Jersey Shoreline Management Plan

Technical Note: Coastal Erosion and Beach Analysis (Appendix I)

Project number: 60580871

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Quality information

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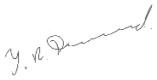			
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Revision History

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0	8/2/19	Draft for comment	8/2/19	Tara-Leigh McVey	Regional Director
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Distribution List

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I. Coastal Erosion and Beach Analysis

I.1 Coastal Erosion (Shoreline Evolution Mapping)

I.1.1 Review of Aerial Imagery

AECOM undertook a desktop coastal erosion study to make a comparison of the position of the top of cliffs from aerial imagery provided by Government of Jersey (GoJ; formerly States of Jersey (SoJ)). The years selected for analysis were based on readily available and suitable quality data to maximise the study duration were:

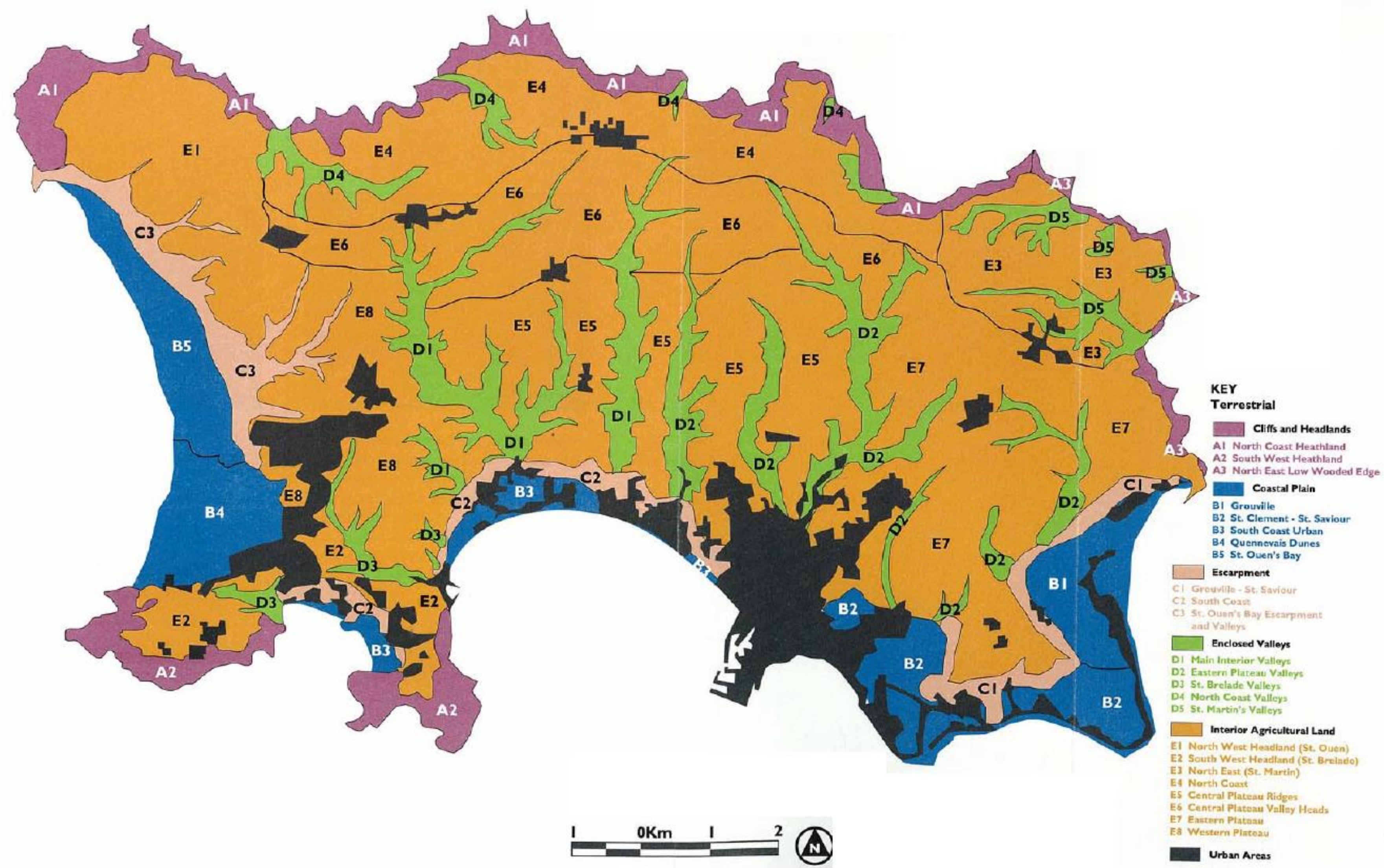
- 2003
- 2006
- 2008
- 2011
- 2014
- 2017

Each aerial image was loaded into a GIS to observe changes in cliff features and evidence of erosion causing recession of the Top of Cliff (ToC). It should be noted that the high-level nature of the study means that no attempt was made to provide a more detailed geological assessment and distinguish the different physical (denudation) processes that can lead to 'loss of material'; for example, through weathering and mass wasting. The study focuses primarily on erosion that has occurred and / or is inferred to have occurred as a consequence of wave action.

I.1.1.1 Cliff Identification and Characteristics

Jersey comprises hard cliffs and soft cliffs based on the underlying geology. The key literature source reviewed to distinguish different types of cliffs was GoJ's Countryside Character Appraisal (CCA, 1999). This study was completed by GoJ's Planning and Environment Committee as part of the Jersey Island Plan Review, which provides a multi-theme characterisation of the island, including geology based on an interpretation (BGS, 1989) of the island's geological features and mapping (BGS, 1982). A GIS layer provided by GoJ, entitled 'Cliffs and Headlands' presented the location of this 'character type' around the island. The CCA also presents other character types, based on the underlying solid and drift geology and landscape features. The different character areas are shown in Figure I-1.

Figure I-1: Character Areas in Island Plan Review Countryside Character Appraisal (1999)



The CCA confirms the presence of cliffs along Jersey’s coastlines, principally the north, and the southwest of the island. The geology of the north coast, between Rozel and St Ouen’s Bay to the west, comprises elevated cliffs (exceeding 100 m) made from hard, volcanic rocks and granite. The cliffs in the southwest of the island are situated on the peninsulas to the west and east of St. Brelade's Bay (Corbière and Noirmont Portelet to the west and east, respectively (States of Jersey Planning Environment Committee, 1999)). The geology in this area is characterised by metamorphic granite including coarse-grained granite of Corbière type, fine-grained granite of Beauport type and porphyritic granite of La Moye type (British Geological Survey, 1982)) with deposits of softer Pleistocene rock, which is more susceptible to erosion.

Cliffs and headlands are also present in other areas of the island but are less extensive. There is a headland near Le Hocq, whose geology is similar to the southwestern cliffs. On the eastern coast between Rozel and Anne Port, cliffs are characterised by harder rock (Rozel Conglomerate Formation overlying Bouley and St. John’s Rhyolite Formations, which is overlain with softer sedimentary rock (glacial Loess and Head deposits) (Nichols, pers.comm. 2019).

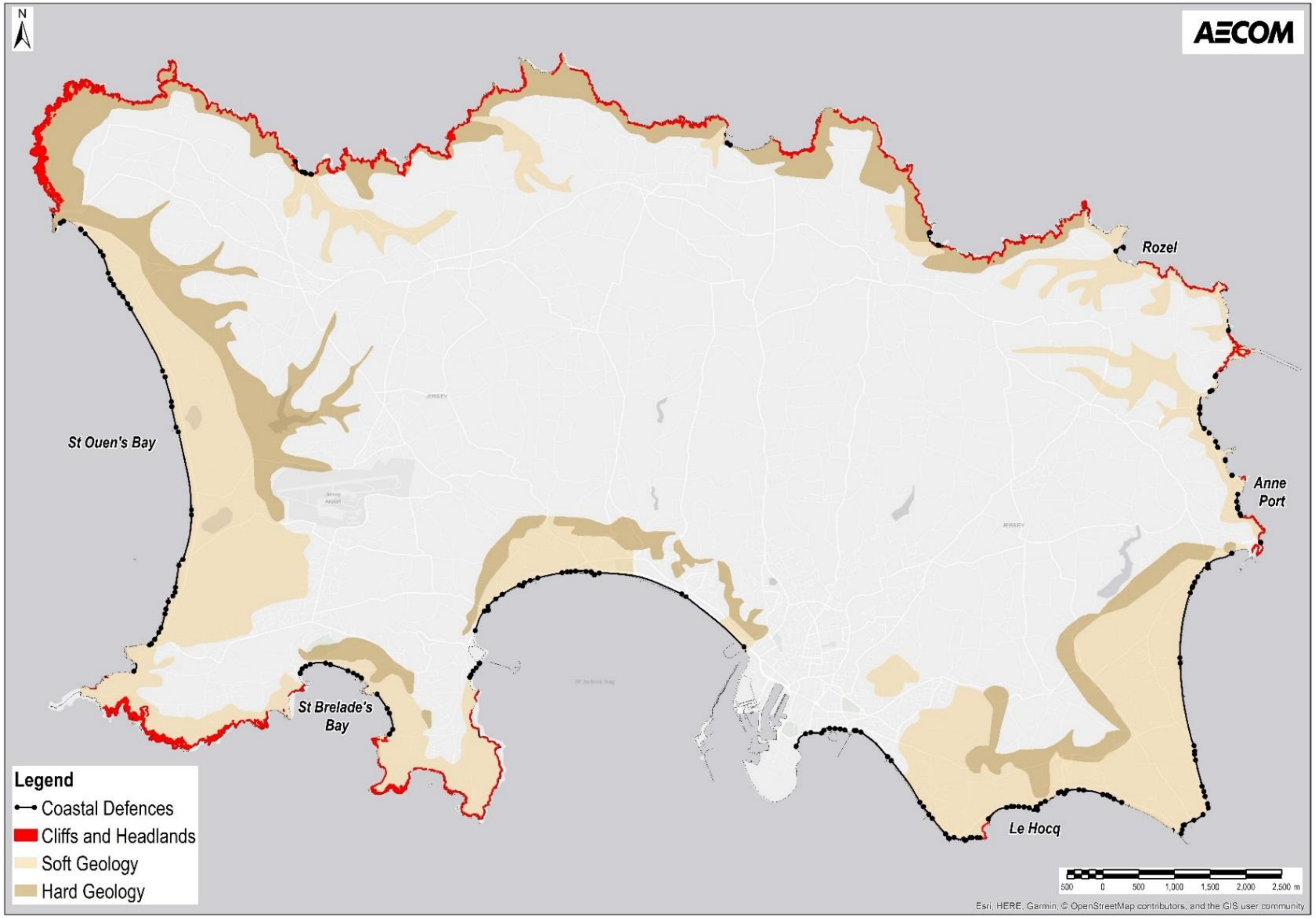
Based on a review of the character areas, a simplified map was created in the GIS to distinguish between hard geology and soft geology reported in the CCA character areas (Figure I-2). The distinction between ‘hard’ and ‘soft’ was made in order identify areas that were likely to more resistant to coastal erosion. The locations of coastal defences were also included in Figure I-2 order to identify the areas of softer geology, without defences, that would be susceptible to erosion. It also enabled the identification of those areas, where defences are present, that should limit the potential for erosion to occur.

Any changes observed in the aerial map review was used to project a future erosion buffer zone and to identify potential assets at risk (residential, commercial, heritage, road infrastructure). The buffer zone distance was based on the historic rate of erosion calculated from the change in position of the 2003 and 2017 cliff line.

It should be noted that a proportionate approach was taken to derive future erosion rates, through the extrapolation of historic rates as supported by previous GoJ studies indicating that erosion is minimal around the Island. There are alternative approaches to estimate future cliff erosion rates, particularly in locations where there is an extensive data set and where cliffs are composed of highly erodible material; however, based on the limited data available and the predominantly hard island geology these alternatives were deemed inappropriate for the purposes of the development of the SMP.

It should also be noted that the analysis excludes offshore reefs and islands such as the Minquiers and Ecréhous groups of islands. Whilst there is the potential for erosion in these locations, GoJ has no formal responsibility to maintain or construct new coastal defences to mitigate erosion.

Figure I-2: Island Map showing areas of cliffs and headlands, hard and soft geology and coastal defences around Jersey



I.1.2 Hard Cliff Erosion

The hard cliff locations between Rozel and St Ouen’s Bay were evaluated and it was concluded that there were no signs of erosion from visual analysis of the historic aerial imagery between 2003 and 2017.

I.1.3 Soft Cliff Erosion

The cliffs and headlands in the eastern and southeastern areas with softer underlying sedimentary rock present (Le Hocq and Rozel to Anne Port) did not show any signs of erosion from the visual analysis of the historic aerial imagery between 2003 and 2017. There was a single area of erosion identified at Portelet Beach, on the peninsula to the east of St Brelade’s Bay. Figure I-3 shows the 2003 cliff line versus the 2017 cliff line. In area terms, the eroded area is approximately 500 m^2 and suggests an annual average rate of erosion of 0.3 m per year at Portelet. This equated to a future buffer zone of 30 m for the next 100 years, noting that this is a conservative projection based on observations at Portelet Beach only. Figure I-4 shows the buffer zone applied to the cliffed / headland areas along with the presence of coastal defences. Assets of interest are outlined in red.

Figure I-3: Evidence of Cliff Erosion at Portelet Beach, Le Portelet

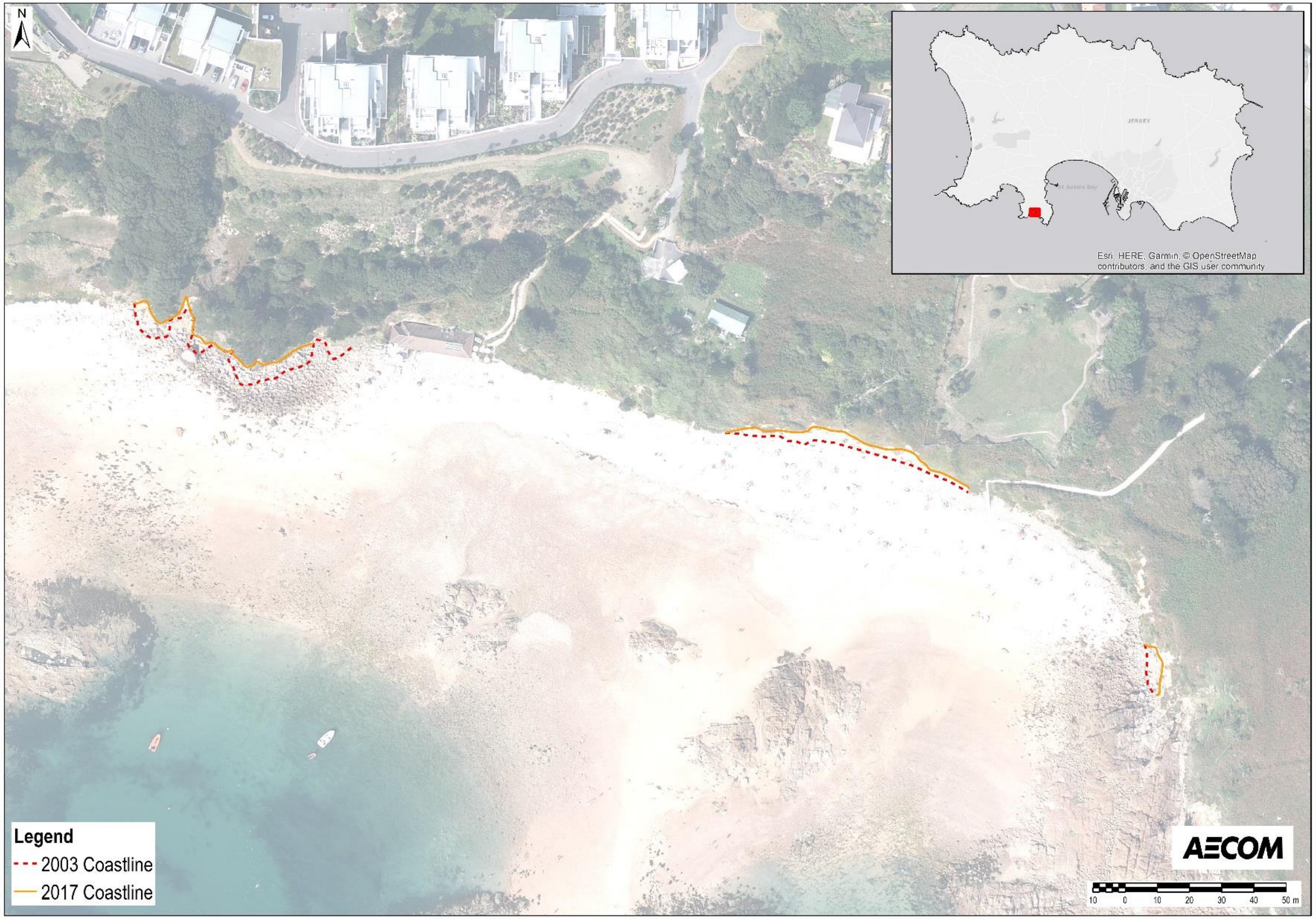
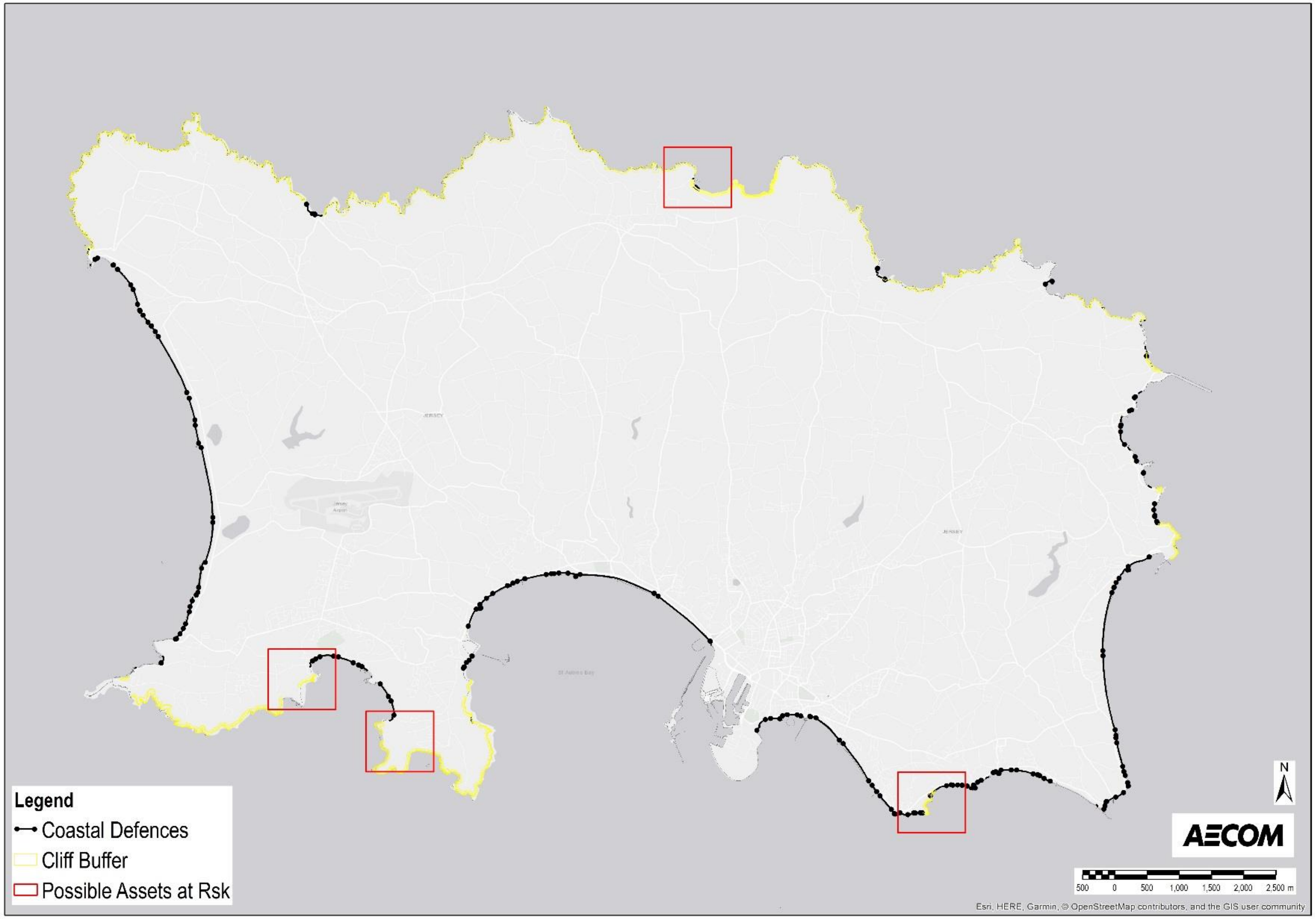


Figure I-4: 30m future erosion buffer zone applied to cliffed areas around Jersey



Owing to limiting factors of hard geology or the presence of defences, few locations were identified within the buffer zone where assets could be at potential risk in the future. The key locations that drew attention are summarised in Table I-1 and these are all on the south coast with the exception of Bonne Nuit on the north coast. Asset locations are shown in Figure I-5 and Figure 1-6.

Table I-1: Locations of Potential Assets at Risk based on Future Erosion Buffer Zone

Coast	Location	Defended / Undefended	Evidence of Historic Erosion	Assets within Buffer Zone
South	Les Creux	part defended (private defences); part undefended	Yes (undefended section)	Residential and Chemin des Creux road
South	Le Ouaisné (Archaeological and Geological Site of Special Interest (SSI))	undefended	Yes	La Cotte de St.Brelade (cave and key Neanderthal site from NW Europe)
South	Portelet (Beach) (Geological SSI)	undefended	Yes	Residential and commercial properties
South	St Clement (between Green Island defences and Le Nez Point to Le Hocq Point defences)	part undefended / part defended	Yes (in undefended section) / No (defended section)	Residential and A4 La Grande Route de la Côte road
North	Bonne Nuit Bay	part undefended / part defended	Yes (in undefended section and prior to defences being built in front of commercial property)	Residential and commercial properties and Les Nouvelles Charrières and Les Charrières de Bonne Nuit roads

Figure I-5: Assets present in future buffer zone – Les Creux, Le Ouaisné and Portelet Beach, and St Clement (between Green Island defences and Le Nez Point to Le Hocq Point defences)

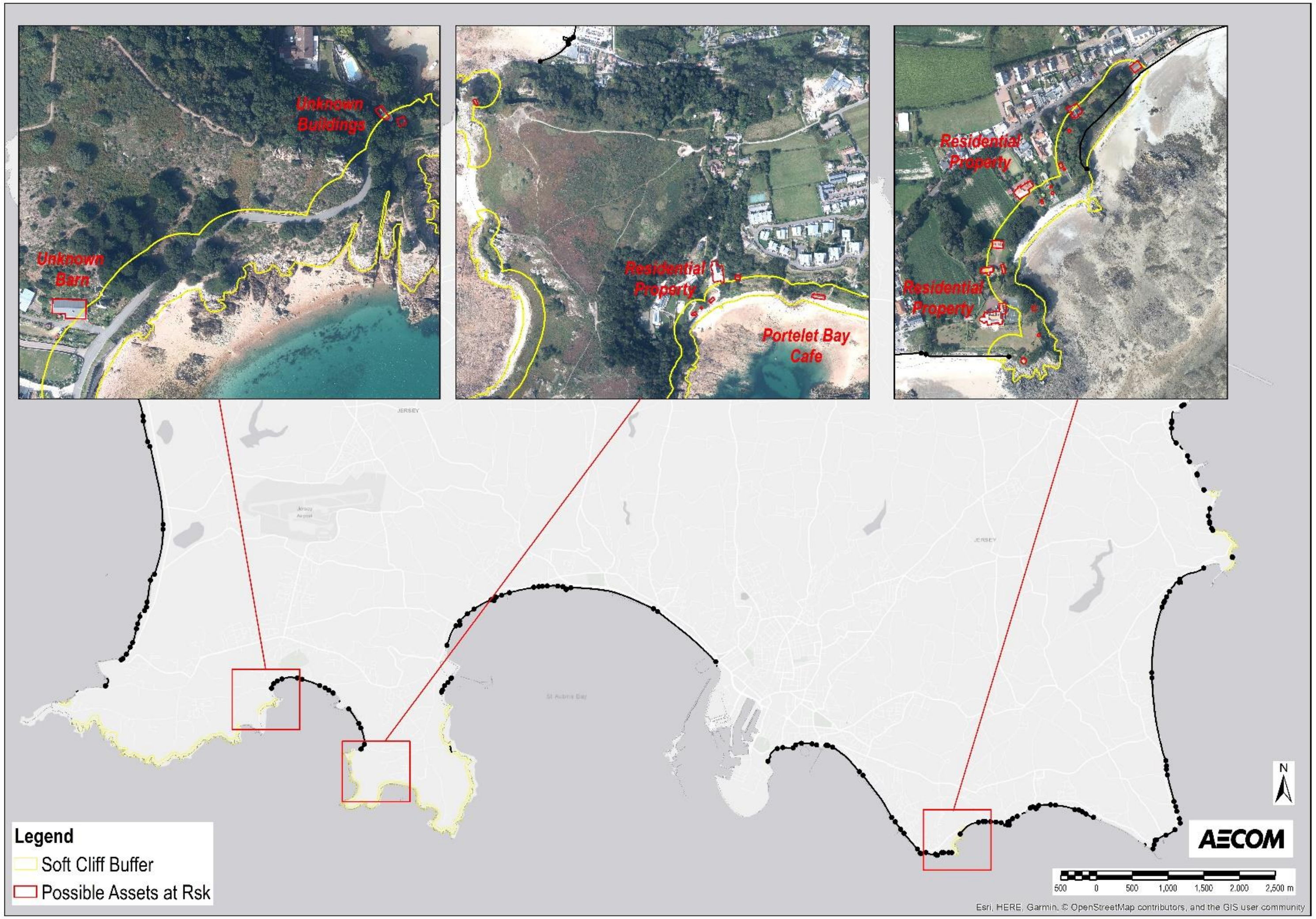


Figure I-6. Assets present in future buffer zone – Bonne Nuit Bay

I.1.4 Summary Conclusions

From the review of selected aerial maps between 2003 and 2017 the key observations are summarised as follows:

- Negligible evidence of hard cliff erosion, which predominate on the north coast.
- Limited evidence of erosion in soft cliff geology.
- Measurable recession observed at Portelet, equating to approximately 0.3 m per year.
- Historic erosion rate has simply been projected to other soft cliff areas, through adding a 30 m buffer to represent the potential erosion over the next 100 years. This assumes historic environmental (marine, atmospheric, geomorphological and geological) conditions continue in the future. Whilst the limitation of this approach is acknowledged, the lack of evidence of historic erosion in this review is aligned with longer term observations on the island by GoJ and is considered appropriate based on the data available.
- Potential assets at risk are identified for areas all on the south coast with the exception of Bonne Nuit Bay on the north coast. The areas of interest and, therefore, appropriate to monitor in the future (as part of GoJ's wider coastal monitoring programme) are in:
  - Les Creux
  - Le Ouaisné
  - Portelet Beach
  - St Clement, between Green Island and the defences between Le Nez Point to Le Hocq Point
  - Bonne Nuit Bay
- If the historic erosion rate continues in the future, some building and infrastructure assets may be at risk on undefended sections of coastline.
- It is recommended that aerial maps are reviewed on an annual basis for evidence of erosion, supported by site observations (photographs and notes recorded). These observations can be acquired during routine structural inspections and in the event of any reported / observed displacement of cliff material as a result of storms and gales on high spring tides with heavy rainfall.

