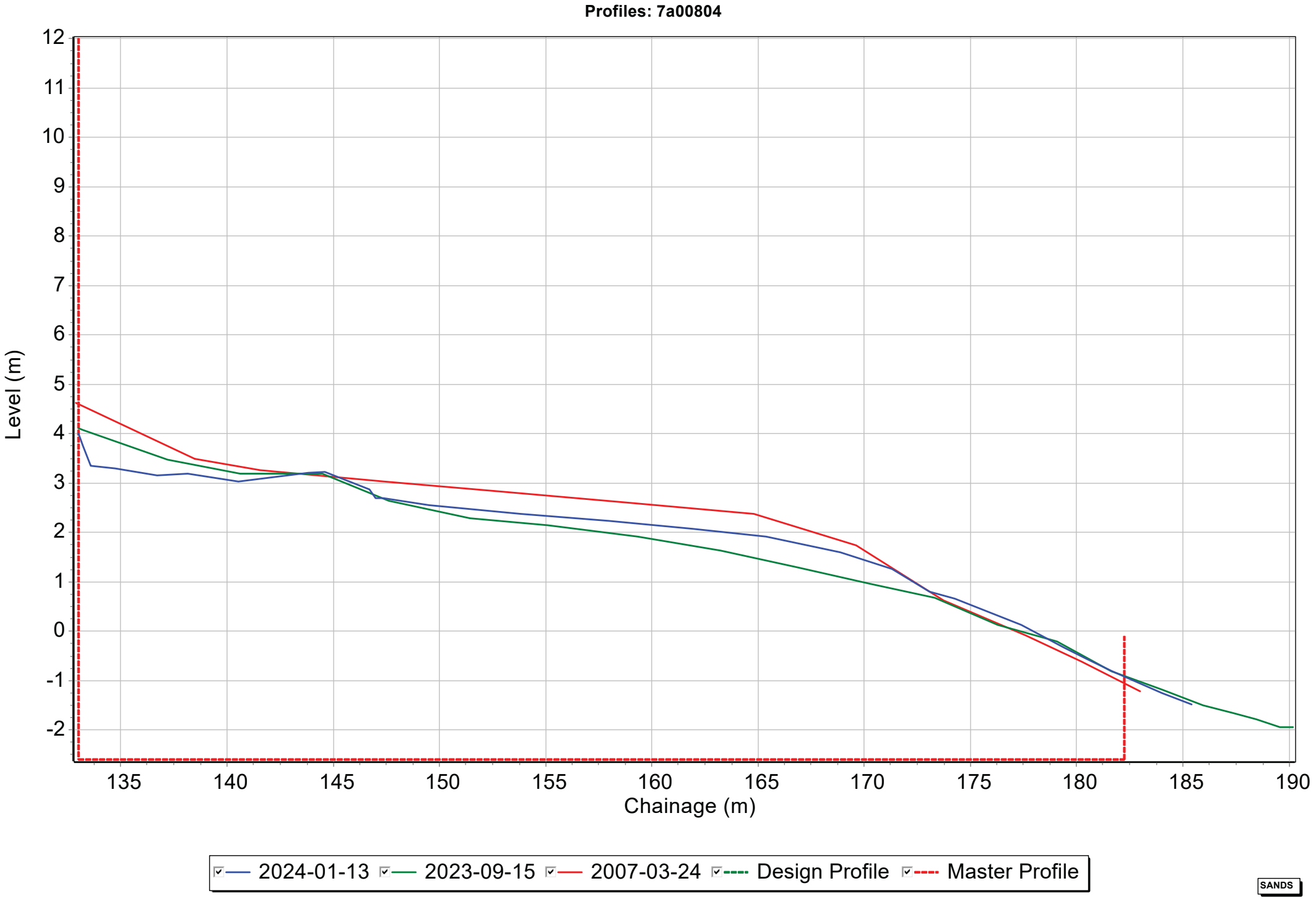

Profiles: 7a00787
Level (m)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
100
150
200
250
300
350
400
450
500
550
600
650
700
Chainage (m)
2024-01-13
2023-09-15
2007-03-24
Design Profile
Master Profile

SANDS


Profiles: 7a00791
Level (m)
22
20
18
16
14
12
10
8
6
4
2
0
-2
100
200
300
400
500
600
700
800
Chainage (m)
2024-01-13
2023-09-15
2007-03-24
Design Profile
Master Profile


Profiles: 7a00795
Level (m)
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
200
300
400
500
600
700
800
900
1,00
Chainage (m)
2024-01-13
2023-09-15
2007-03-24
Design Profile
Master Profile


Profiles: 7a00799
Level (m)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
100
200
300
400
500
600
700
800
900
1,000
1,100
1,200
Chainage (m)
2024-01-13
2023-09-15
2007-03-24
Design Profile
Master Profile


Profiles: 7a00804
Level (m)
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
135
140
145
150
155
160
165
170
175
180
185
190
Chainage (m)
2024-01-13
2023-09-15
2007-03-24
Design Profile
Master Profile