I.2 Present Day Beach Stability and Implications for Flood Risk (Beach Volume Change Risk)

I.2.1 Method

I.2.1.1 Beach Profile Data

AECOM were provided with the historic profile analysis conducted by Hydraulics Research (1991) on behalf of GoJ. The profile locations are shown in Figure I-9. The data covers four seasonal surveys carried out in February, May, August and November during 1992 through to 1998. For 1999, only three seasonal profiles; February, May and August were completed, and for the 2003 survey only February and May were surveyed.

AECOM collated all data from multiple formats into a new master spreadsheet, allowing for a more efficient cross examination of the data throughout the above survey periods. The data was attributed to a GIS feature class at 20m interval chainage markers along the profile lines supplied by GoJ. By creating the above chainage markers in GIS, it allowed AECOM to extract the 2017 elevations from the 2017 Digital Terrain Model (DTM), which were then combined to the master database.

The differences in data collection used by Hydraulics Research for the 1992-2003 surveys and that used by AECOM based on the 2017 DTM were sometimes made obvious when compared next to each other. This highlighted some discrepancies and, where the 2017 data was of poor quality, this was removed from the analysis. Future monitoring plans should focus on each profile to be surveyed using terrain-based survey equipment at the chainage markers (as conducted during the 1992-2003 surveys) to ensure a more accurate comparison of the beach profiles.

I.2.1.2 Cross-sectional Area Analysis

To compare the change in beach profiles (Figure I-7) during the survey periods, cross sectional areas were calculated for selected profiles, based on the area under the profile line down to the intersection with Mean Level Water Neap (MLWN) which was -1.88m AOD. The selection of profiles was undertaken based on priority areas and the relative amount of clustering / spread of profiles; the profiles of most relevance in relation to the overtopping and still water level analysis were considered i.e. profiles in areas of significant overtopping of still water level flooding were selected. The inspection of profiles led to the following profiles being selected for cross sectional analysis:

Table I-2: Areas for Cross-section Analysis

Profile ID	Location	Basis of Selection
PSD4	Grouville – between Towers 3 and 4, Grouville	Overtopping projection
PSD8	Grouville – Royal Jersey Golf Club, Grouville	Overtopping and Still Water Level projections
HR4	St Ouen's Bay – The National Trust for Jersey Wetland Centre	Overtopping projection
HR12	St Aubin's Bay – between La Haule and Beaumont, St Aubin's Bay	Overtopping and Still Water Level projections
HR16	St Helier – Havre de Pas	Overtopping and Still Water Level projections
HR17	Le Squez – Greve d'Azzette	Overtopping and Still Water Level projections
HR18	Le Squez – La Mare	Overtopping projection
HR19	St Clement – Le Nez Point to Le Hocq Point	Overtopping projection

The change in cross sectional areas for the selected profiles at each year are displayed in Section 2.2.3.

I.2.1.3 Beach Change Scenarios based on Cross-sections and Aerial Maps

AECOM calculated the averages of the levels recorded at each chainage point for each year a survey was undertaken. Through a process of iteration, 10% of the average value was calculated, and was added or deducted from the average level to provide an indication of typical beach levels and average upper and lower levels. Inspecting the upper and lower average levels allowed AECOM to determine how many of the survey results fell within 10% of the average level, and how many were outside the 'typical' values within the range of average values; these were determined as extreme results. The extreme values were calculated by taking the highest and lowest values recorded at each chainage point across all survey years.

The supplied aerial maps were inspected to identify any significant plan changes in beach form for the years available.

I.2.1.3.1 Estimating Probable (Typical) Beach Change

Using the supplied profile elevations between 1992 and 2003, combined with the elevation data from the 2017 DTM, AECOM calculated the typical change in beach elevation over 100 years, applying a 10% change to the average elevation and dividing this by the years the current survey data covers (26 years, 1992-2017 inclusive), which was then multiplied by 100 years.

$$Typical\ Change\ in\ Elevation = \left(\frac{10\%\ of\ Average\ Elevation}{26\ years}\right) \times 100\ years$$

I.2.1.3.2 Estimating Extreme Beach Change

Using the beach profile data, AECOM calculated the extreme changes in elevation, taking the average levels at each chainage point on a profile, and by comparing it to the lowest level recorded across all surveys. Results were divided by the years the current survey data covers (26 years) and multiplied by 100 years.

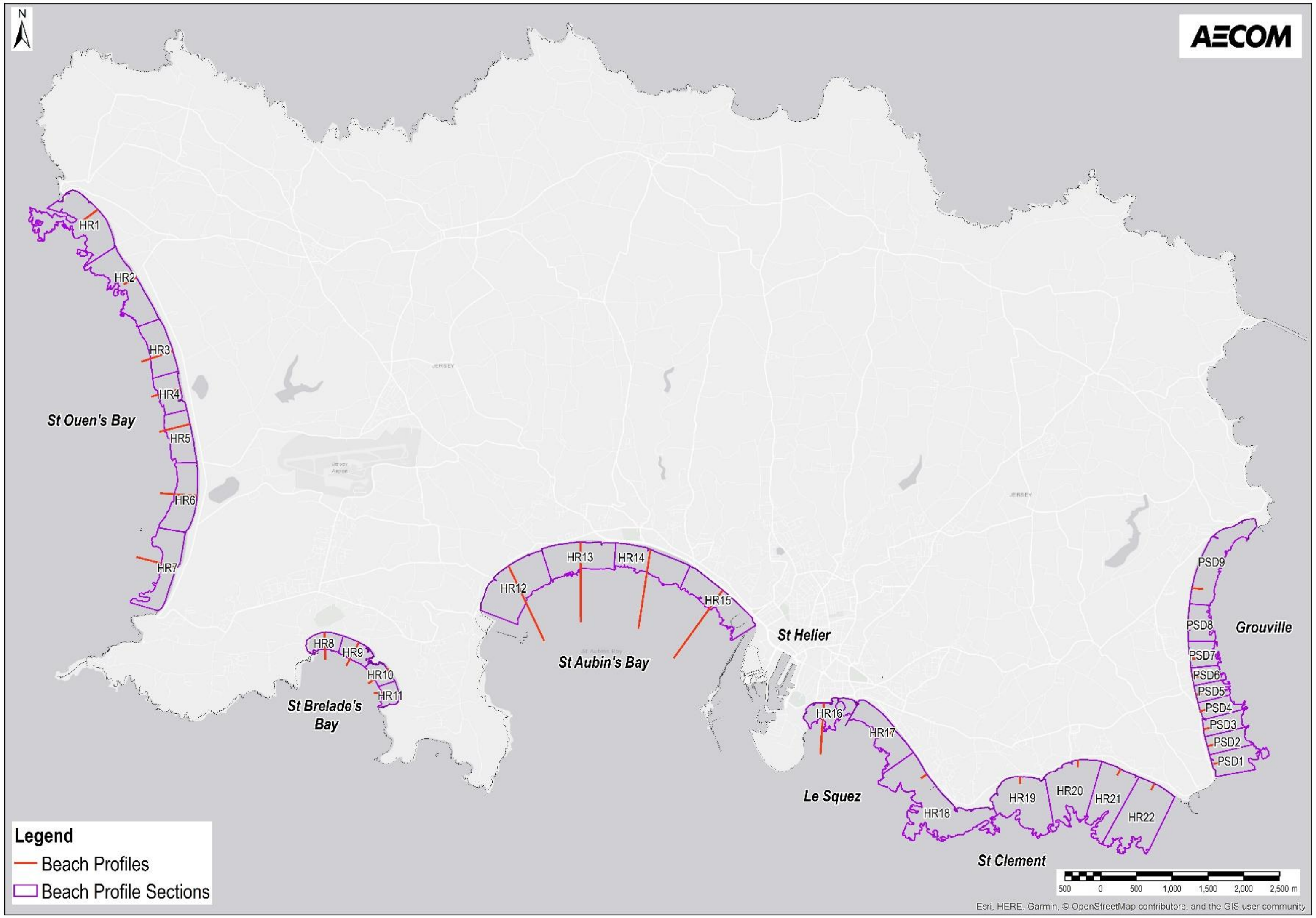
$$Extreme\ Change\ in\ Elevation = \left(\frac{Average\ Level - Lowest\ Level}{26\ years}\right) \times 100\ years$$

Based on an initial review of the profile data, AECOM used the results for the extreme changes (taking a more conservative approach) and applied the duration of each epoch (20, 50 and 100 years), in order to report predicted potential levels of beach elevation change along the chainage of the profile for each epoch. Taking the potential changes as lowering rather than accreting, information for selected profiles was put through overtopping analysis to test the sensitivity of lowering to the results. Wave models were rebuilt and rerun using projected lower bed levels along the coastline for three priority locations (Appendix B of Hydraulic Modelling Report for overtopping analysis).

I.2.1.4 2017 Beach Volumes

The 2017 beach volumes were calculated by taking the cross sectional areas of profiles and multiplying these by the lengths of coastline; the length of coastline was determined by the parcels of beaches set out in Figure I-7, which were set out using natural breaks north and south (or east and west) of each profile.

Figure I-7: Beach Profile Areas of Extent



I.2.2 Results and Discussion

I.2.2.1 Historic Beach Profile Graphs (annual change)

AECOM produced a set of beach profile charts to present and compare each of the annual averages of the historic surveys prepared as explained in Section 2.1. A summary of key observations is provided for each geographical area, as per the CSA analysis. These charts show the relative clustering or spread of profiles for different years and also bring out the historic behaviour of different parts of the profile.

The review of beach plans in the aerial maps found negligible net changes in beach plan shape for the period 2003 to 2017. Whilst beaches did show what appears to be some erosionary and accretionary behaviour; the overall message was for no trend either way or nil change behaviour.

I.2.2.1.1 Grouville

The trend in the CSA analysis for steady profiles over the course of the surveys is seen in the charts with profiles generally clustered together (Figure I-40 - Figure I-48). The lowering of the PSD1 profile in the DTM (near Tower 1, La Rocque) is clearly seen in Figure I-8 in the upper portion and elevated levels in the lower portion. The 1998 profile also shows lowering in the upper portion, which can be seen in Figure I-10. For PSD4 (near Tower 3, Le Hurel), this shows lowering in the upper profile for 1998, whilst the 1996 results show accretion further down the profile.

Figure I-8: Annual change of historic beach profiles – PSD1

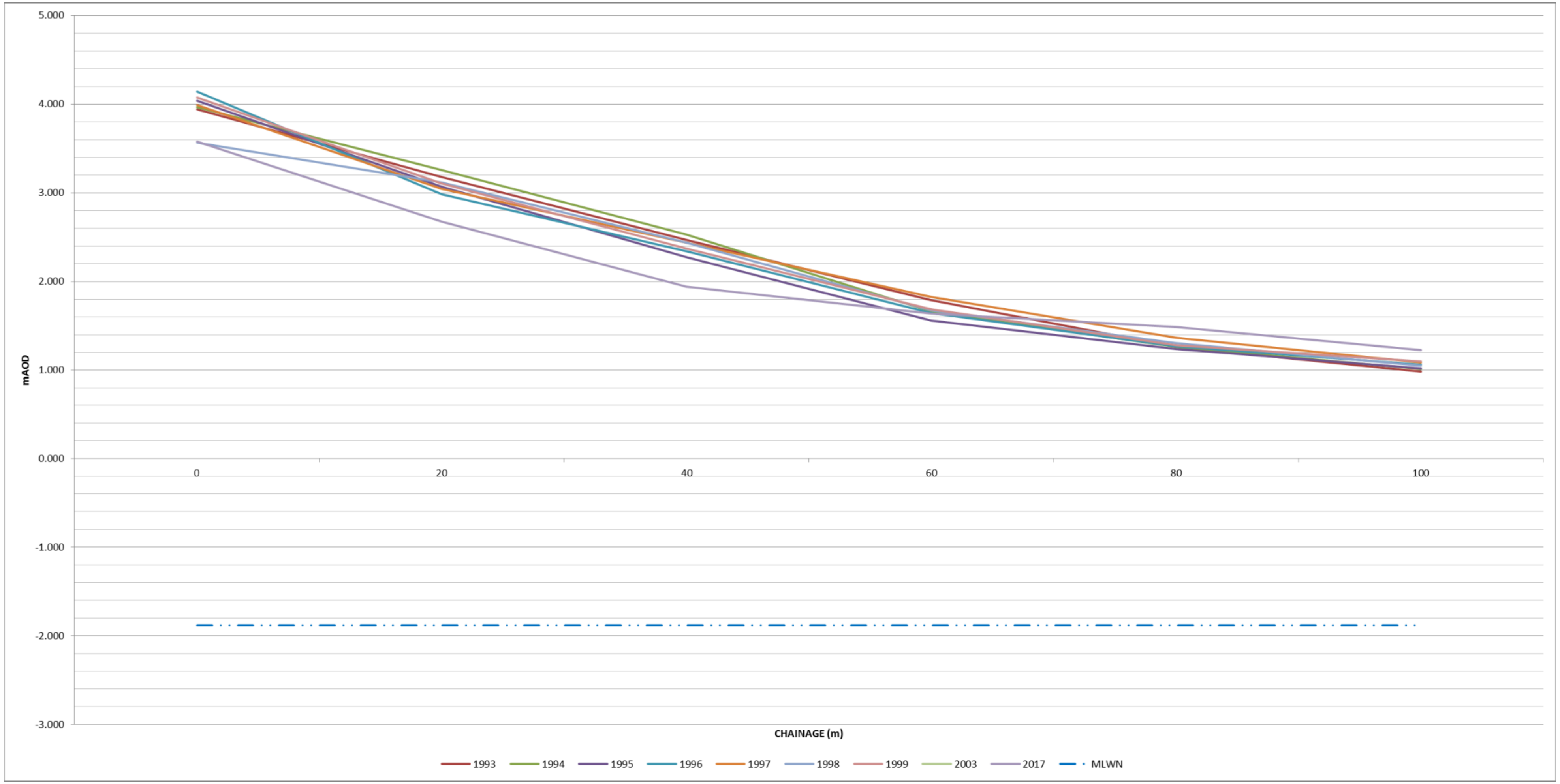


Figure I-9: Annual change of historic beach profiles – PSD2

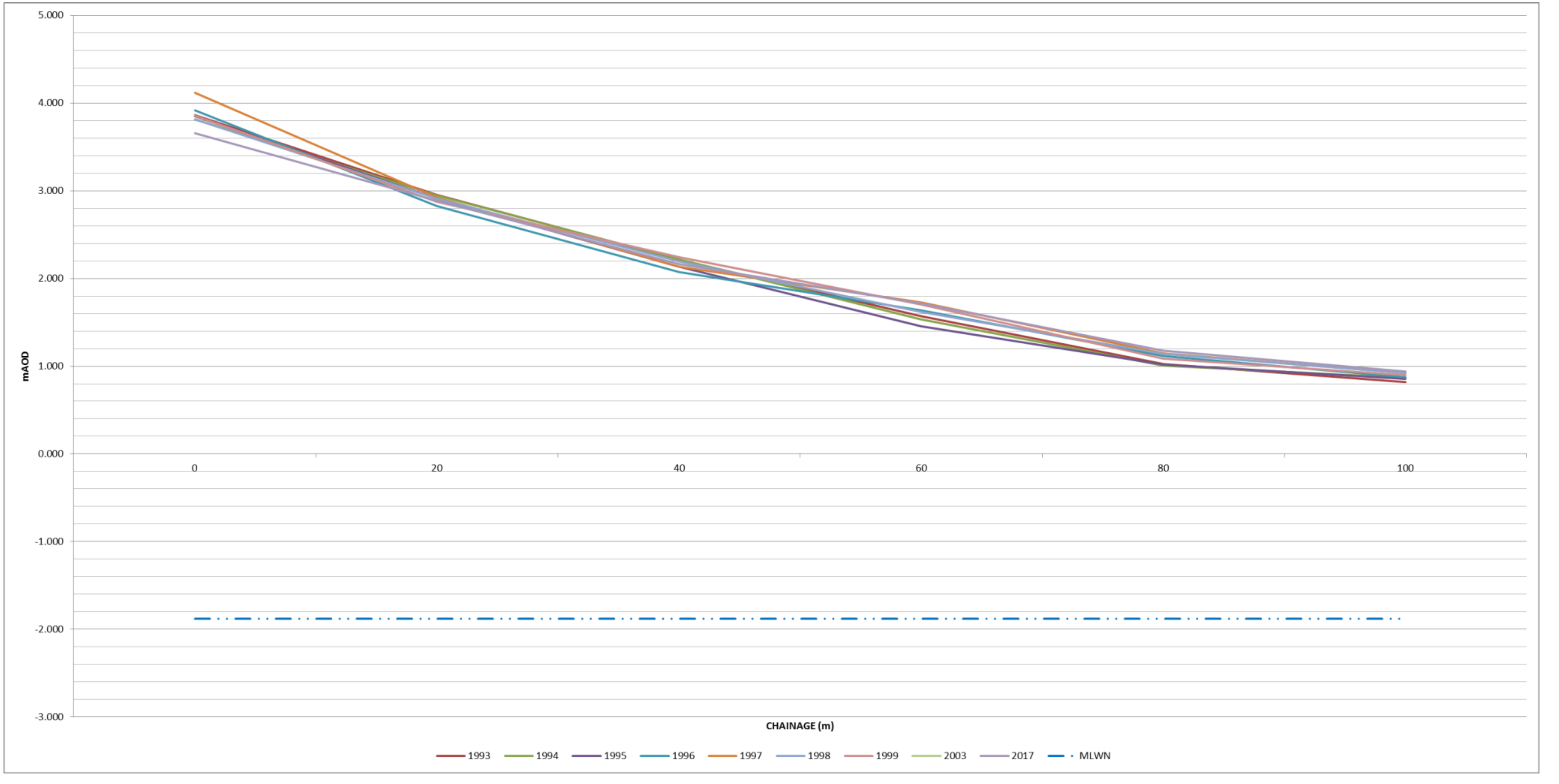


Figure I-10: Annual change of historic beach profiles – PSD3

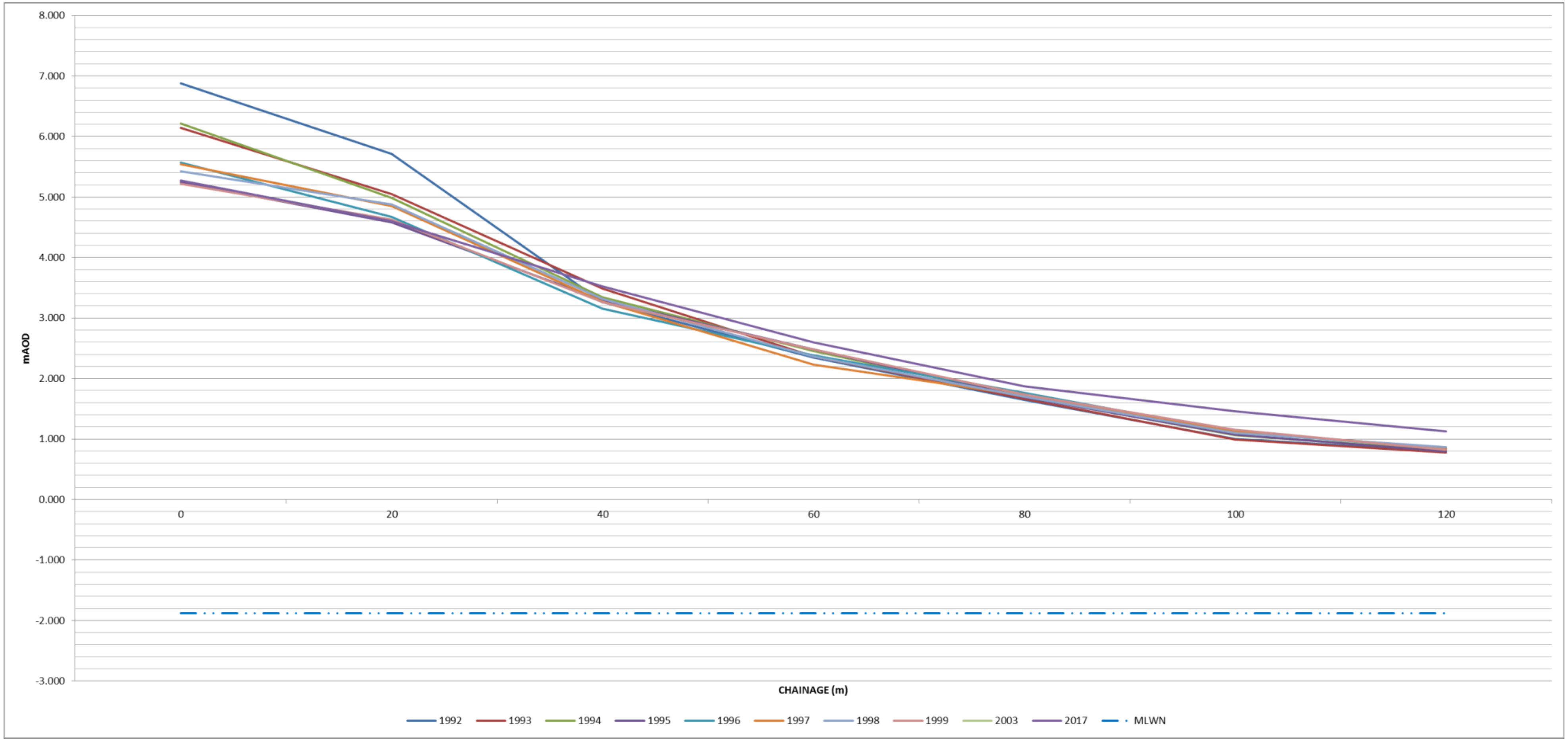


Figure I-11: Annual change of historic beach profiles – PSD4

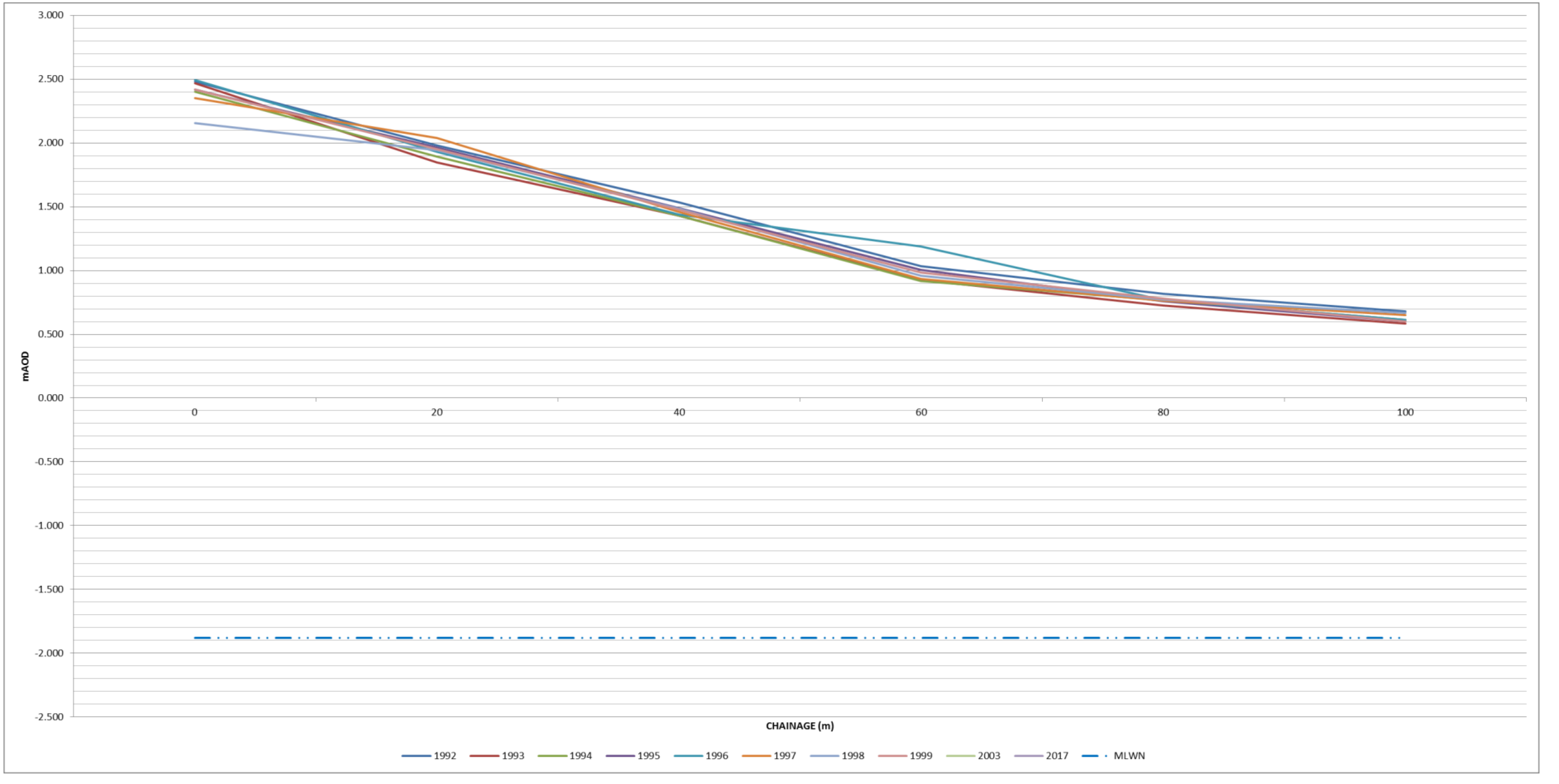


Figure I-12: Annual change of historic beach profiles – PSD5

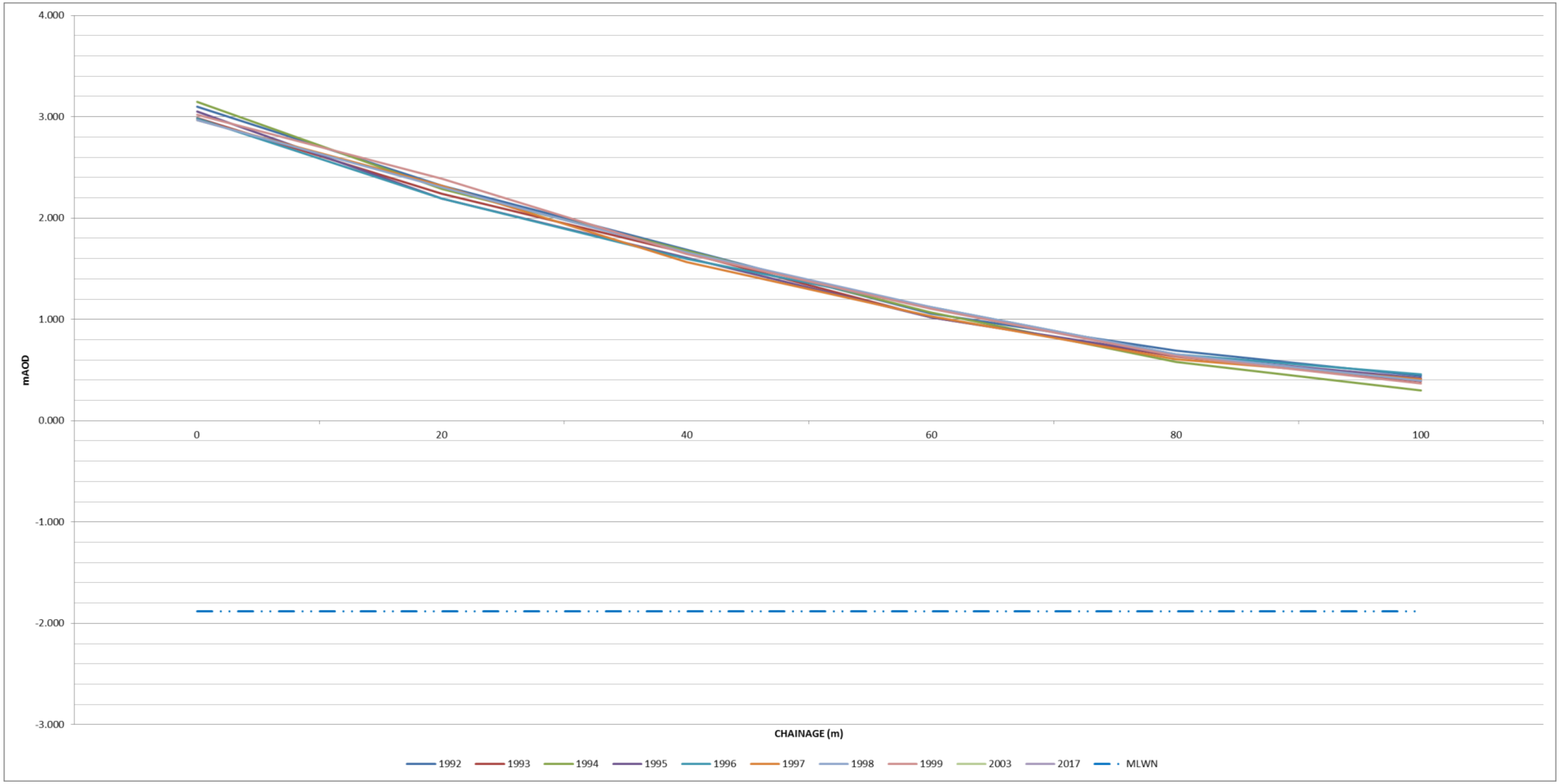


Figure I-13: Annual change of historic beach profiles – PSD6

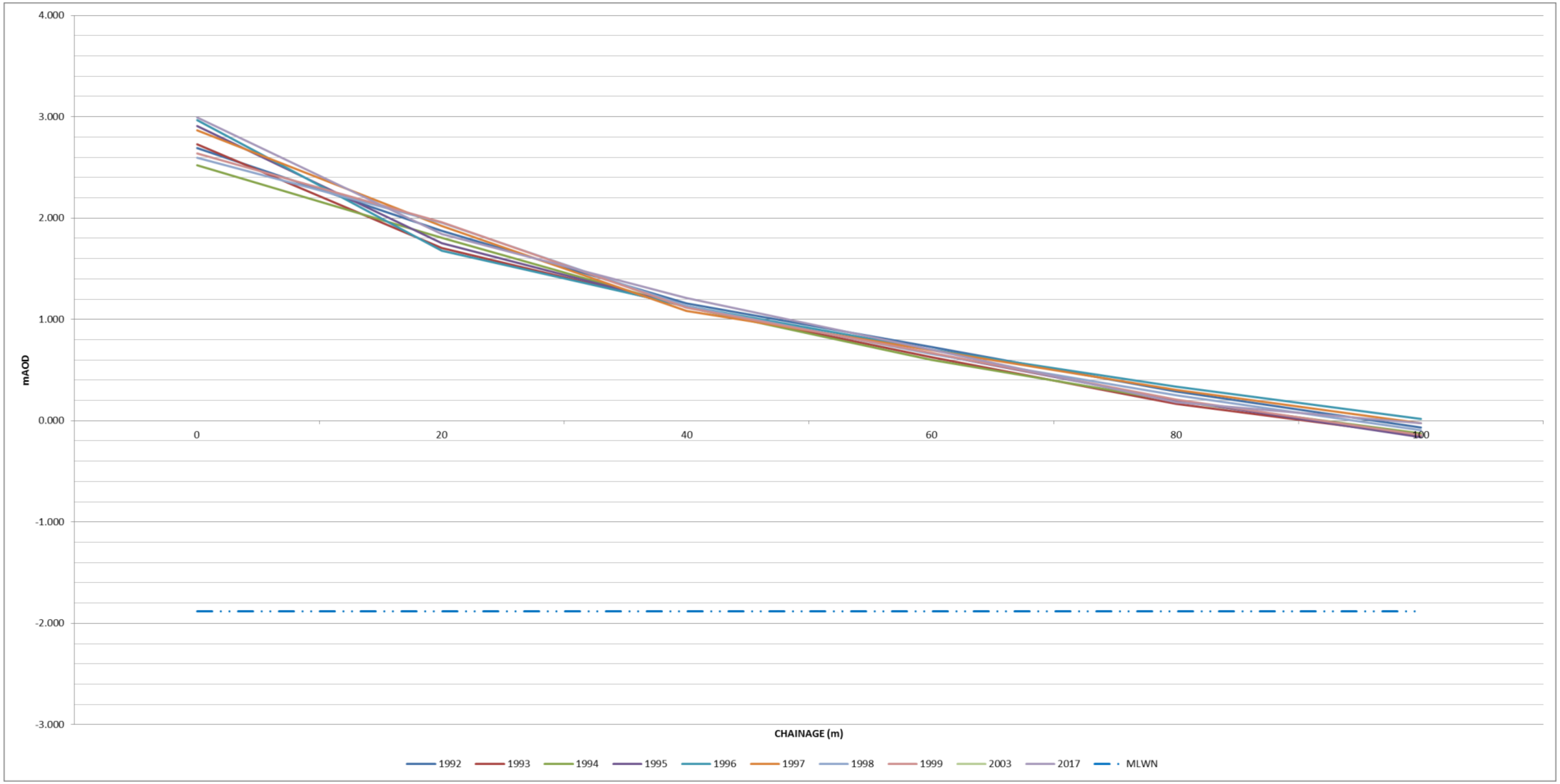


Figure I-14: Annual change of historic beach profiles – PSD7

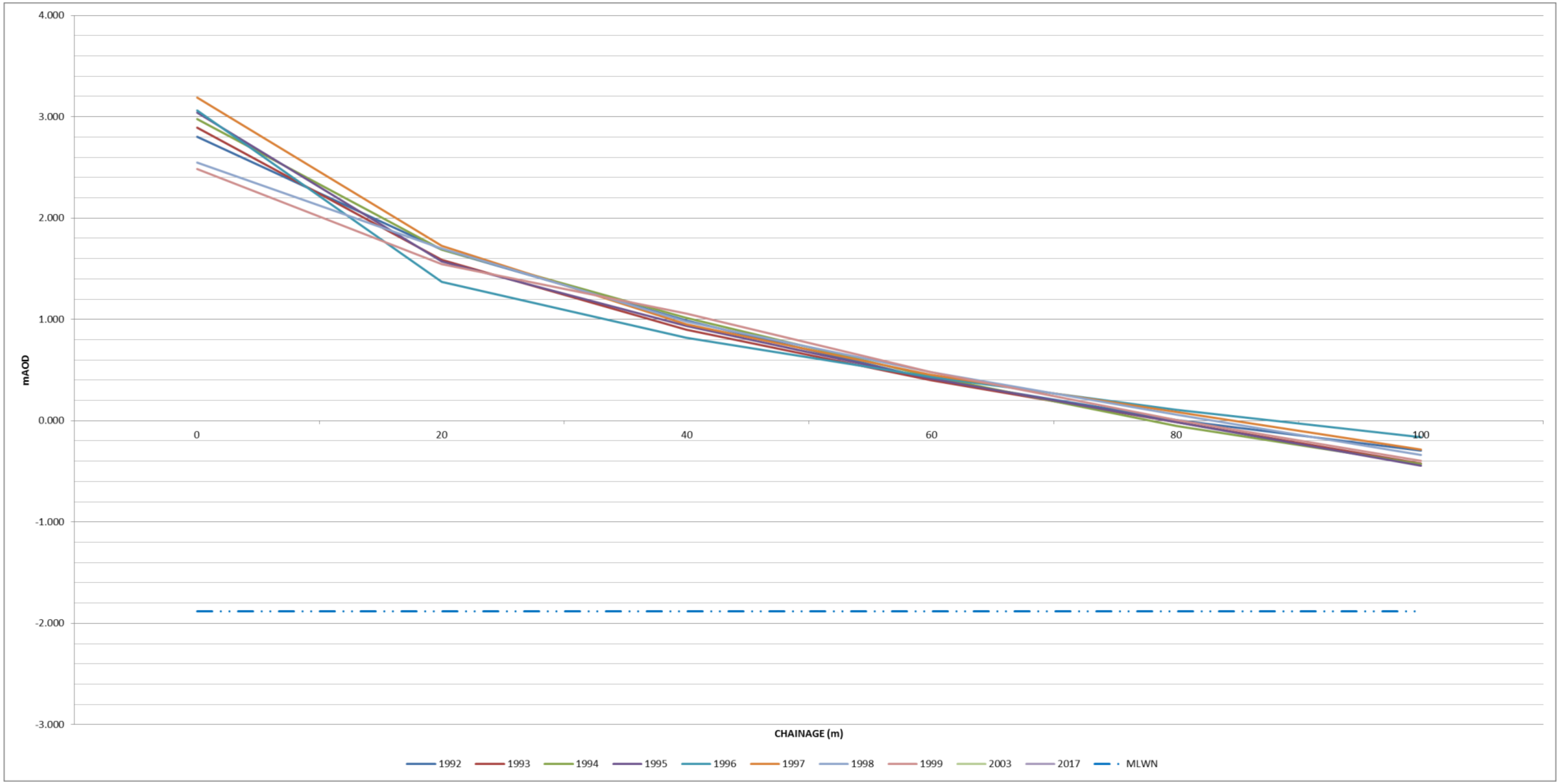


Figure I-15: Annual change of historic beach profiles – PSD8

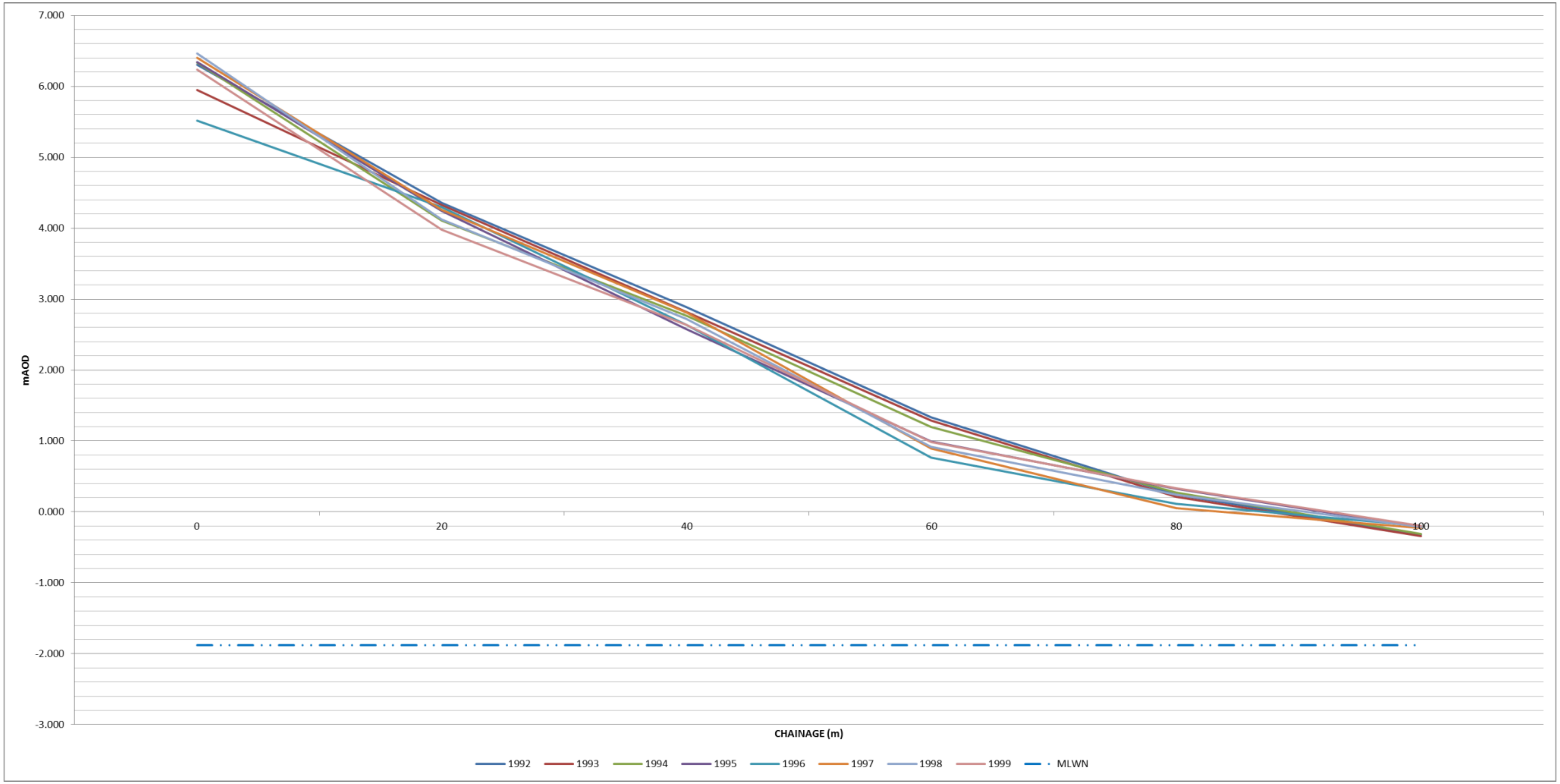
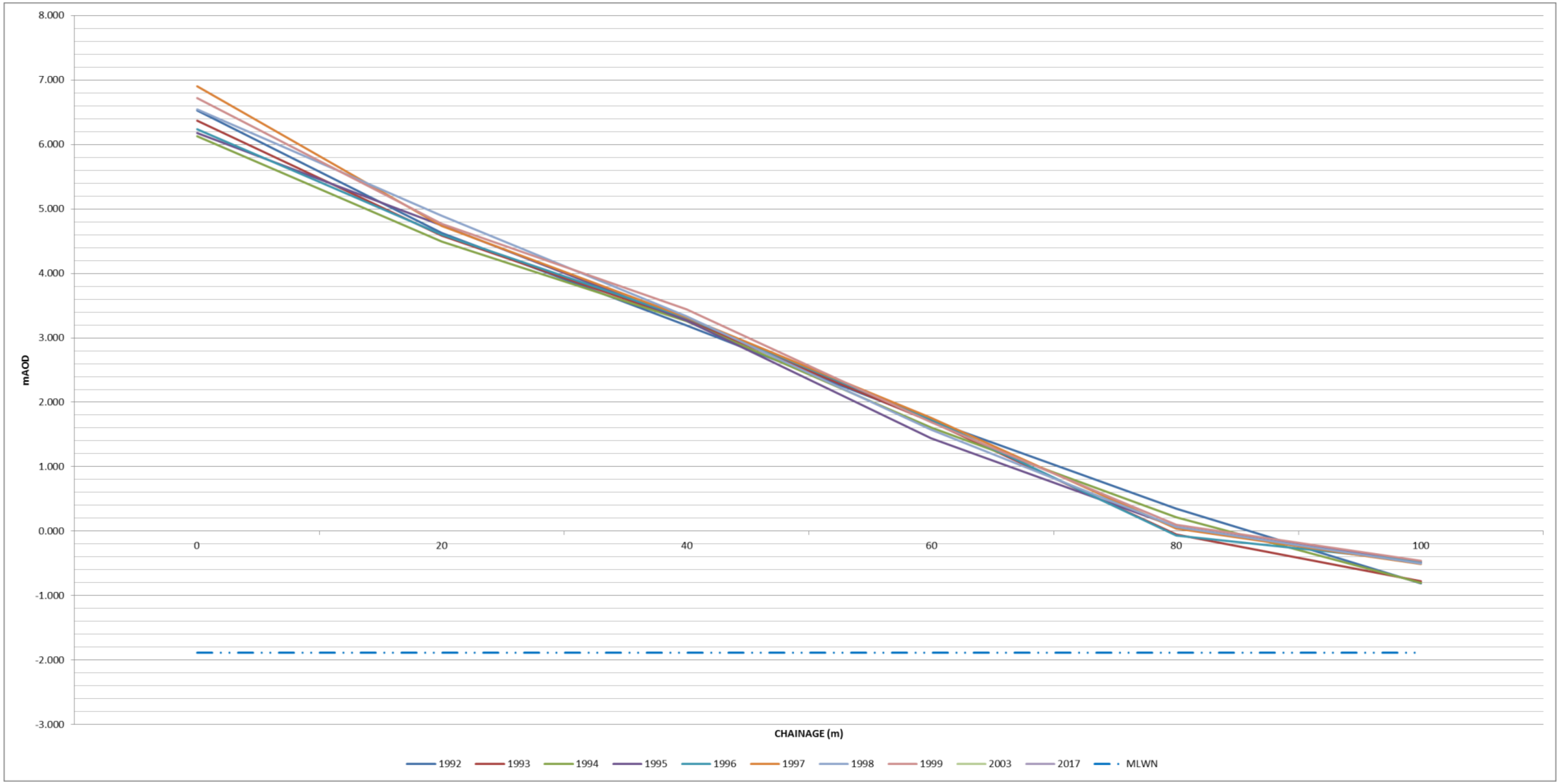


Figure I-16: Annual change of historic beach profiles – PSD9



I.2.2.1.2 St Ouen’s Bay

Figure I-17 to Figure I-23 show the historical beach profiles for St Ouen’s Bay. It can be seen there is evidence of elevation changes in the northern profiles (shown in profile HR2, in Lower Laveurs, in the upper portion and lower portion). The chart for HR7, opposite La Moye Golf course, reveals the relatively changeable nature of the lower portion of the profile compared to the upper portion.

Figure I-17: Annual change of historic beach profiles – HR1

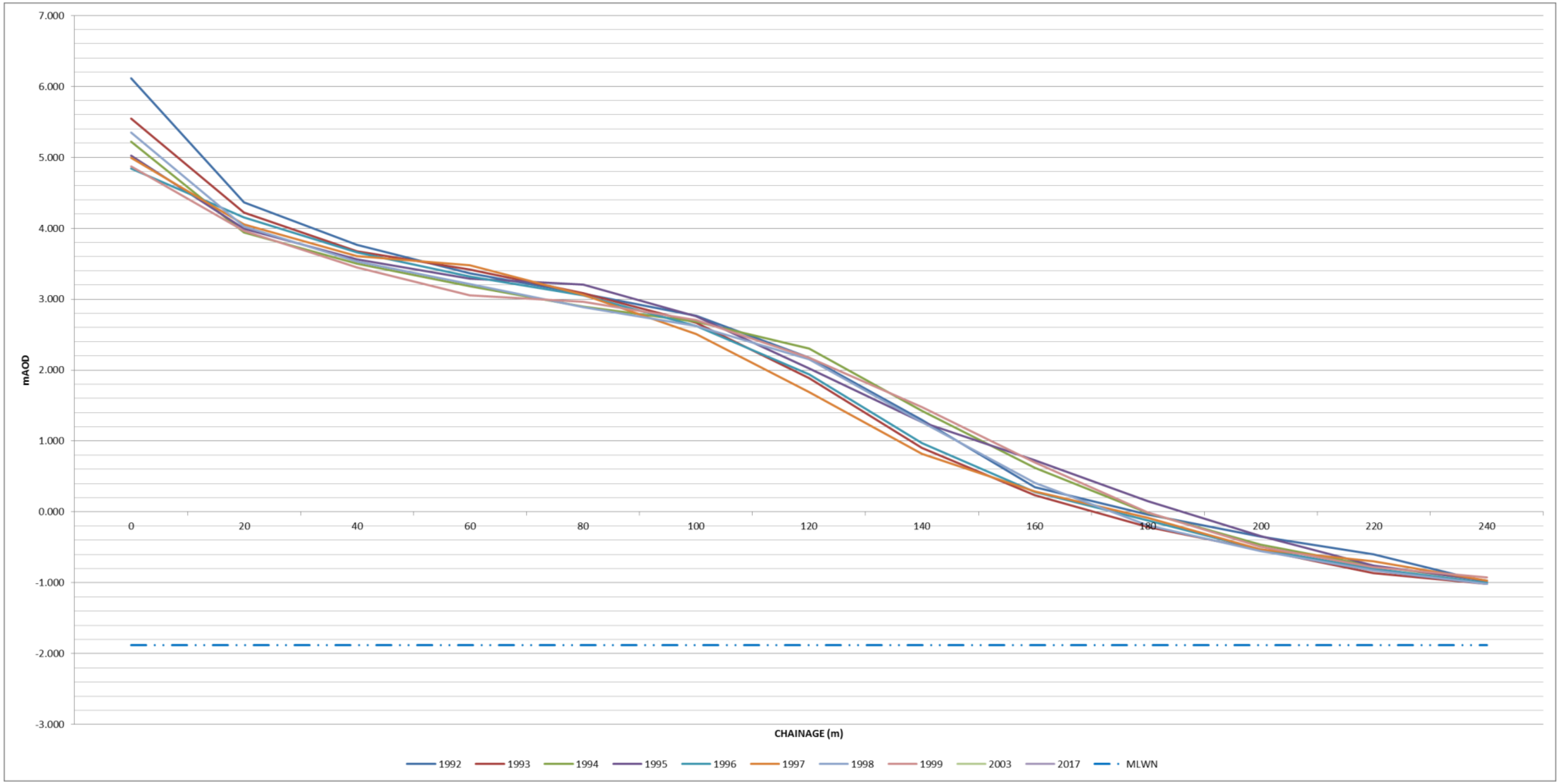


Figure I-18: Annual change of historic beach profiles – HR2

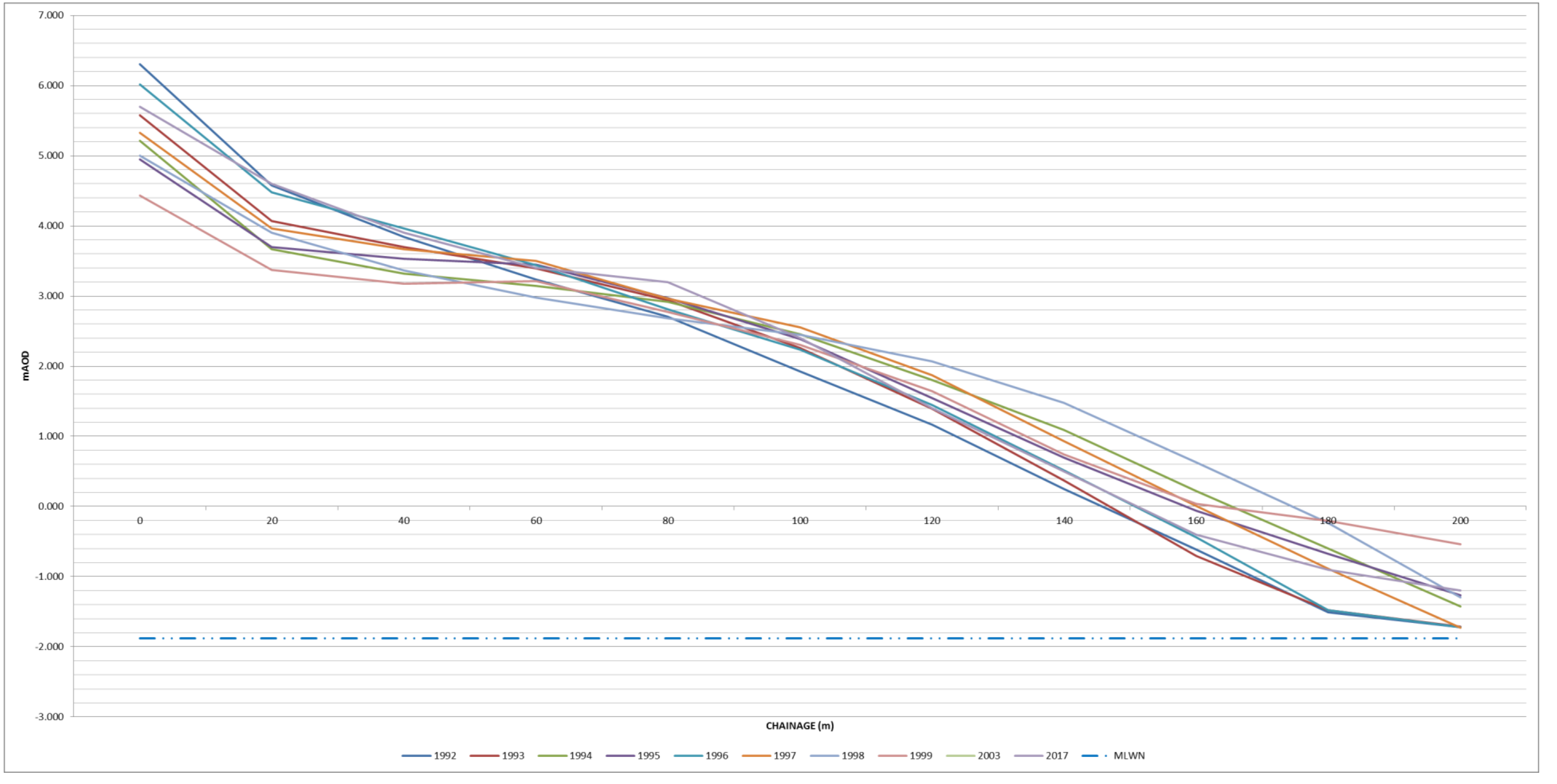


Figure I-19: Annual change of historic beach profiles – HR3

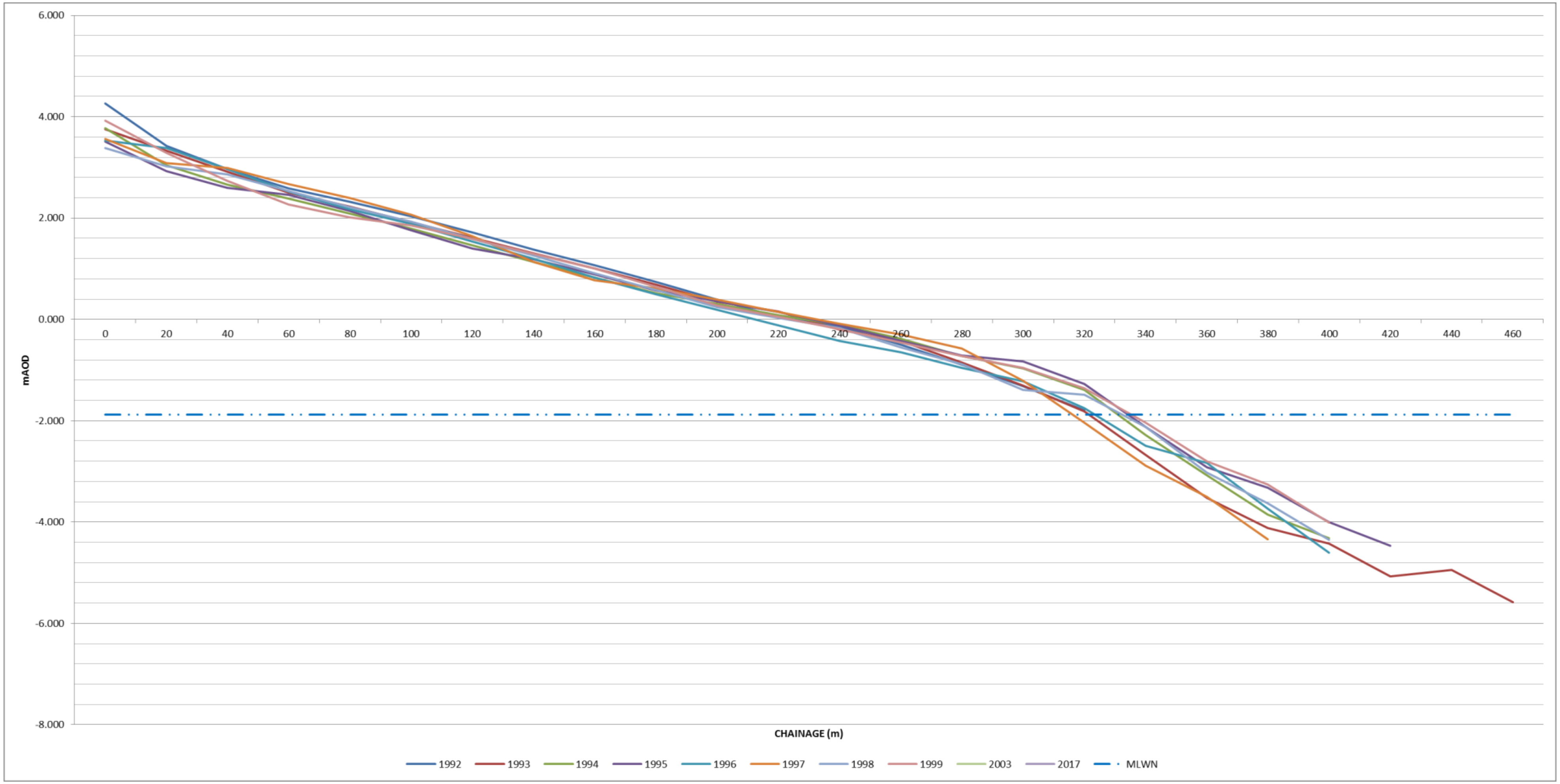


Figure I-20: Annual change of historic beach profiles – HR4

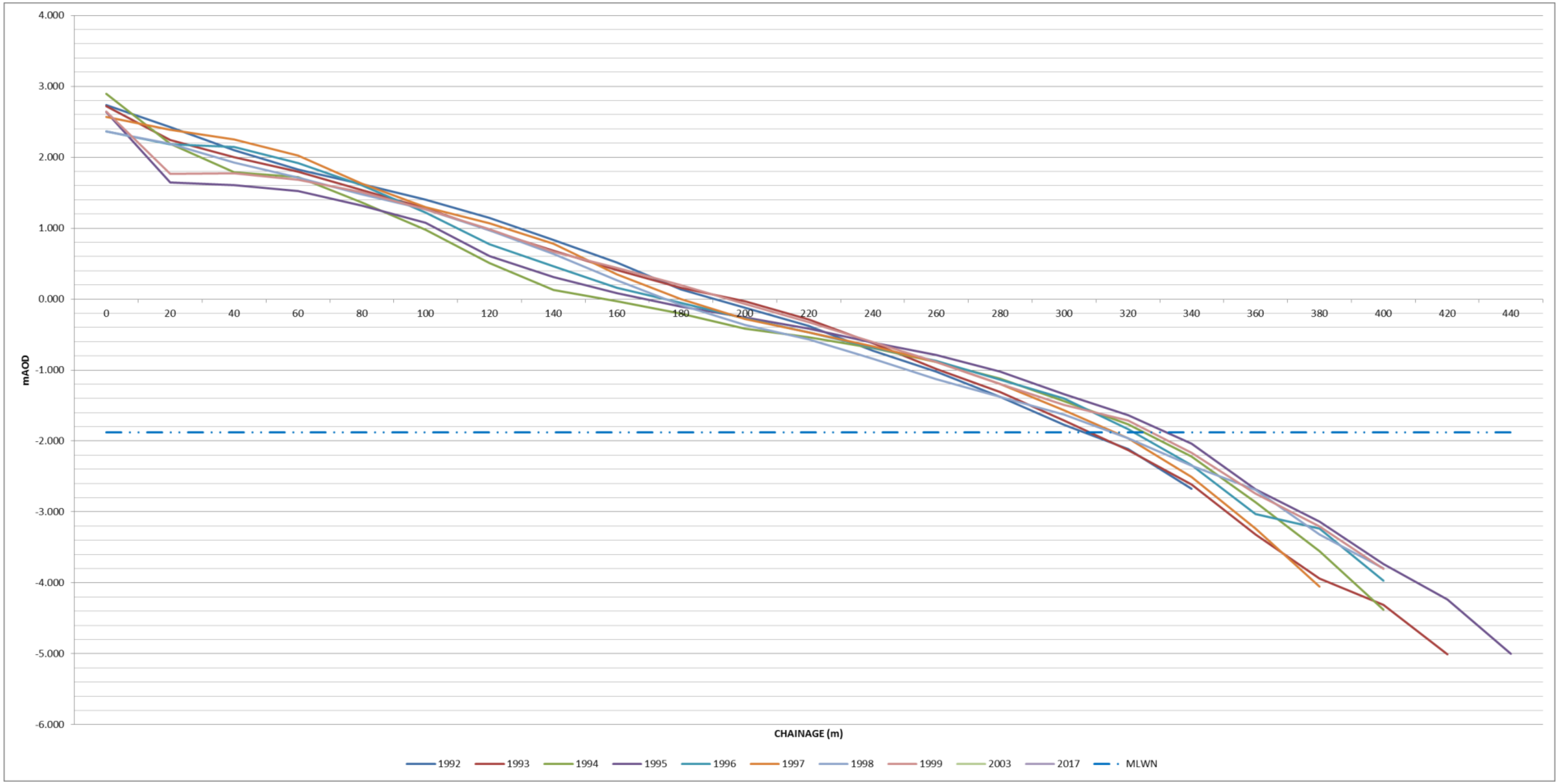


Figure I-21: Annual change of historic beach profiles – HR5

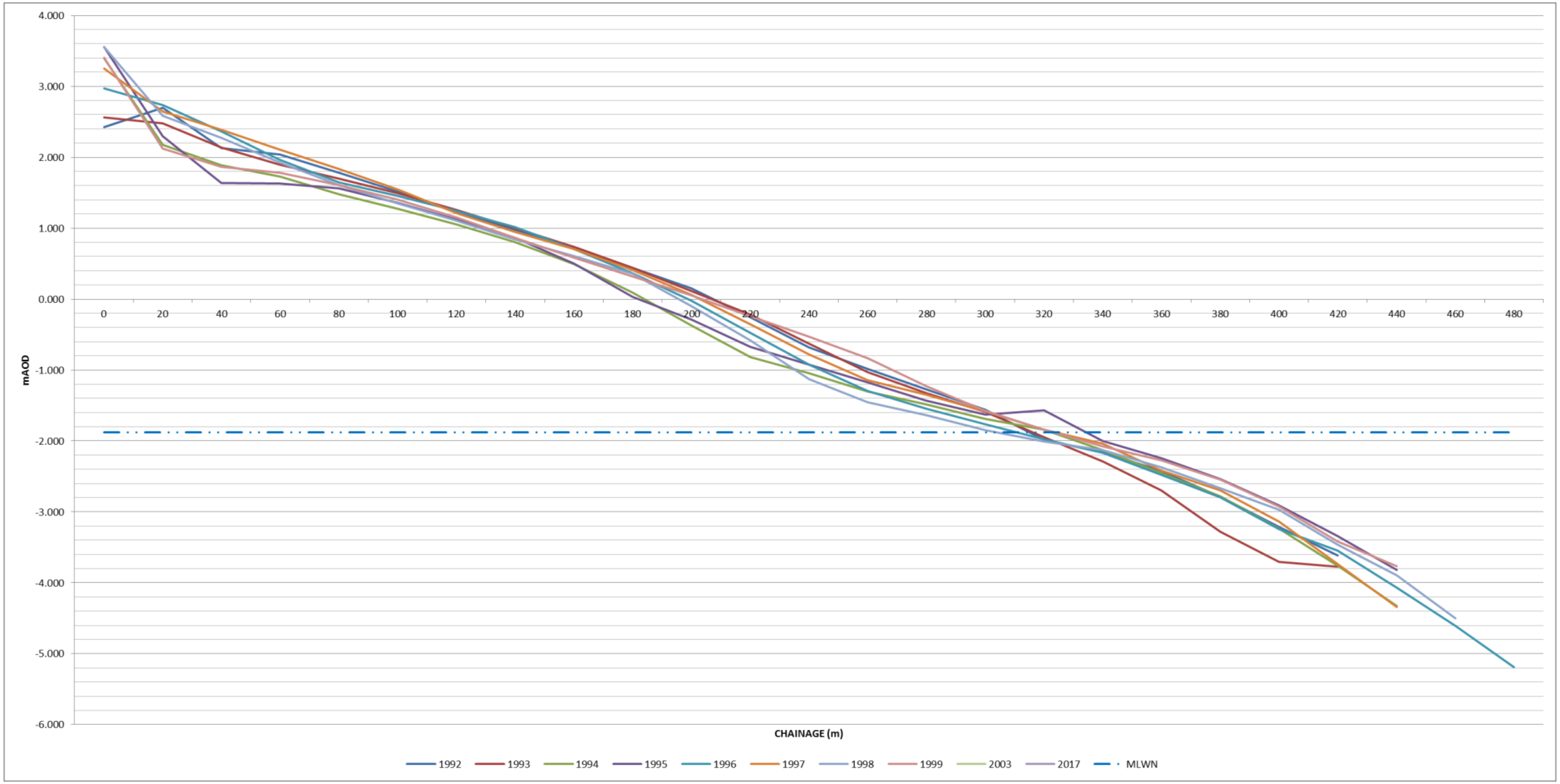


Figure I-22: Annual change of historic beach profiles – HR6

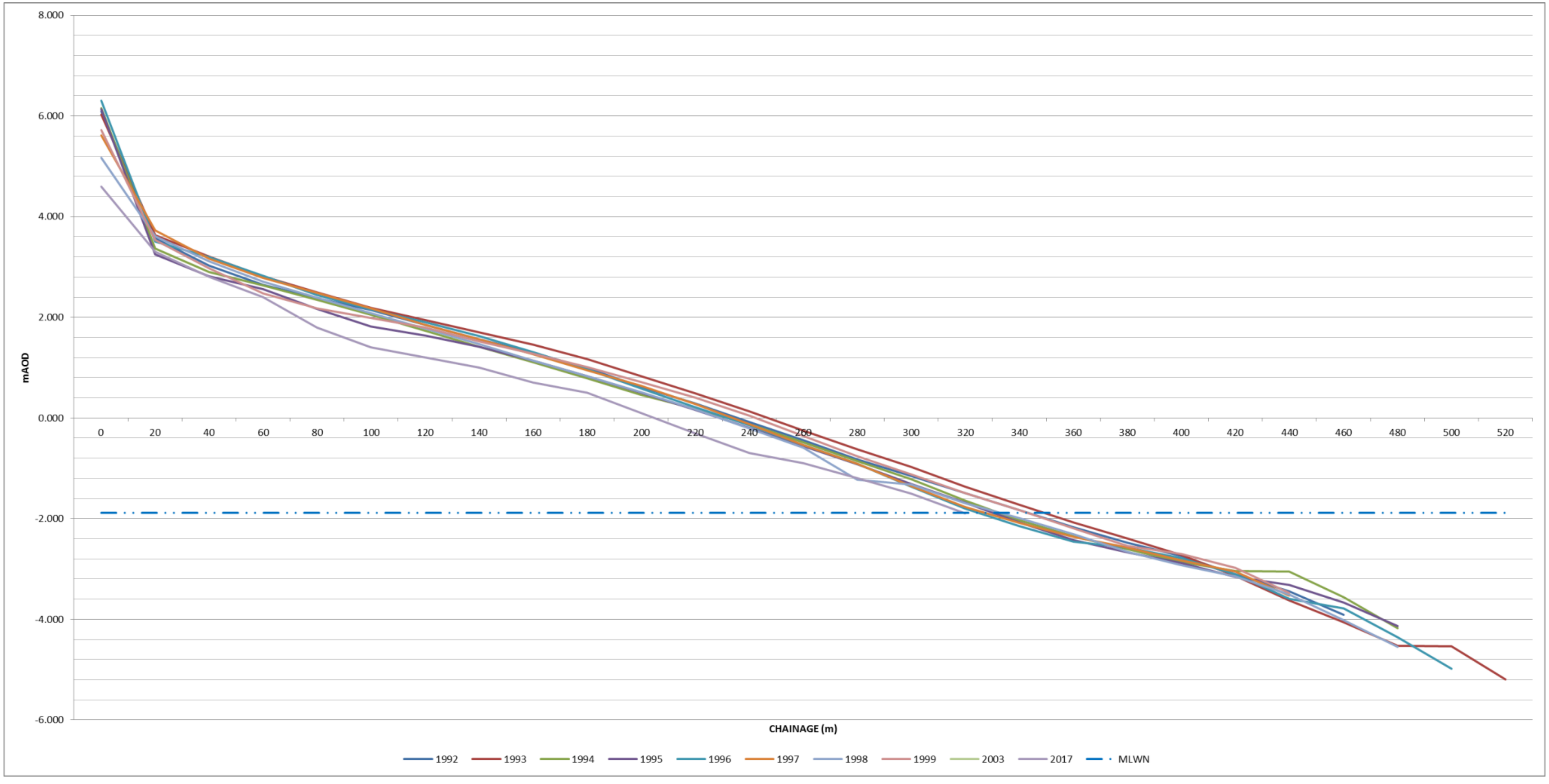
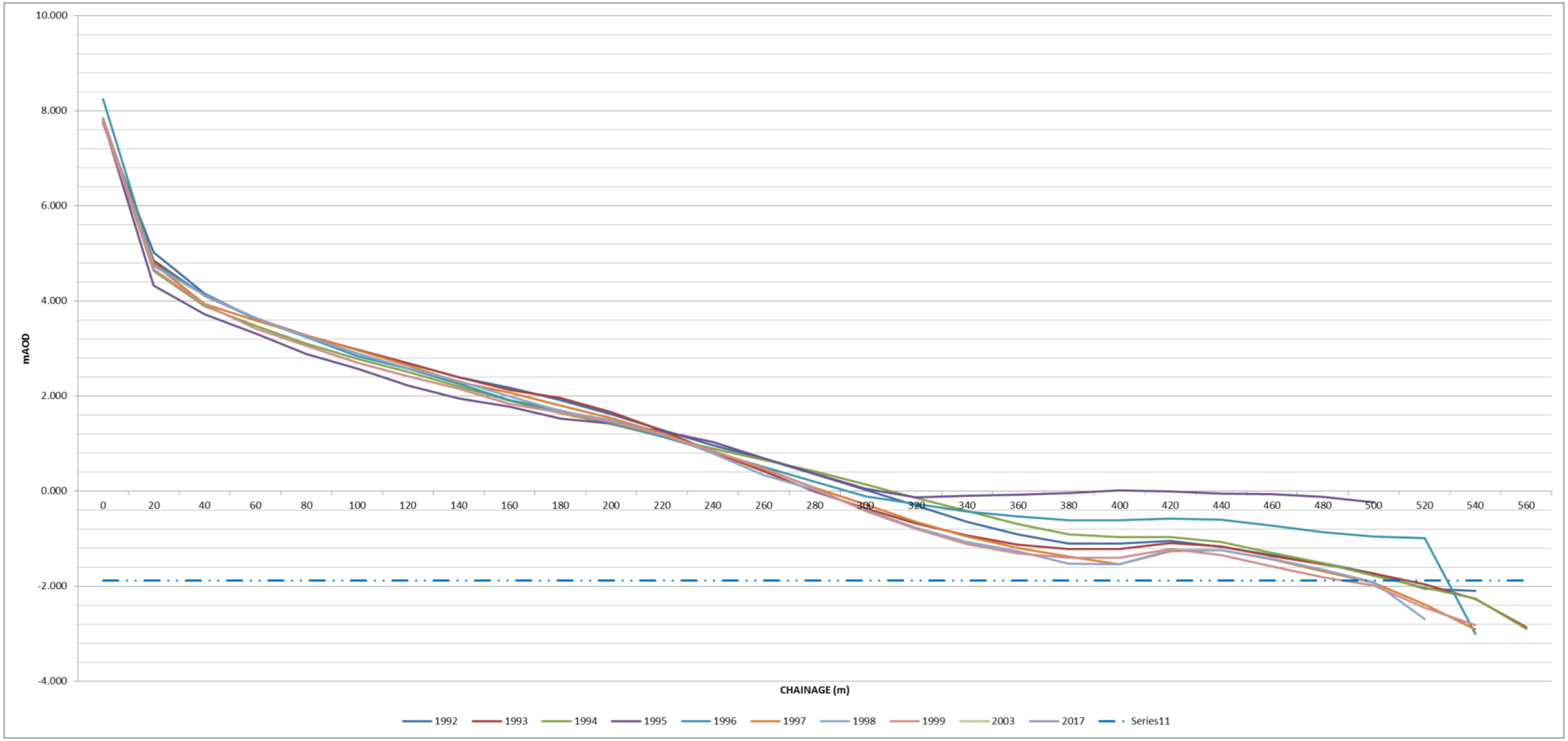


Figure I-23: Annual change of historic beach profiles – HR7



I.2.2.1.3 St Brelade's Bay

The results for beach profiles at St Brelade's Bay are shown in Figure I-24 to Figure I-27 and the results would suggest stability with tight clustering of the profiles. The main specific observation is on HR10 in Figure I-26, which is elevated in 1992 compared to subsequent years.

Figure I-24: Annual change of historic beach profiles – HR8

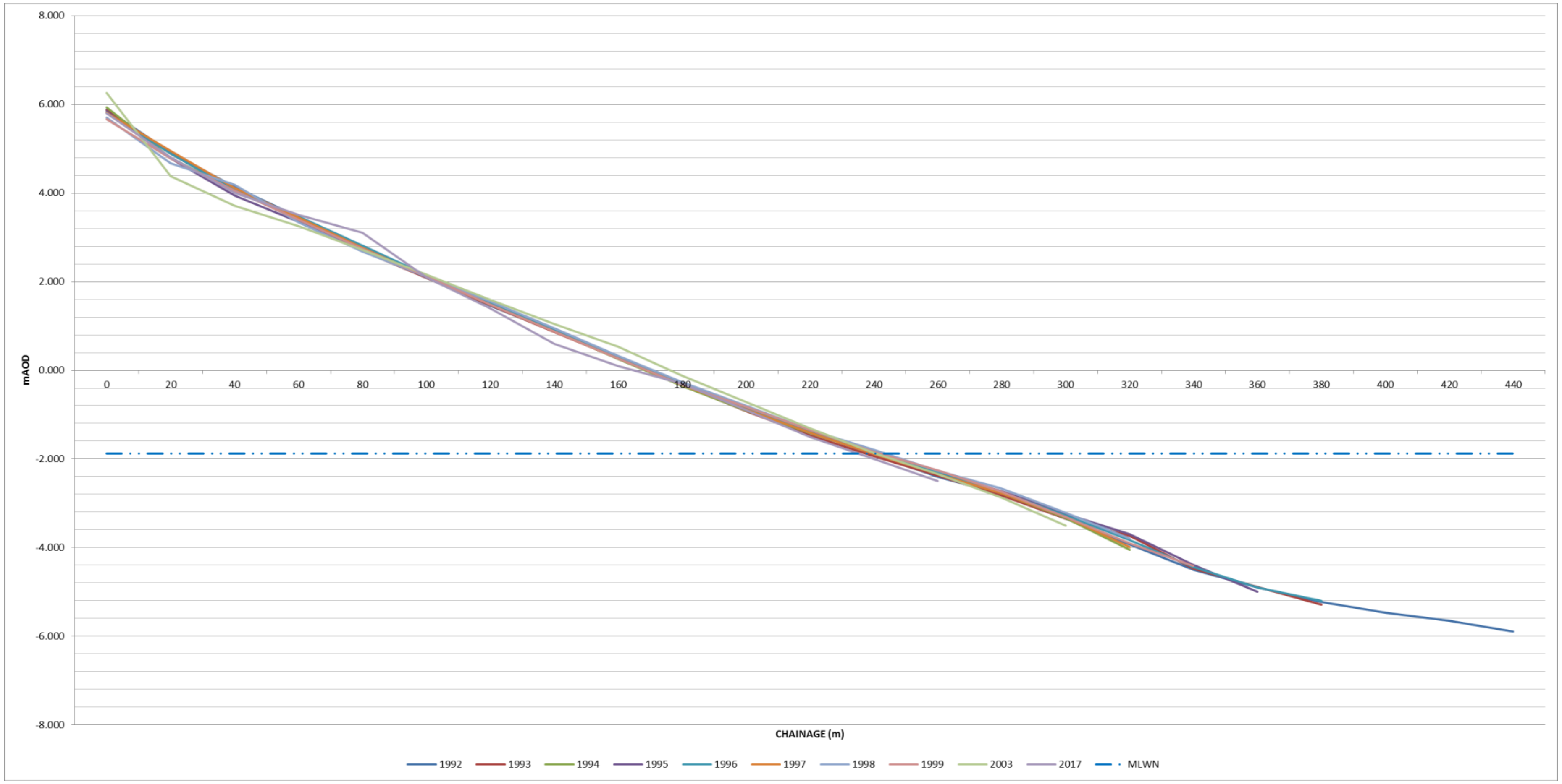


Figure I-25: Annual change of historic beach profiles – HR9

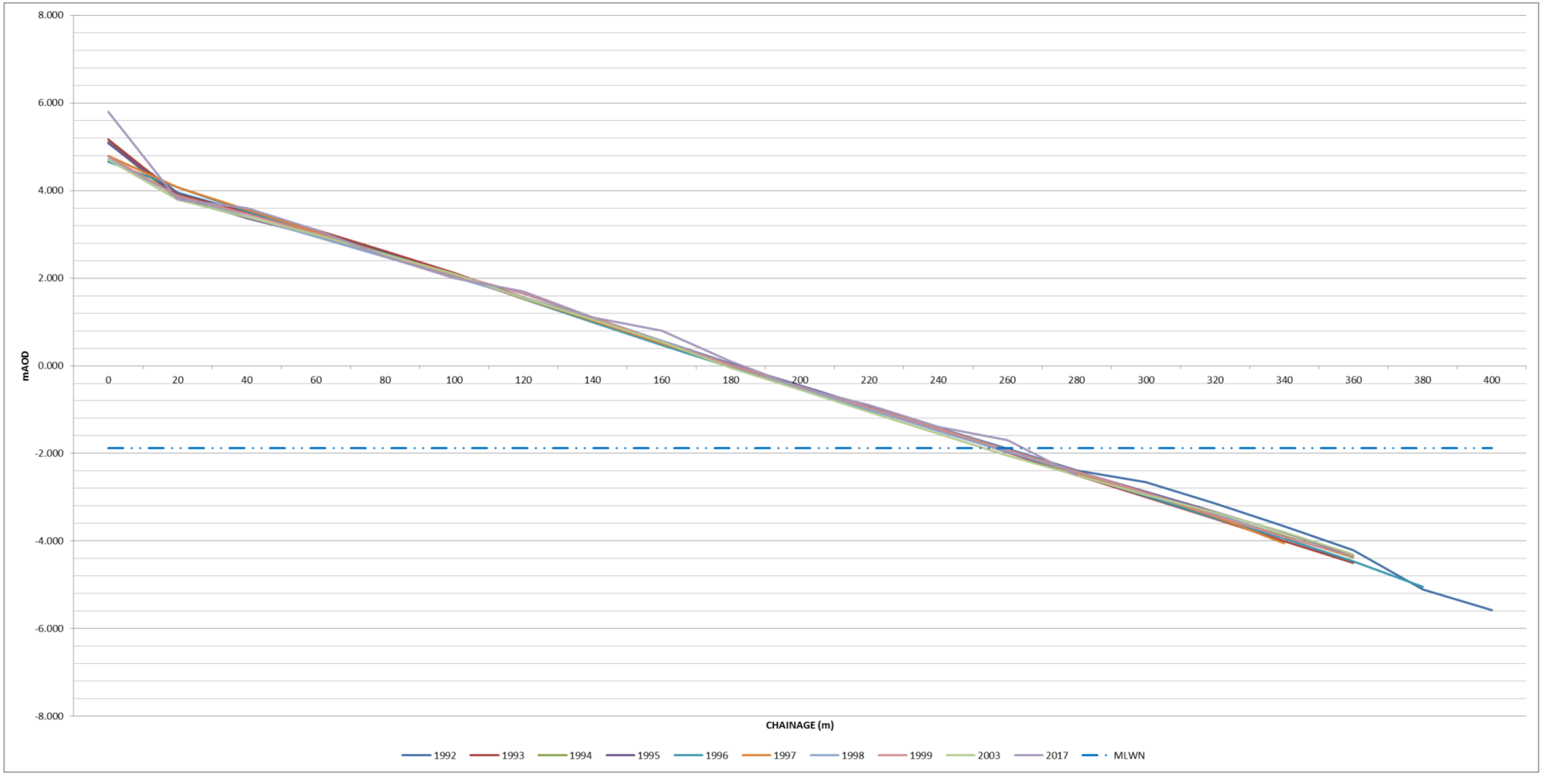


Figure I-26: Annual change of historic beach profiles – HR10

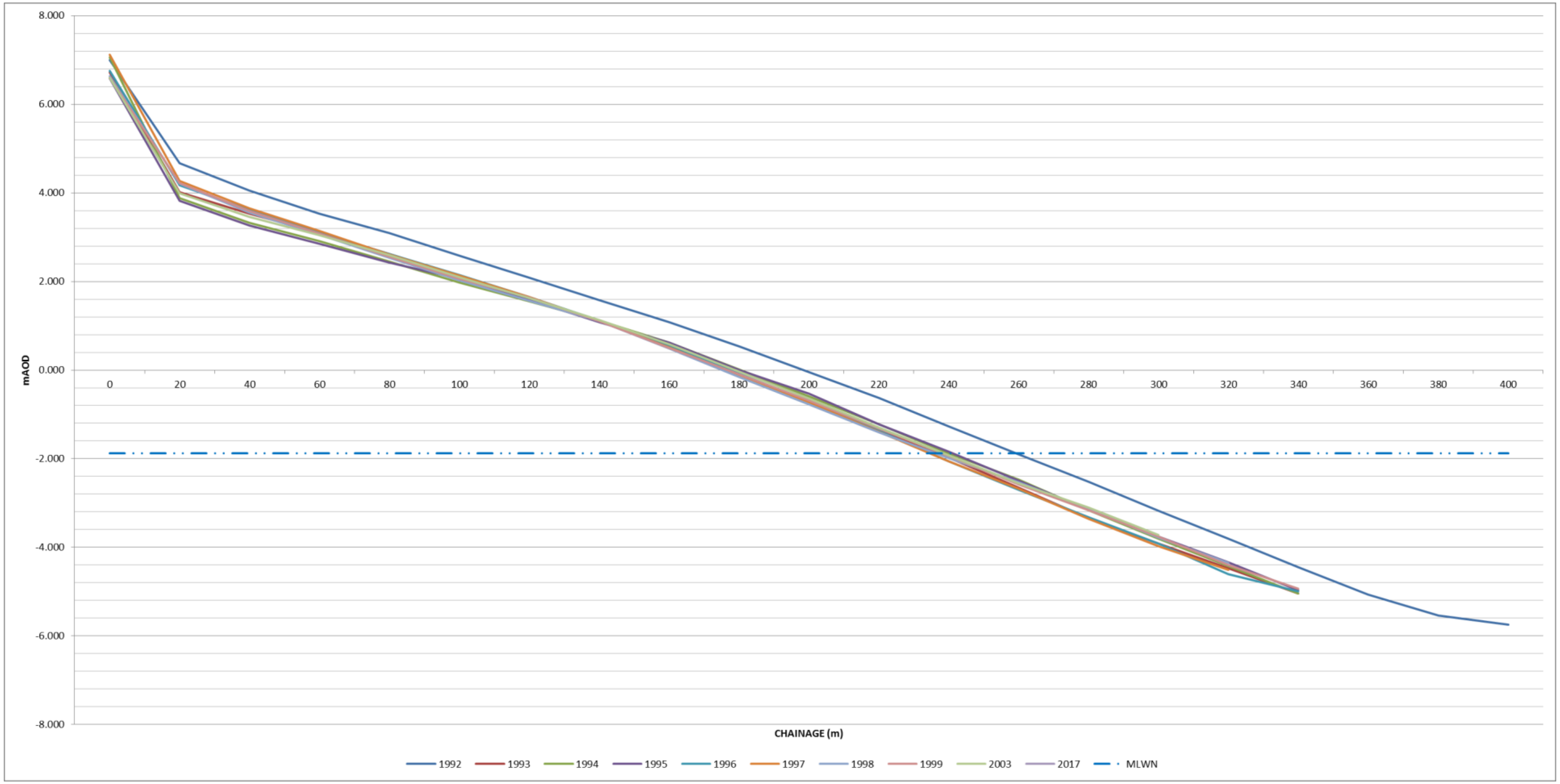
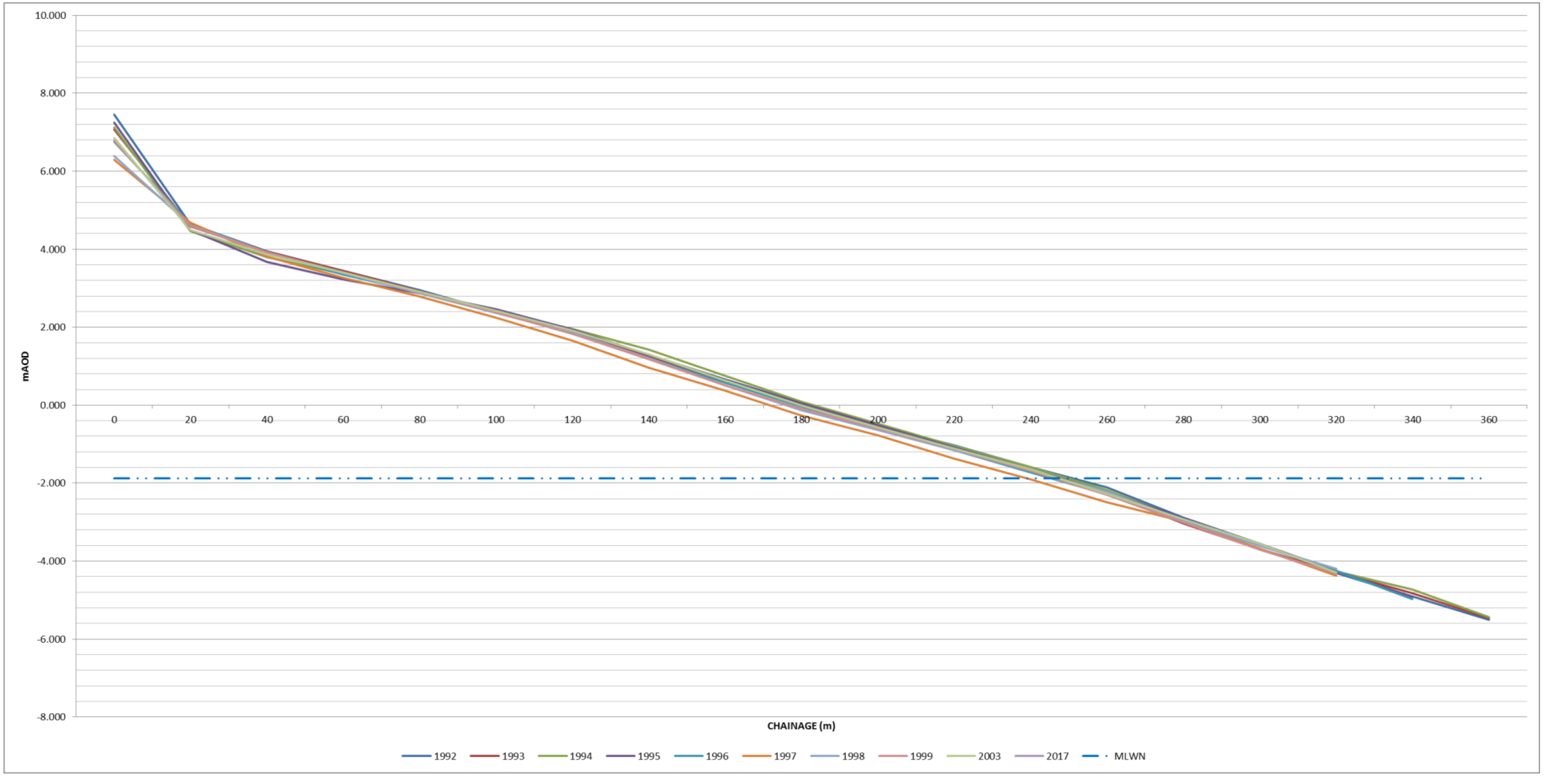


Figure I-27: Annual change of historic beach profiles – HR11



I.2.2.1.4 St Aubin’s Bay

The relative overall stability seen in the St Aubin’s Bay profiles can be seen in Figure I-28 to Figure I-31. There are some noticeable spikes in the surveys for HR15, which is at the eastern end of the bay; these are all below MLWN and could be related to accumulations and troughs around rock outcrops. For HR14 (Old Station Café) it can be seen that there is some variability mid profile between the MLWN contour elevation and Mean Sea Level (approximately 0.1 m AOD) but this isn’t seen in the other profiles. The historic surveys for HR15 showed some potential discrepancies in the data, first in the February 1996 surveys, with a drop in the levels at 1060m chainage, and similarly during the February 1999 surveys, there was an increase in the levels at 660m chainage.

Figure I-28: Annual change of historic beach profiles – HR12

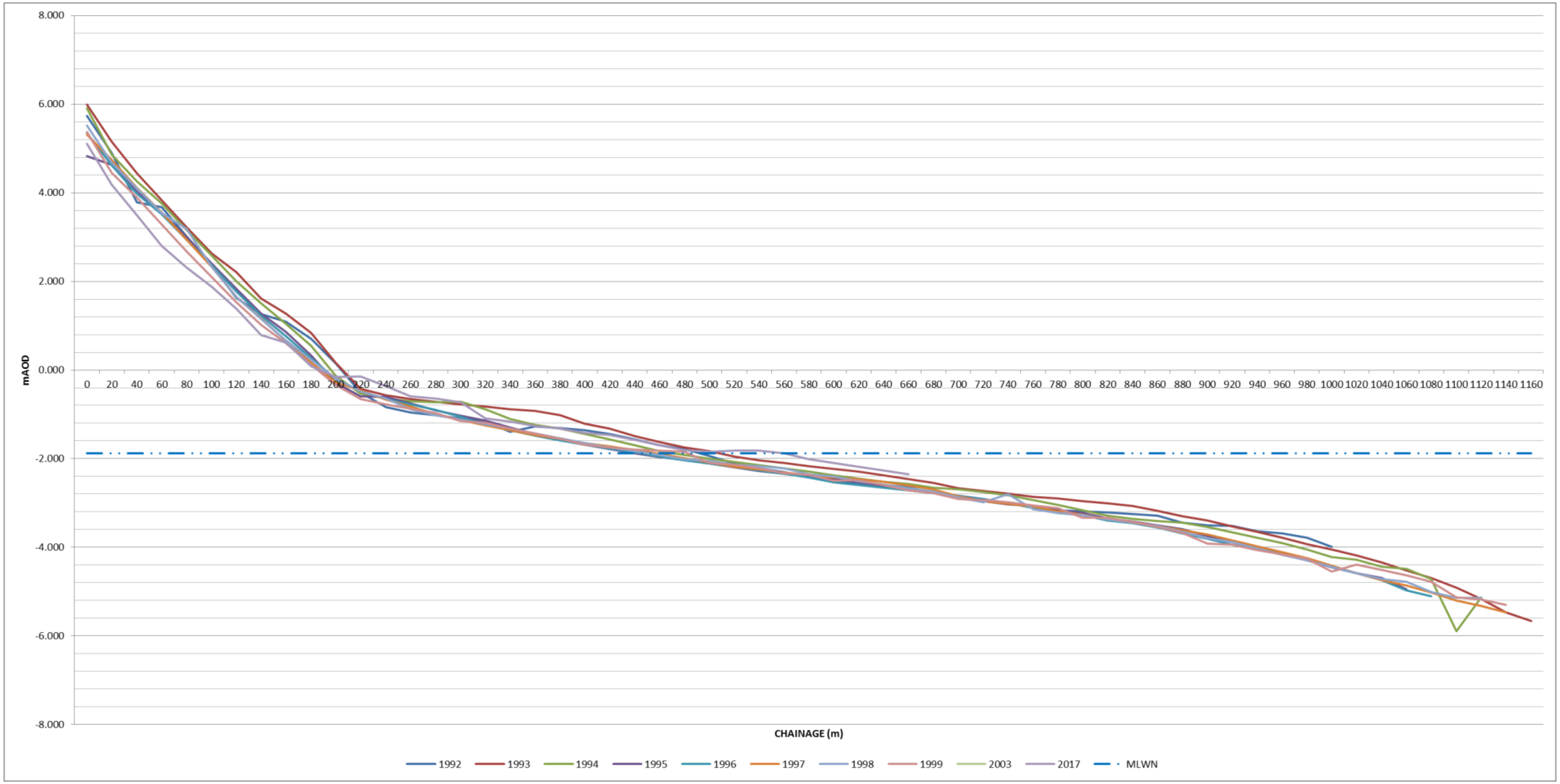


Figure I-29: Annual change of historic beach profiles – HR13

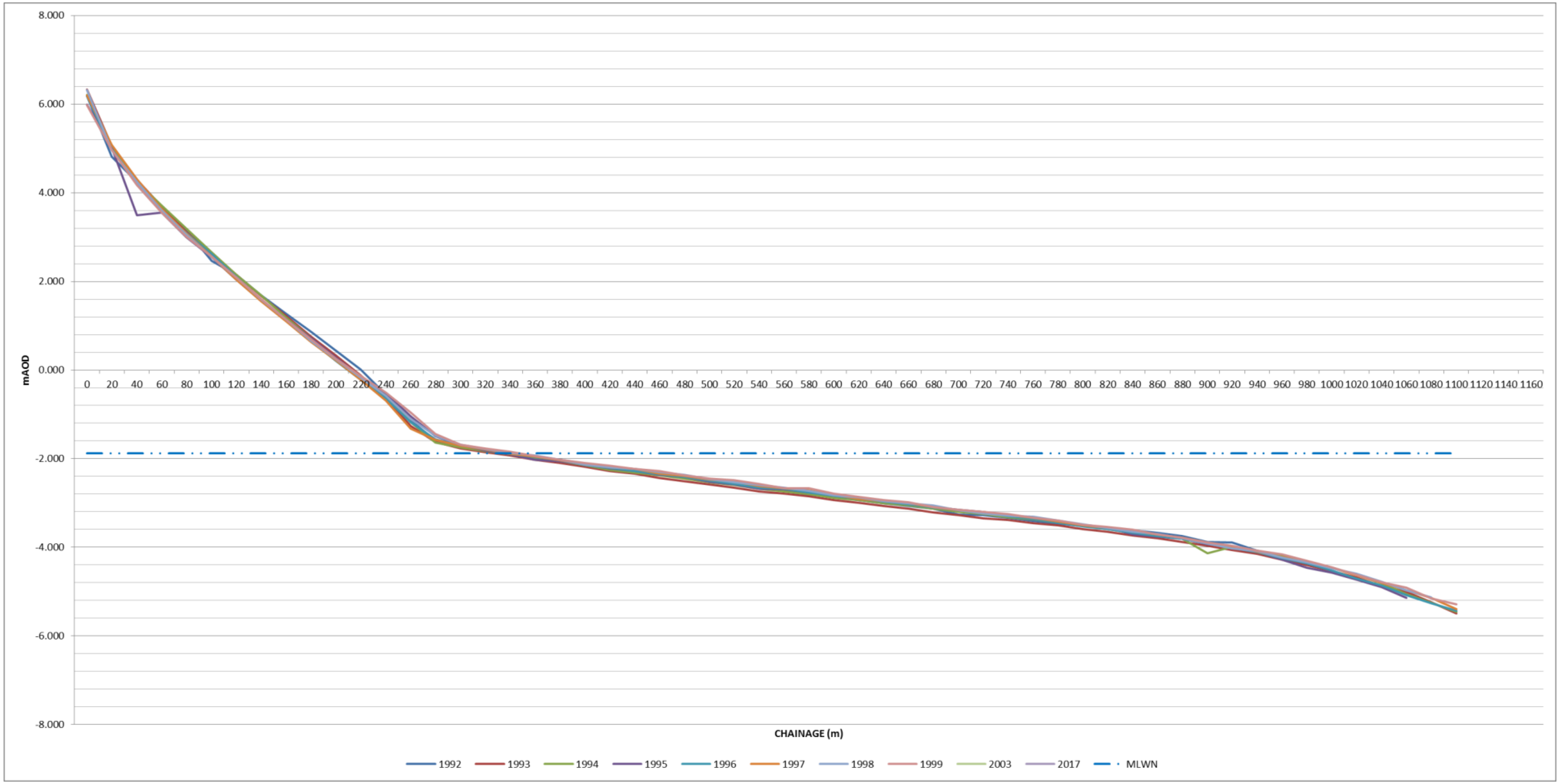


Figure I-30: Annual change of historic beach profiles – HR14

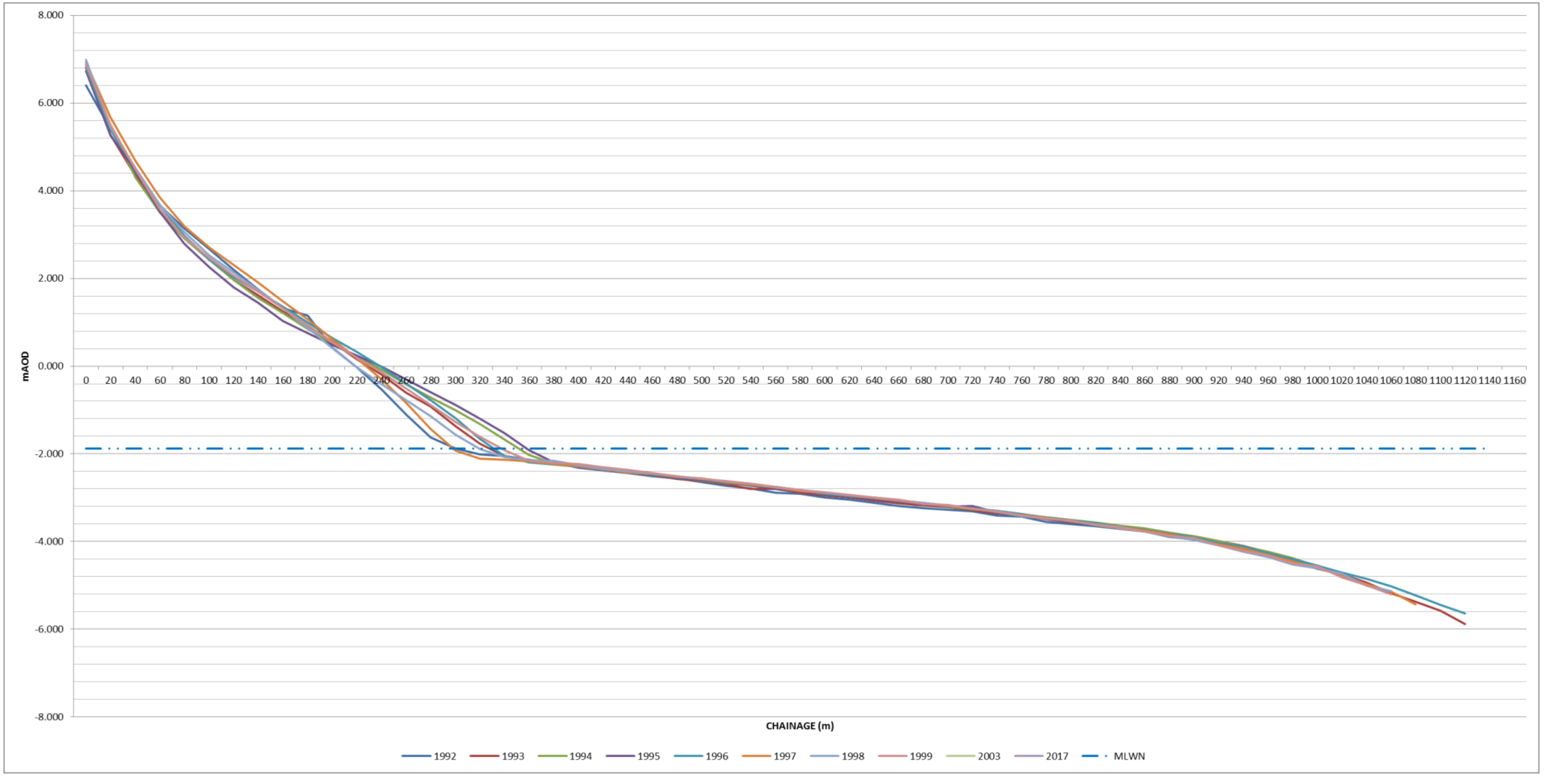
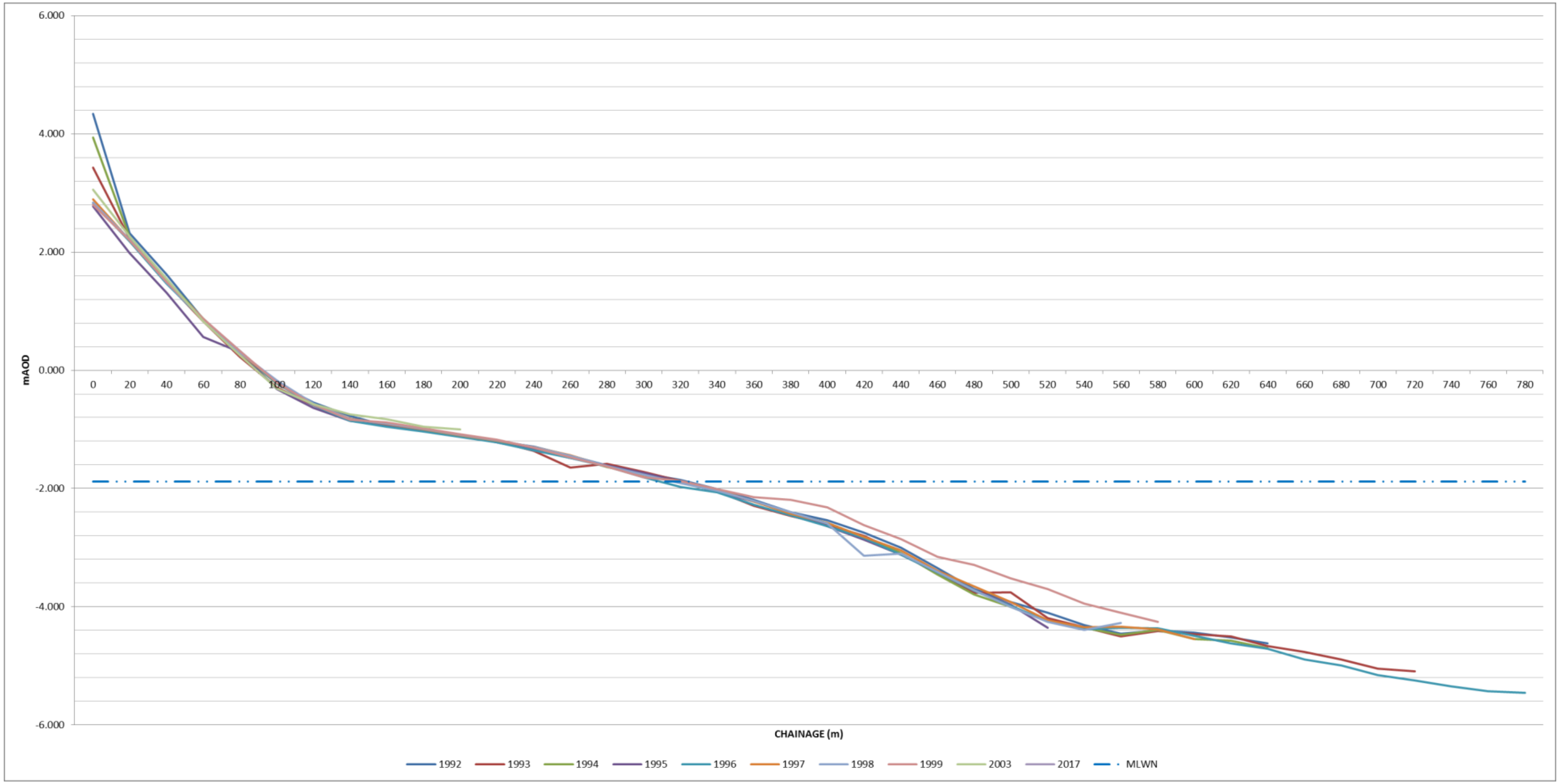


Figure I-31: Annual change of historic beach profiles – HR15

I.2.2.1.5 St Helier

For HR16, it is the very upper portion of the profile that shows the most change above MLWN (Figure I-32). There is also more variability in the profile below MLWN, which is for the 1999 survey. This might be related to the offshore rock outcrops in the area resulting in periodic accumulation of sediment.

Figure I-32: Annual change of historic beach profiles – HR16



I.2.2.1.6 St Clement

The profiles at St Clement (Figure I-33 to Figure I-38) are all relatively short (100m chainage); therefore, the elevations shown are all above the MLWN contour. Profiles are generally stable, however, distinct separation in profile lines can be seen in HR17 (opposite Plat Douet Road), HR18 at La Mare (Figure I-34) and HR21 at Le Bourg (Figure I-37).

Figure I-33: Annual change of historic beach profiles – HR17

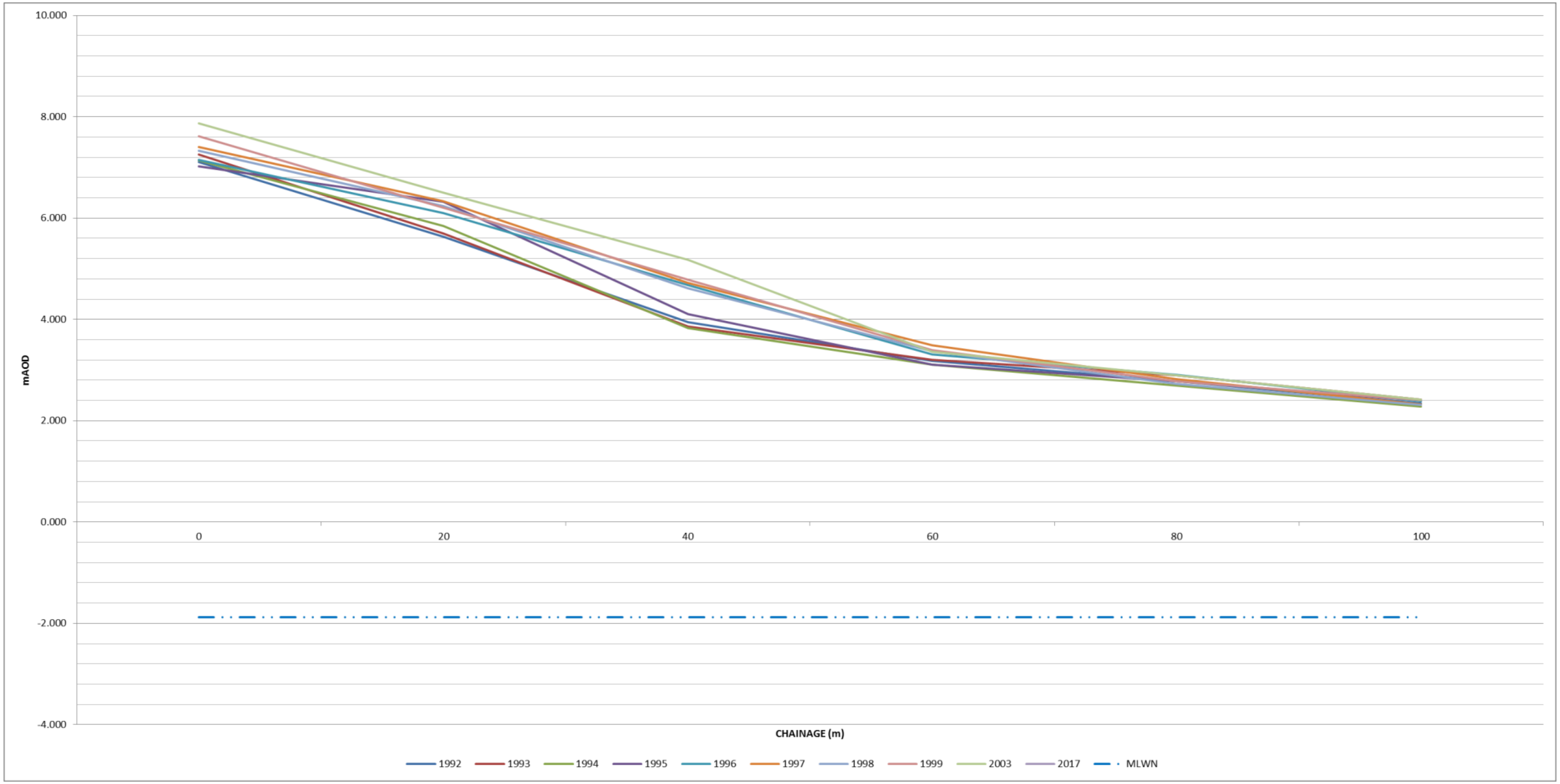


Figure I-34: Annual change of historic beach profiles – HR18

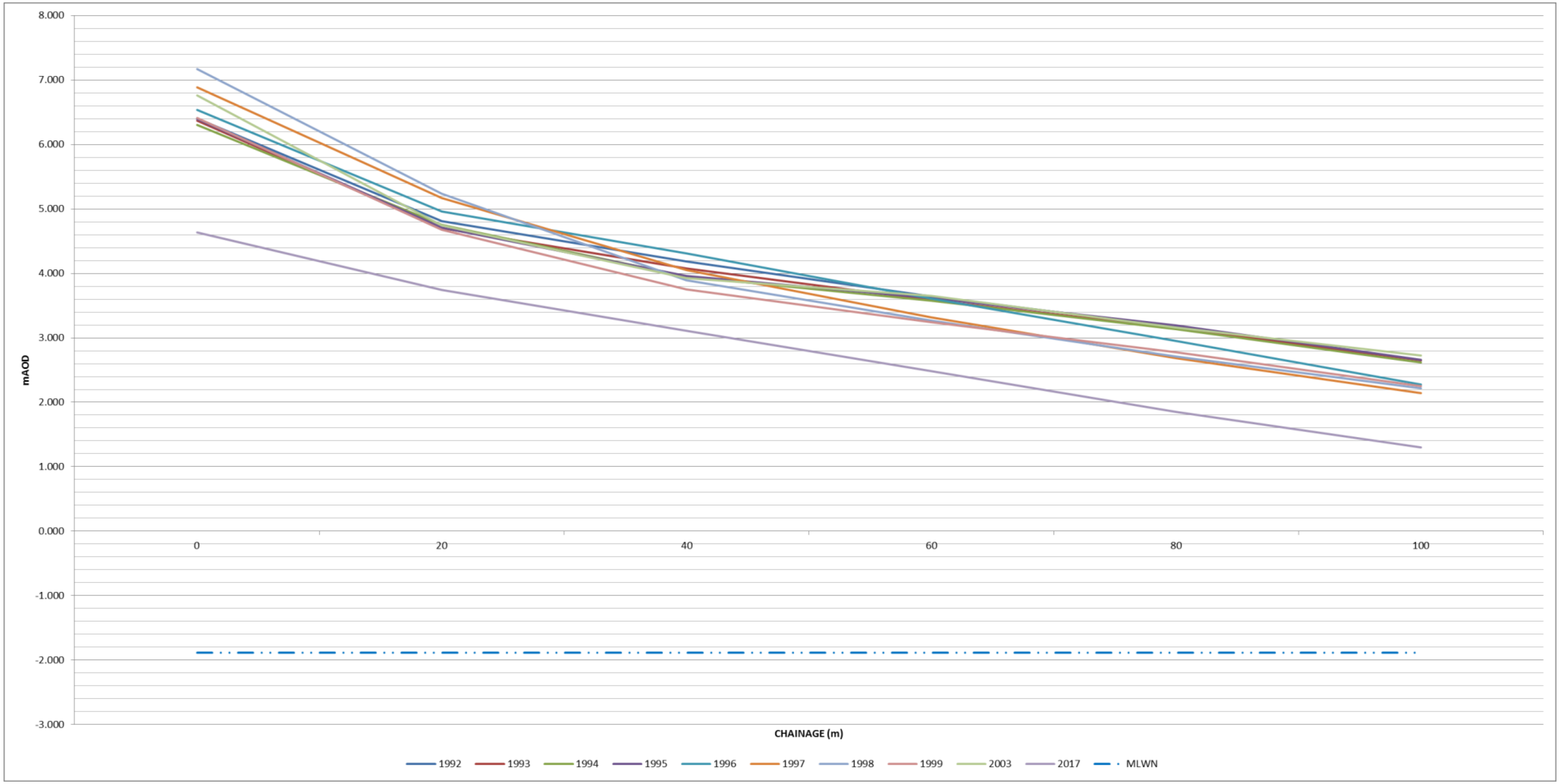


Figure I-35: Annual change of historic beach profiles – HR19

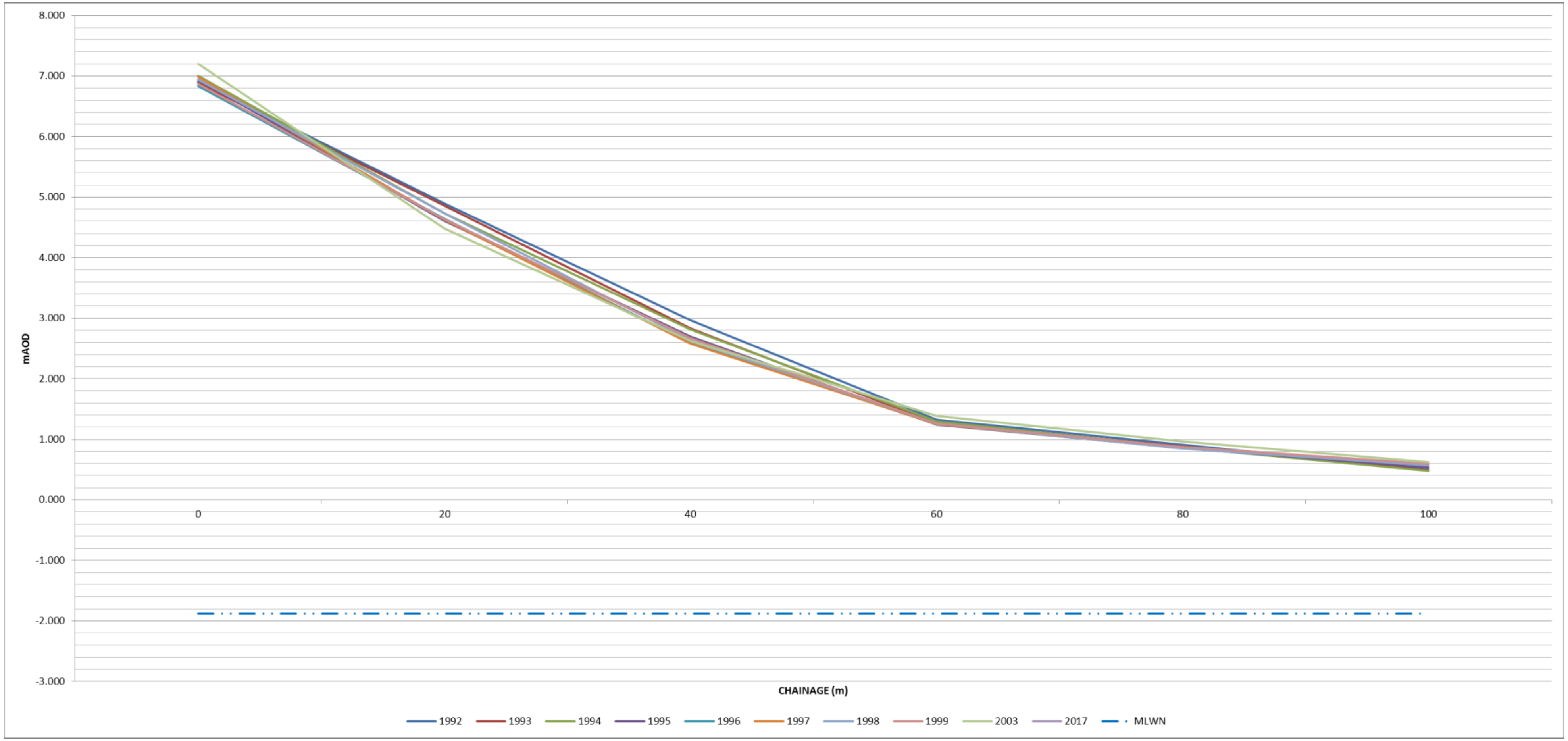


Figure I-36: Annual change of historic beach profiles – HR20

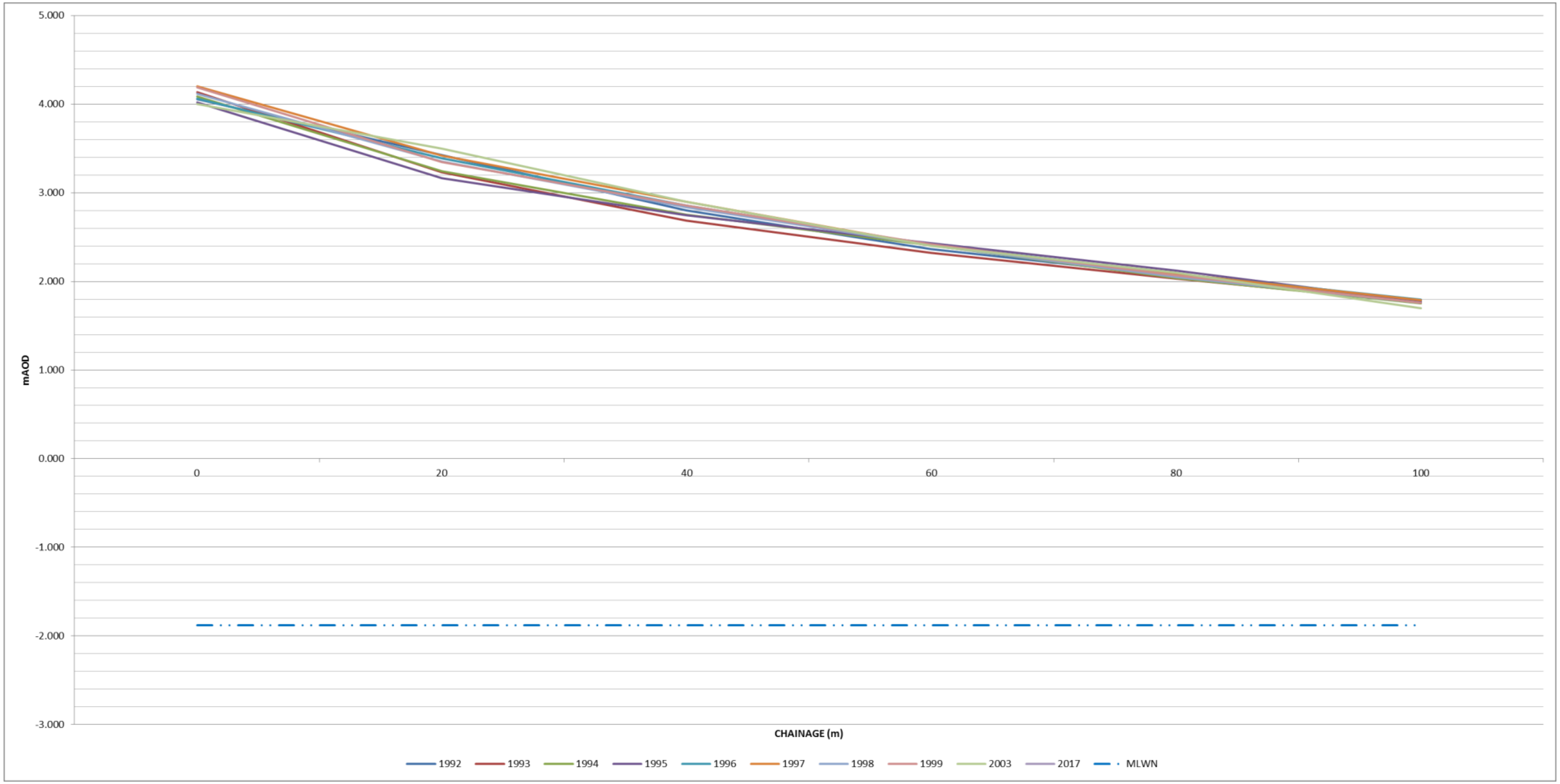


Figure I-37: Annual change of historic beach profiles – HR21

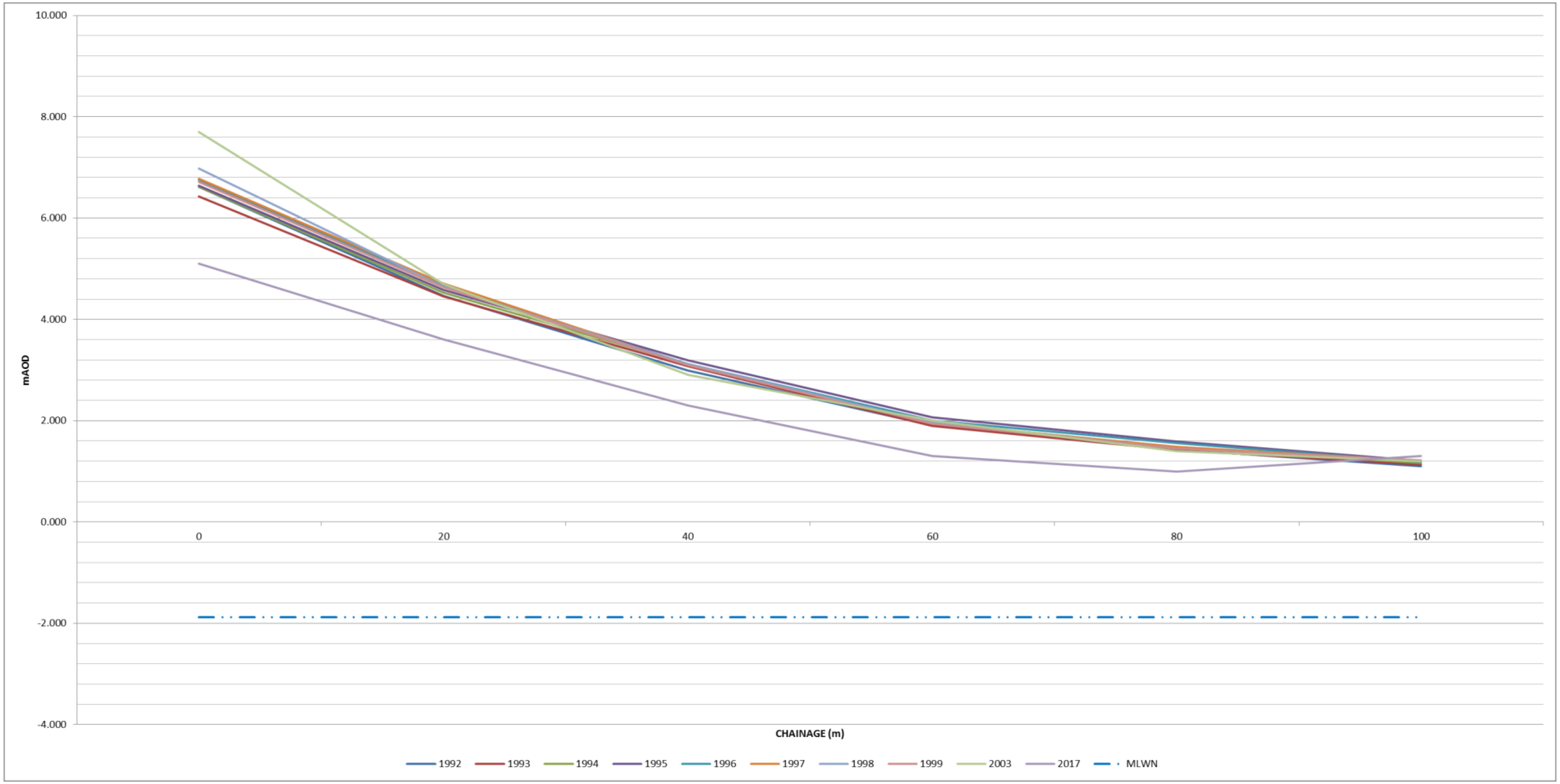
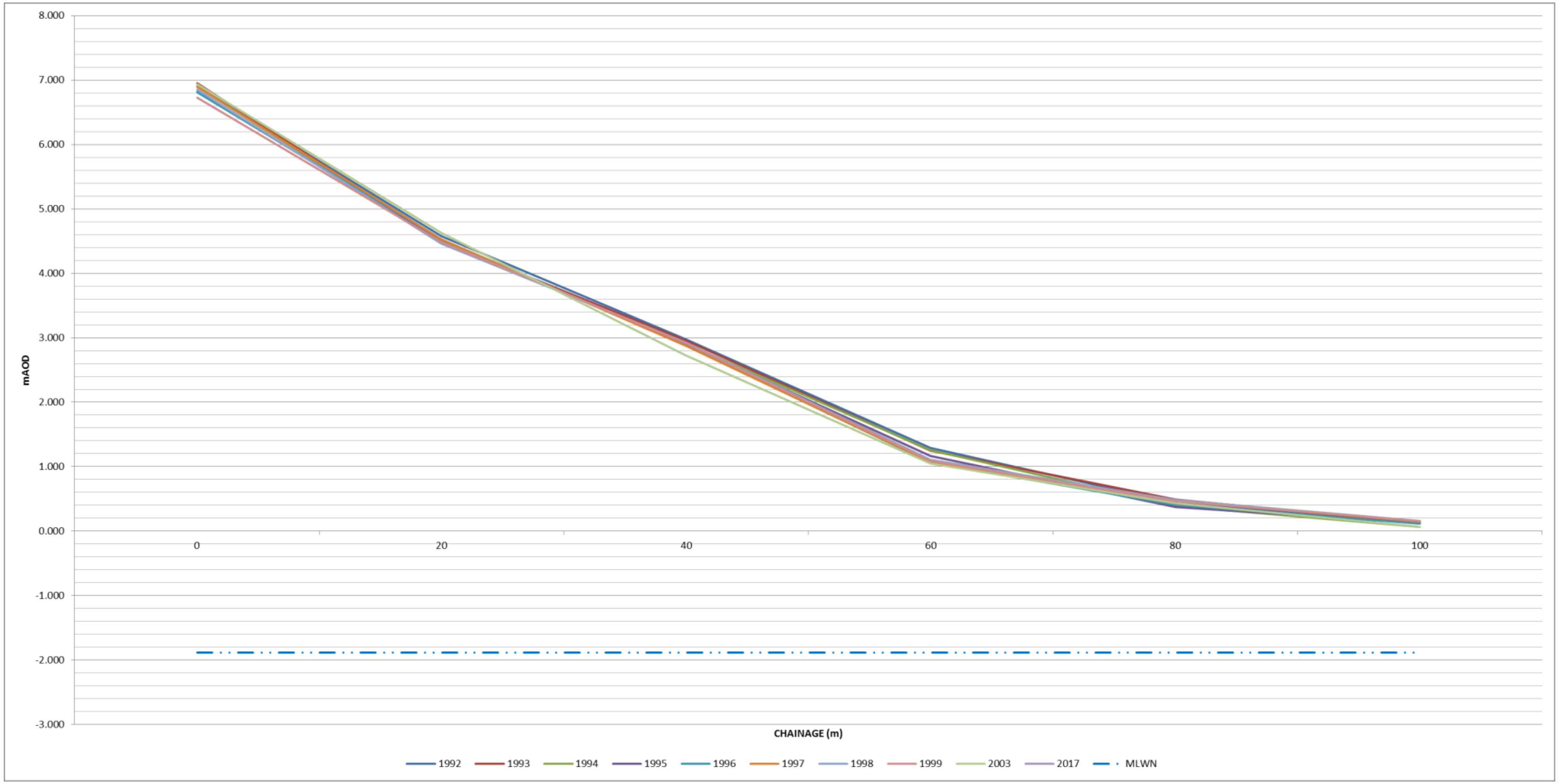


Figure I-38: Annual change of historic beach profiles – HR22



I.2.2.2 Probable and Extreme Beach Profile Graphs

The following charts display the average levels (shown as a teal line) along the chainage for each profile of each of the years previously surveyed, along with the average upper (orange line) and lower levels (pale blue line), and the extreme lower levels of each profile (dark blue line). These are to illustrate how each of the annual average survey relates to the average range of values and to demonstrate the profiles, and portions of profiles, that sit outside the average range i.e. representing relatively extreme profiles. A brief commentary is provided for each geographical area, as per the other sections of this Technical Note.

I.2.2.2.1 Grouville

The results for Grouville are shown in Figure I-39 to Figure I-47. These show that the majority of the profiles are within 10% of the elevations recorded in the surveys, as seen in the relative clustering of the average profiles in Section 2.2.1. Where extreme profiles can be seen, e.g. in PSD1 in Figure I-39, this is commonly seen in the DTM.

Figure I-39: Annual change of historic beach profiles, compared with extreme averages – PSD1

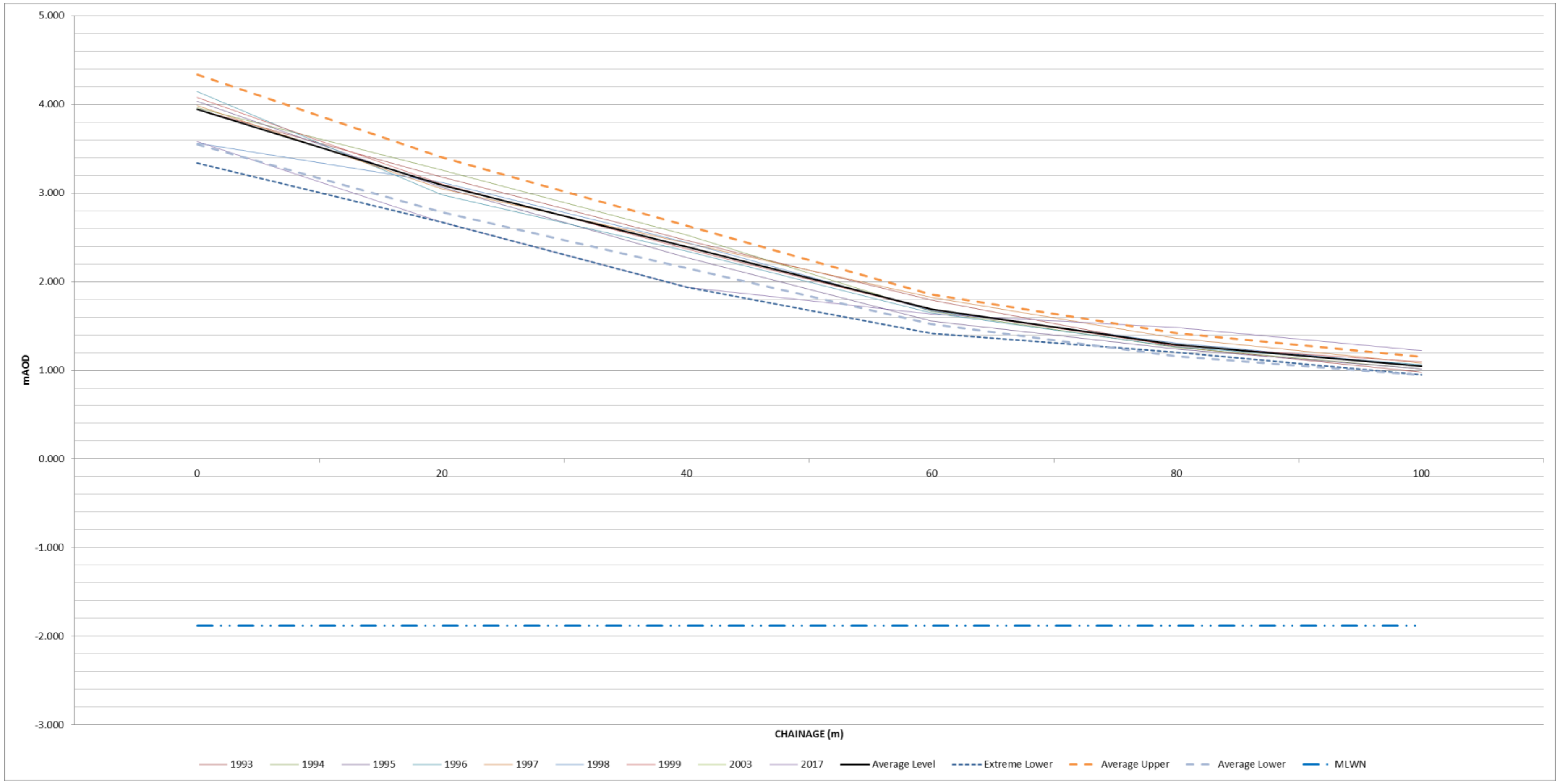


Figure I-40: Annual change of historic beach profiles, compared with extreme averages – PSD2

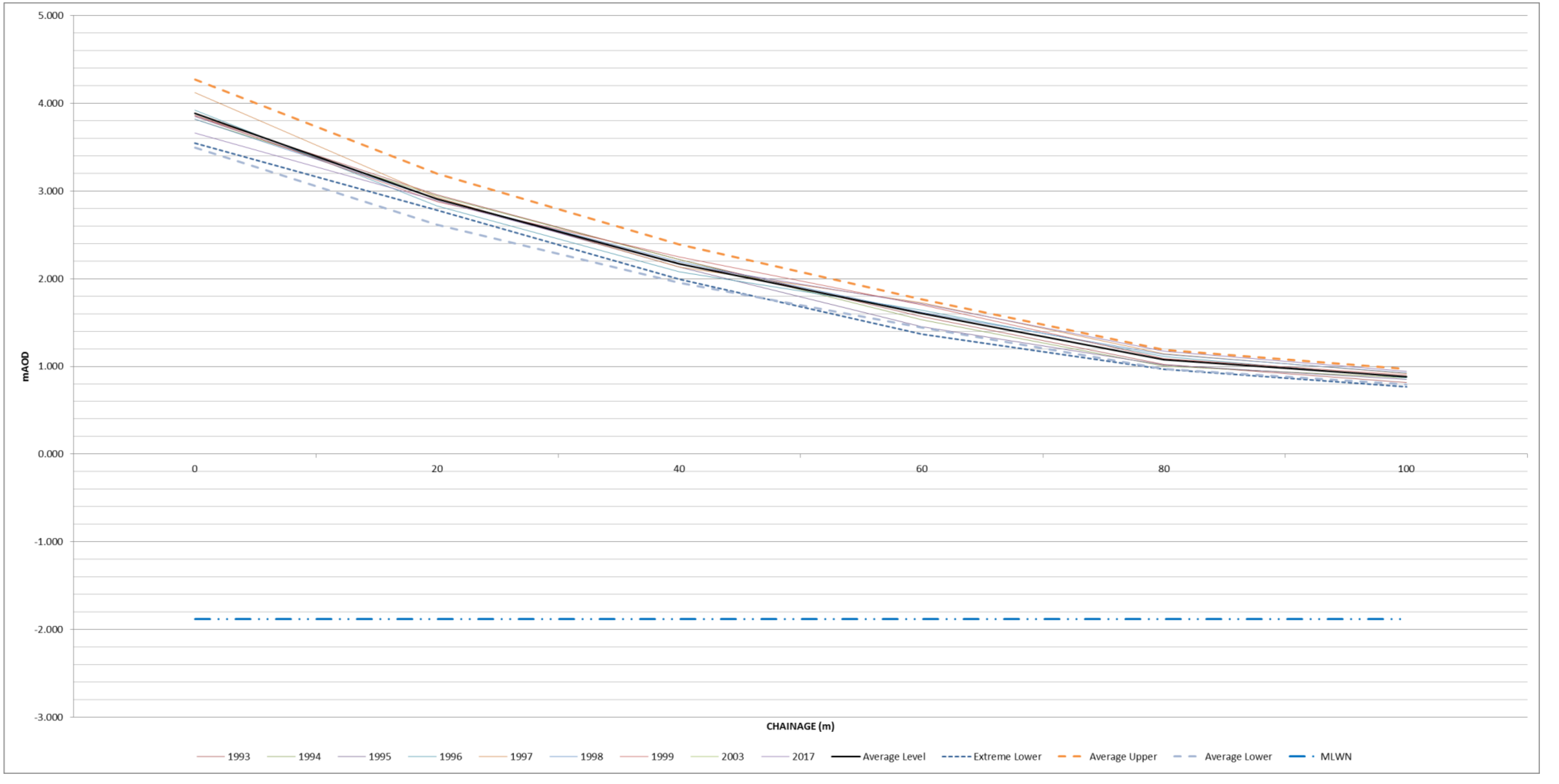


Figure I-41: Annual change of historic beach profiles, compared with extreme averages – PSD3

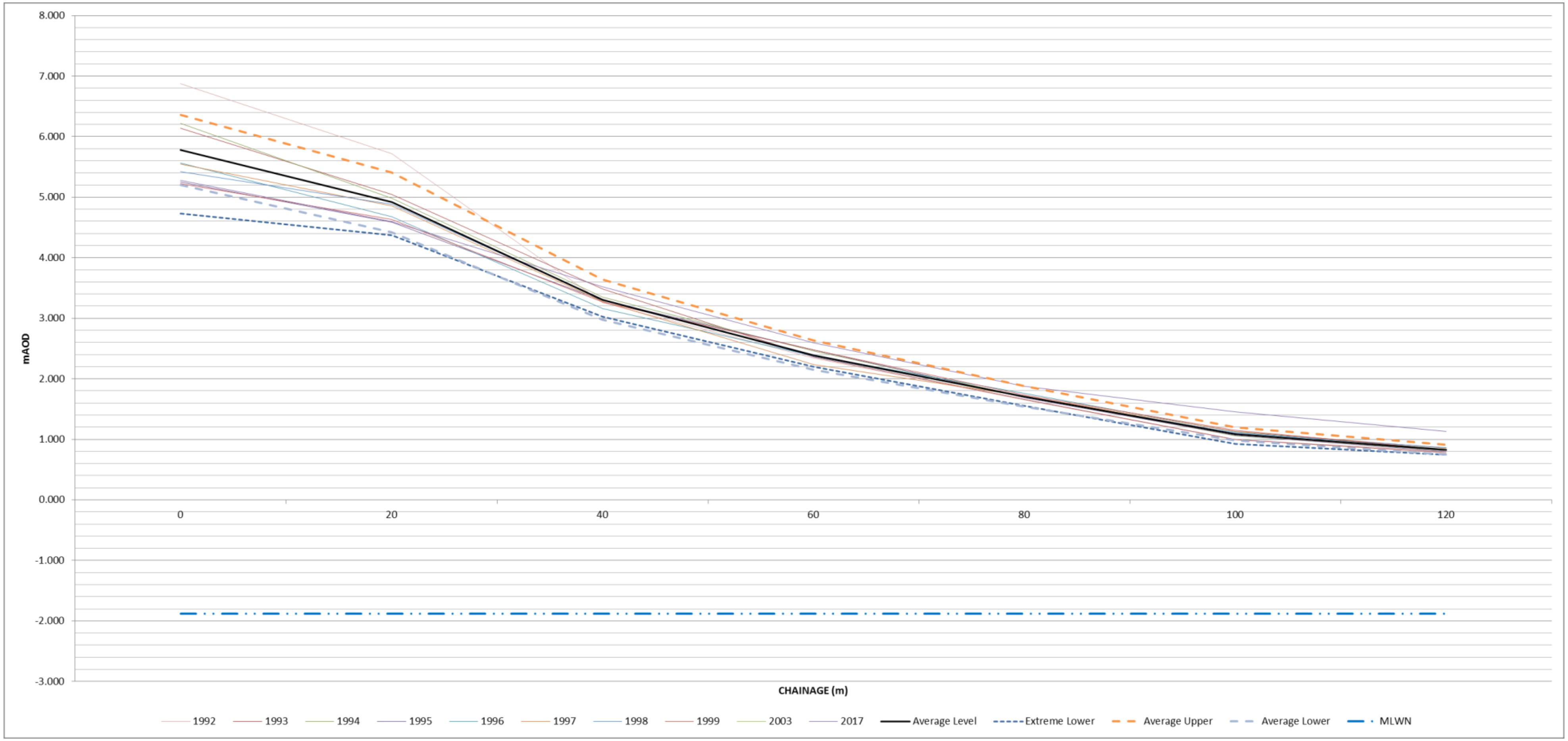


Figure I-42: Annual change of historic beach profiles, compared with extreme averages – PSD4

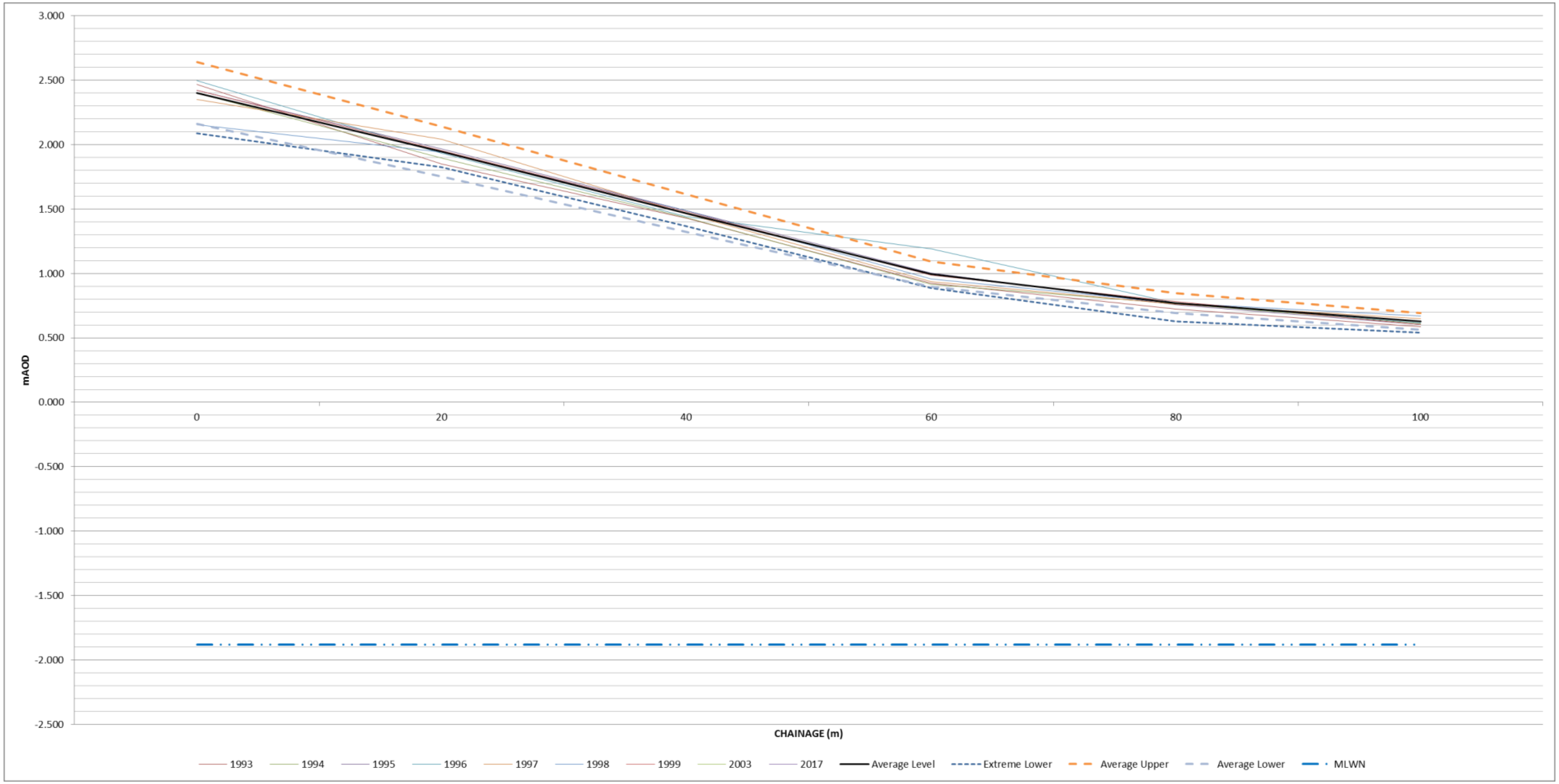


Figure I-43: Annual change of historic beach profiles, compared with extreme averages – PSD5

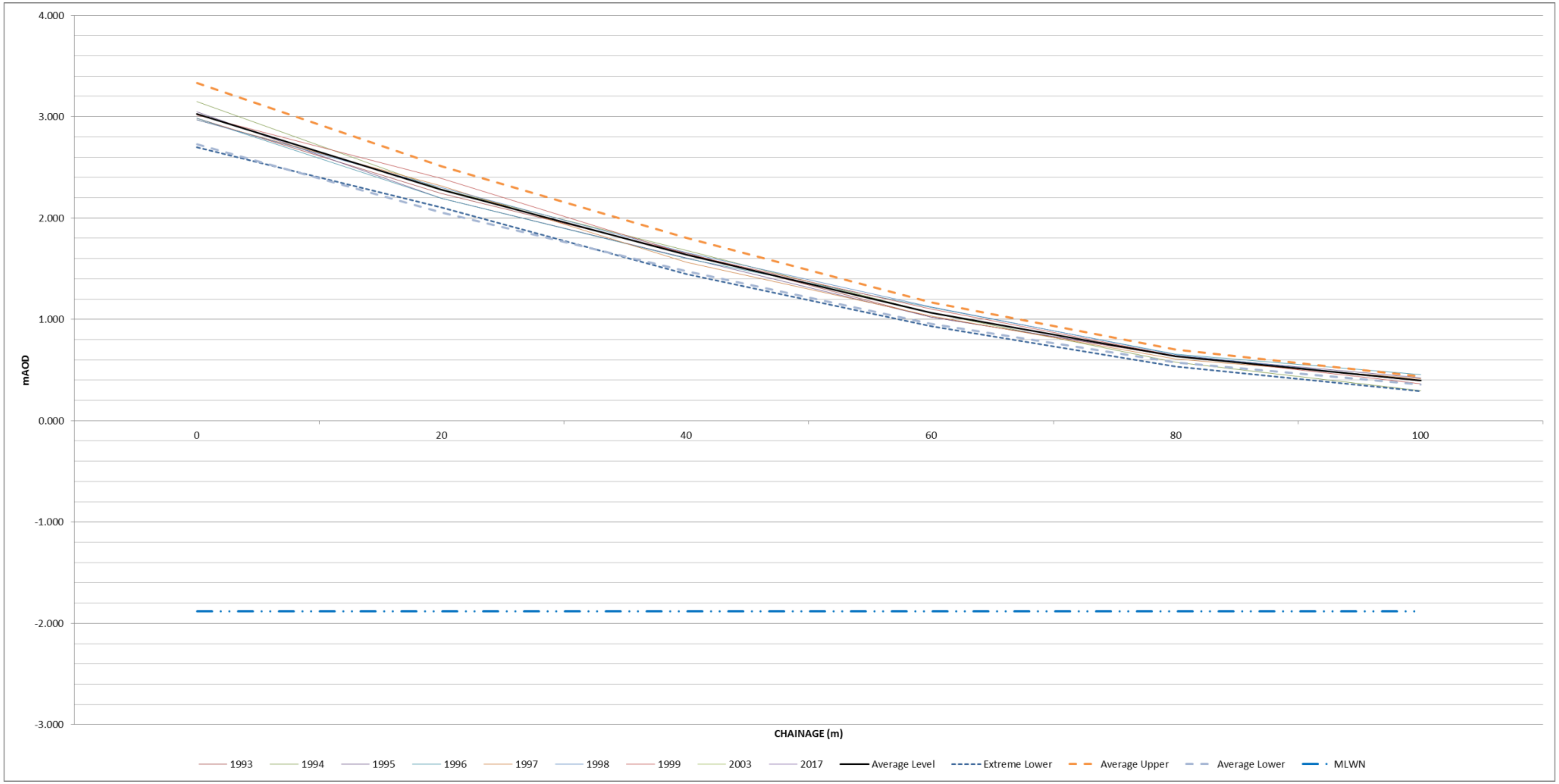


Figure I-44: Annual change of historic beach profiles, compared with extreme averages – PSD6

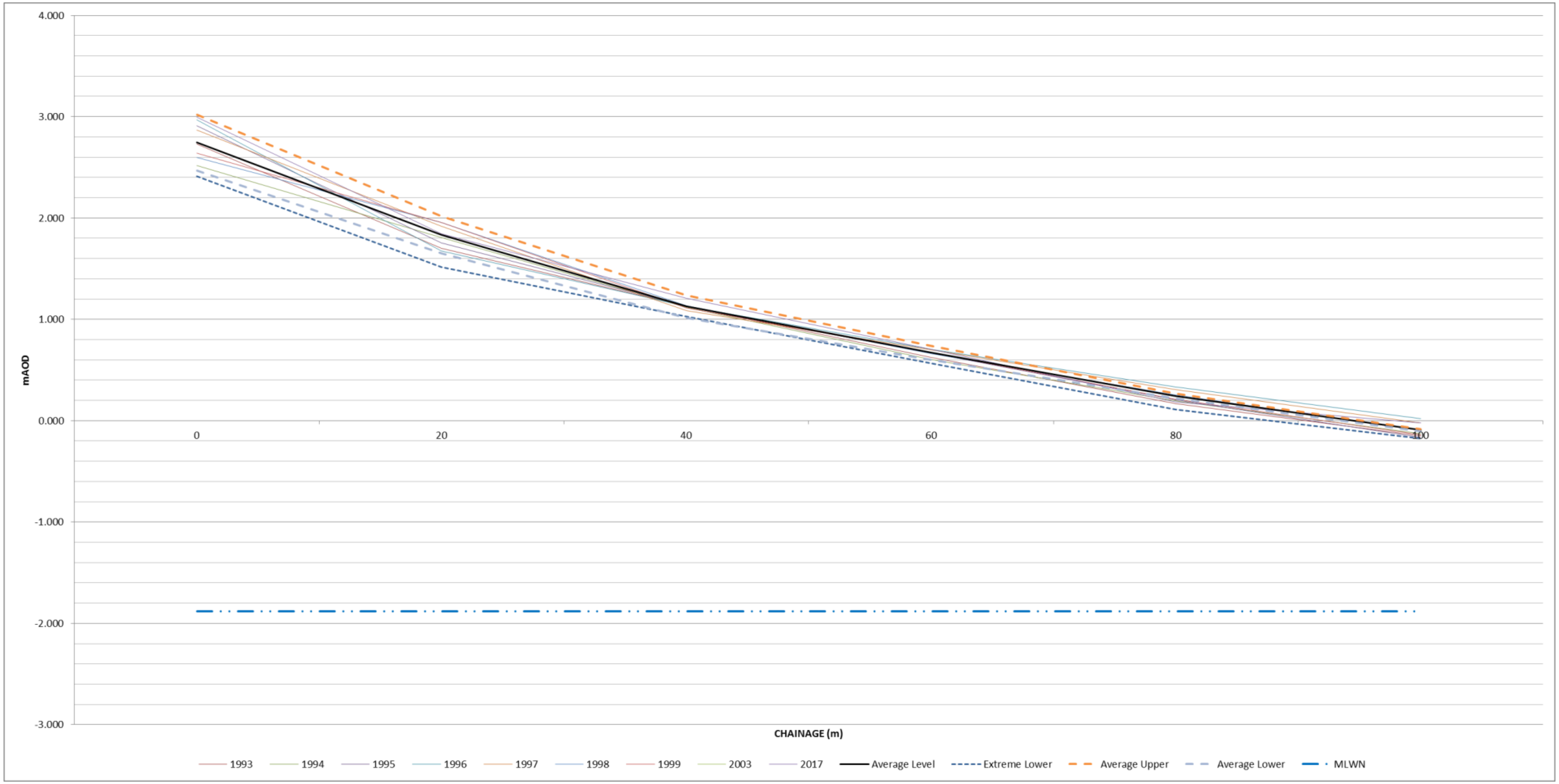


Figure I-45: Annual change of historic beach profiles, compared with extreme averages – PSD7

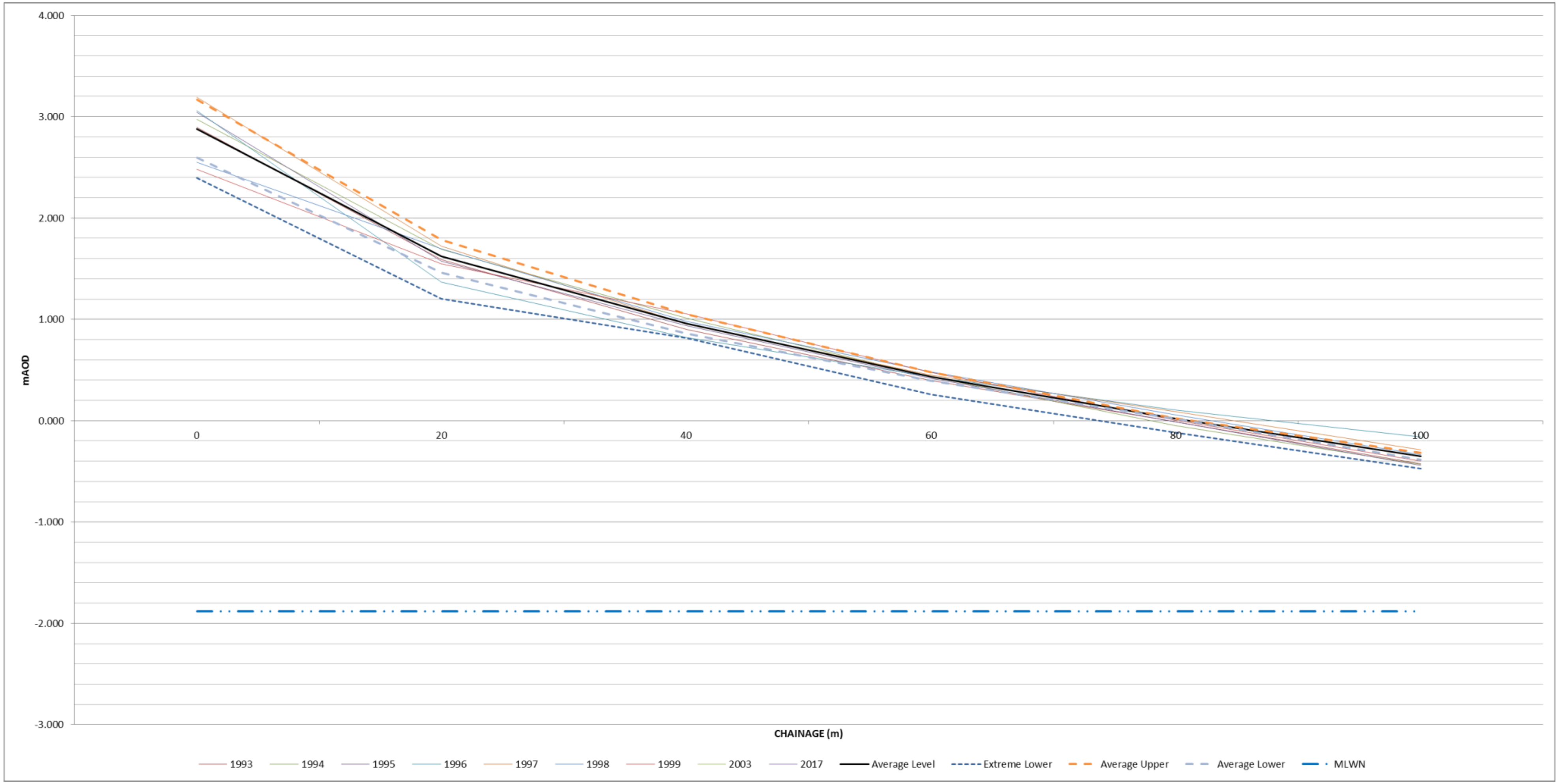


Figure I-46: Annual change of historic beach profiles, compared with extreme averages – PSD8

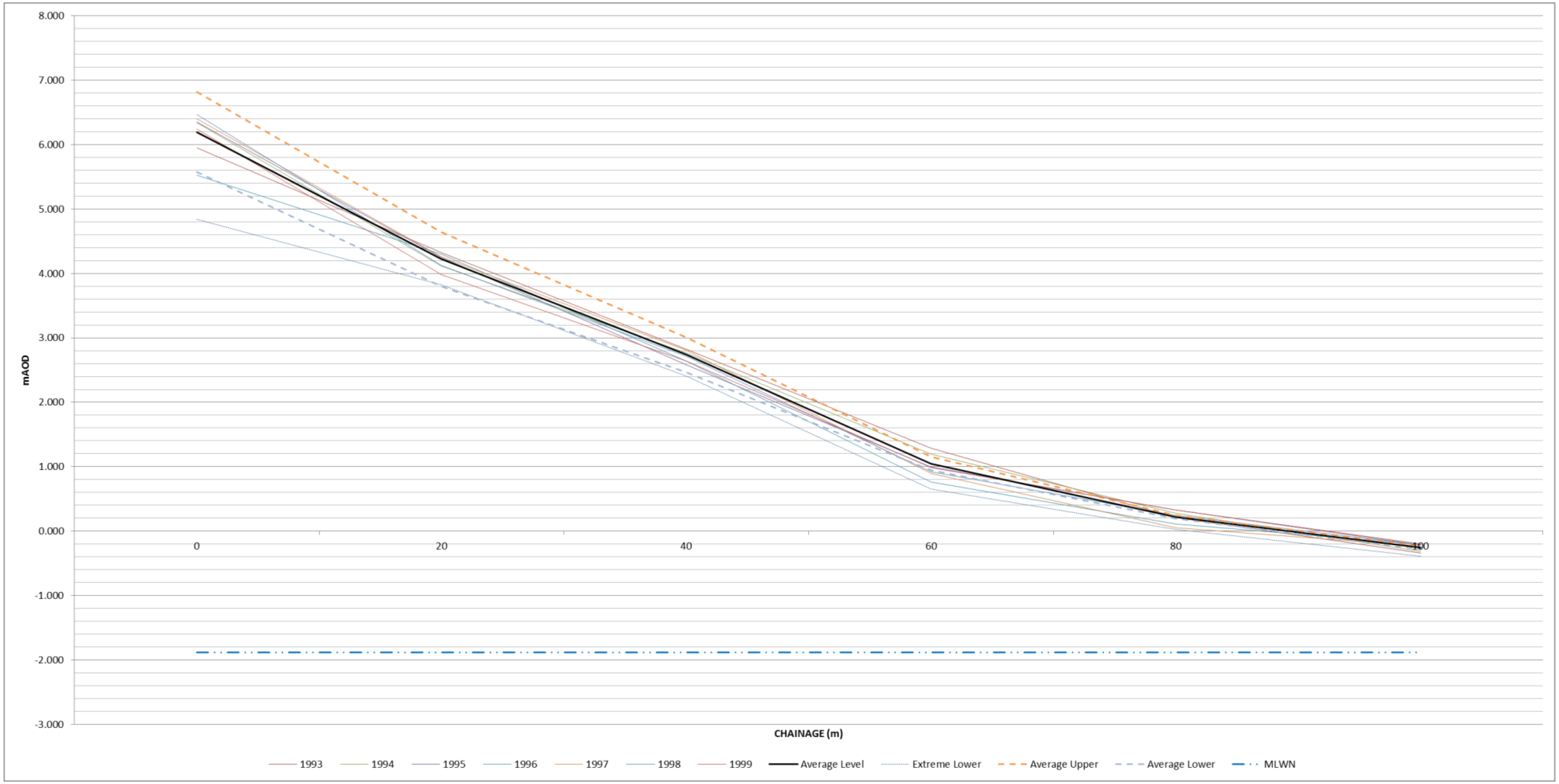
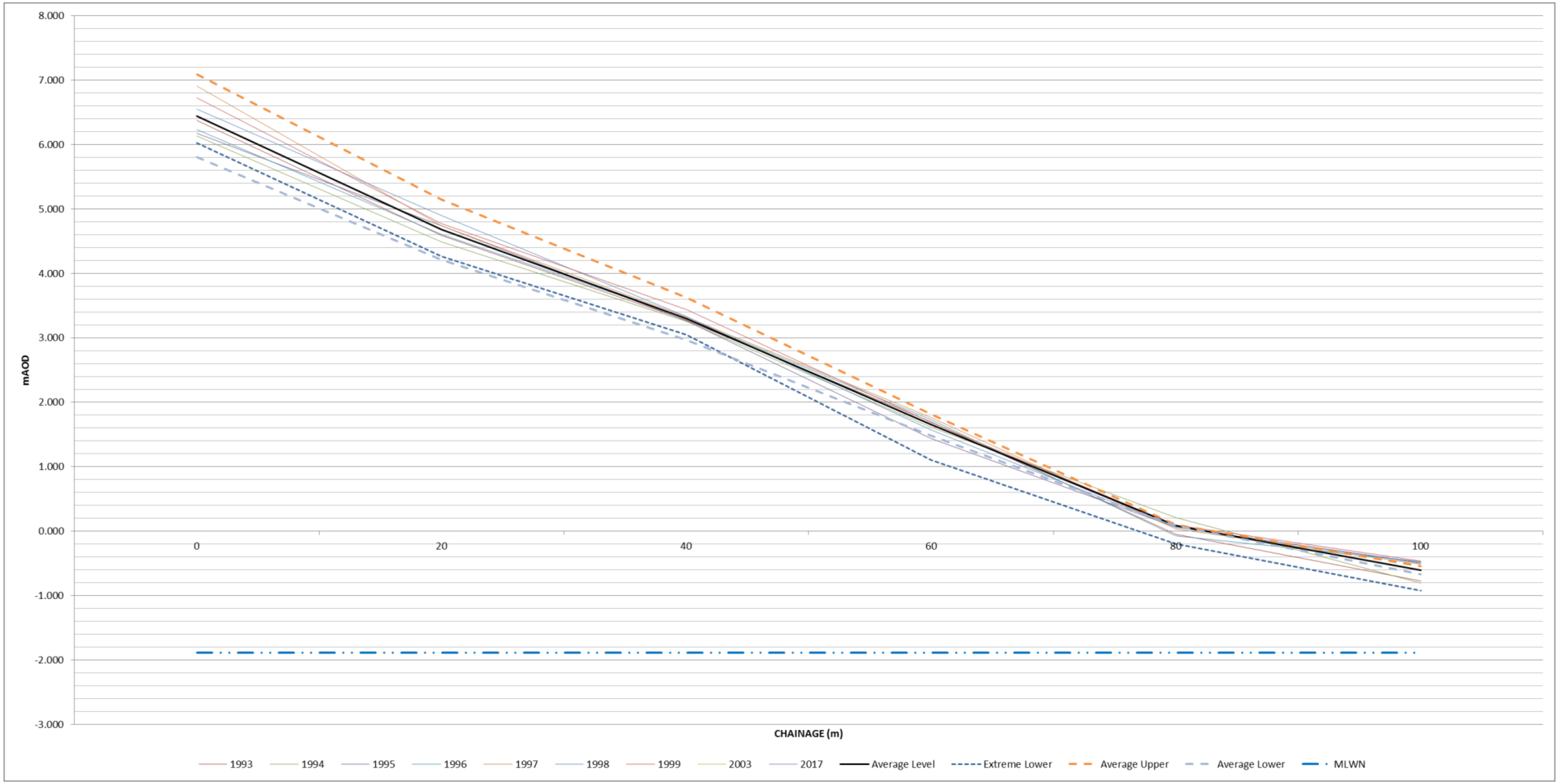


Figure I-47: Annual change of historic beach profiles, compared with extreme averages – PSD9



I.2.2.2.2 St Ouen's Bay

The results for St Ouen's Bay profiles are shown in Figure I-48 to Figure I-54. Figure I-49 shows the surveys from 1998 and 1999 going beyond the average range for HR2, and also in Figure I-53, where the results for HR6 for the extreme lower line correspond to the 2017 DTM results.

Figure I-48: Annual change of historic beach profiles, compared with extreme averages – HR1

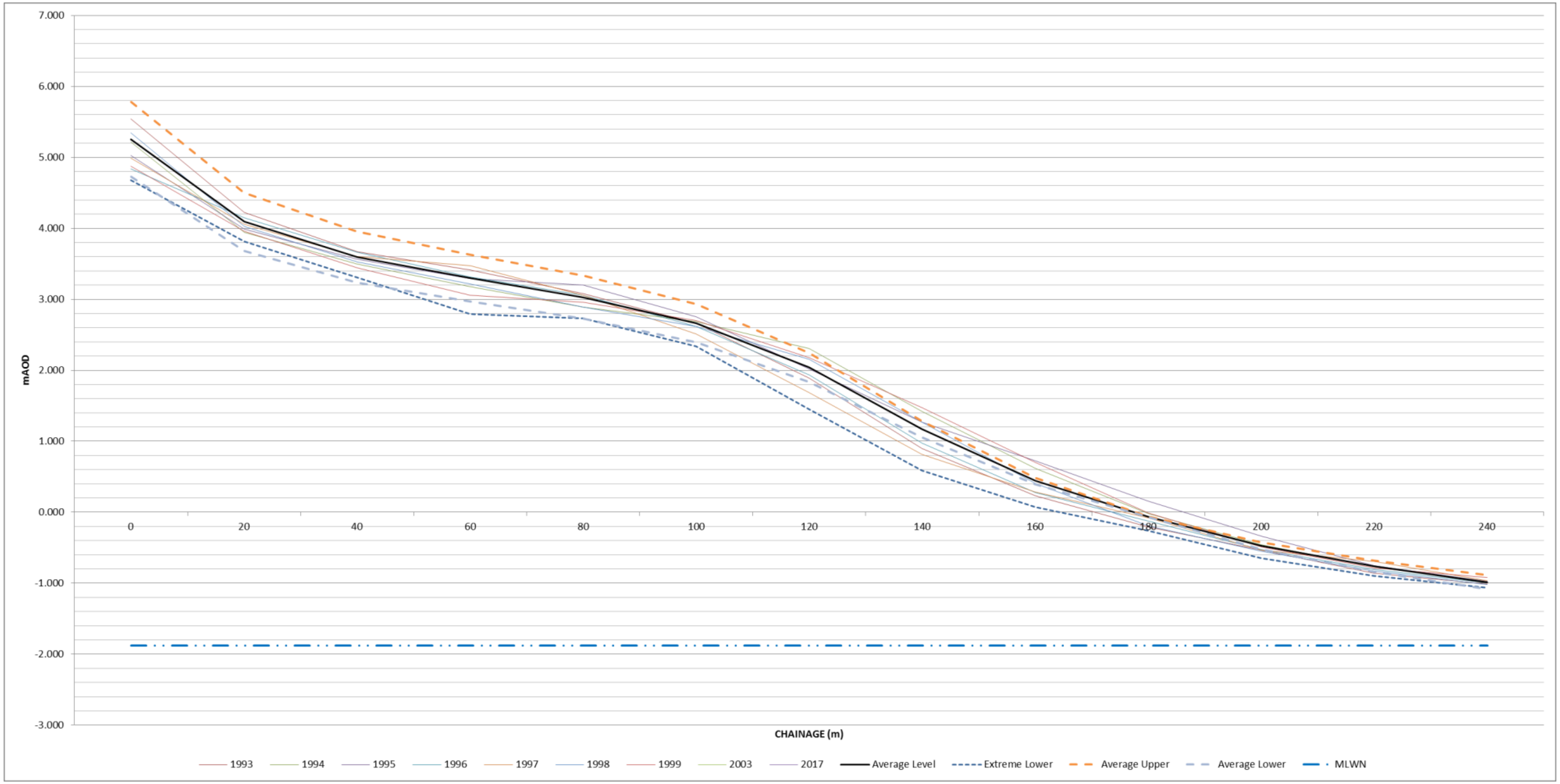


Figure I-49: Annual change of historic beach profiles, compared with extreme averages – HR2

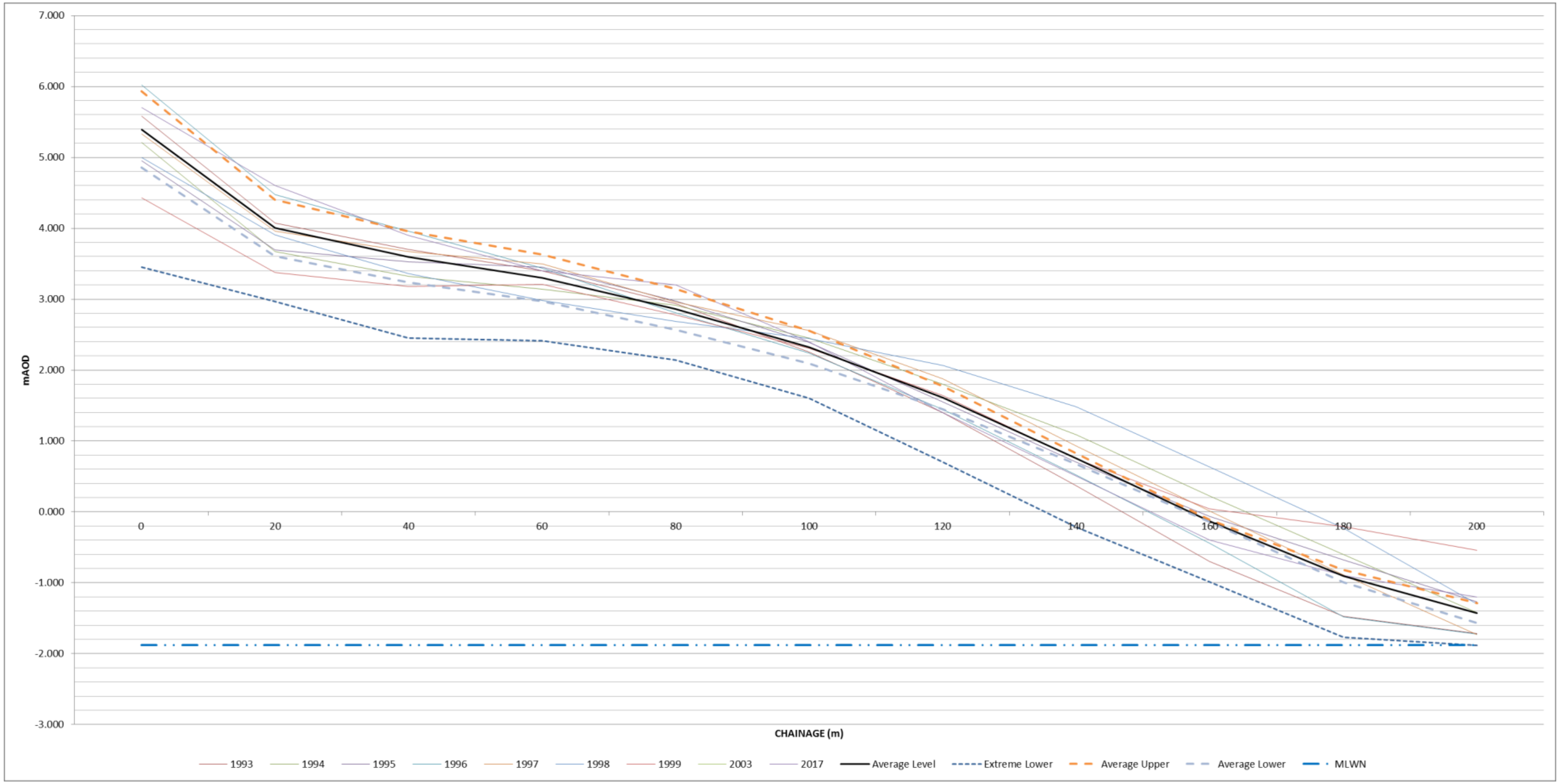


Figure I-50: Annual change of historic beach profiles, compared with extreme averages – HR3

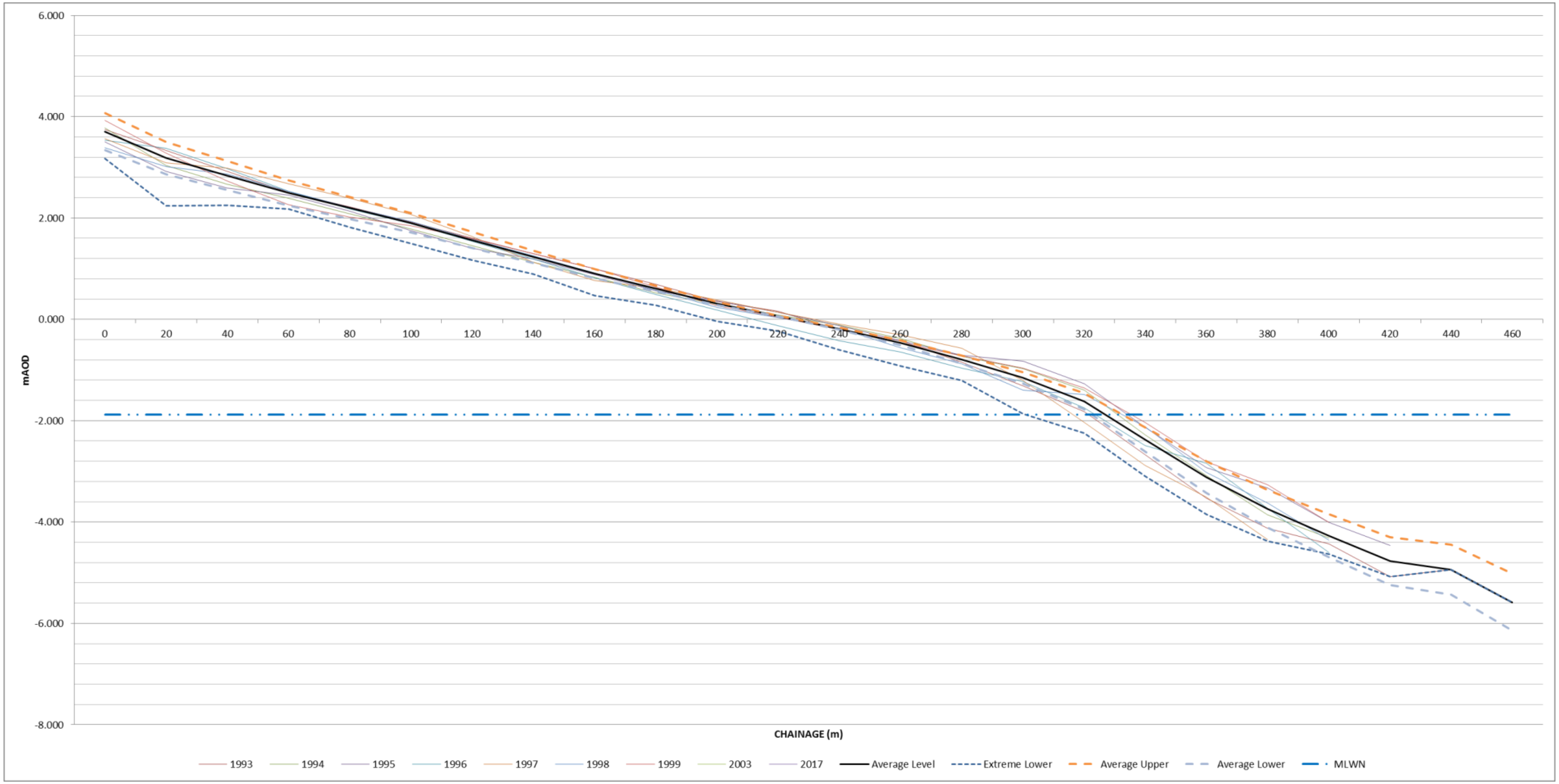


Figure I-51: Annual change of historic beach profiles, compared with extreme averages – HR4

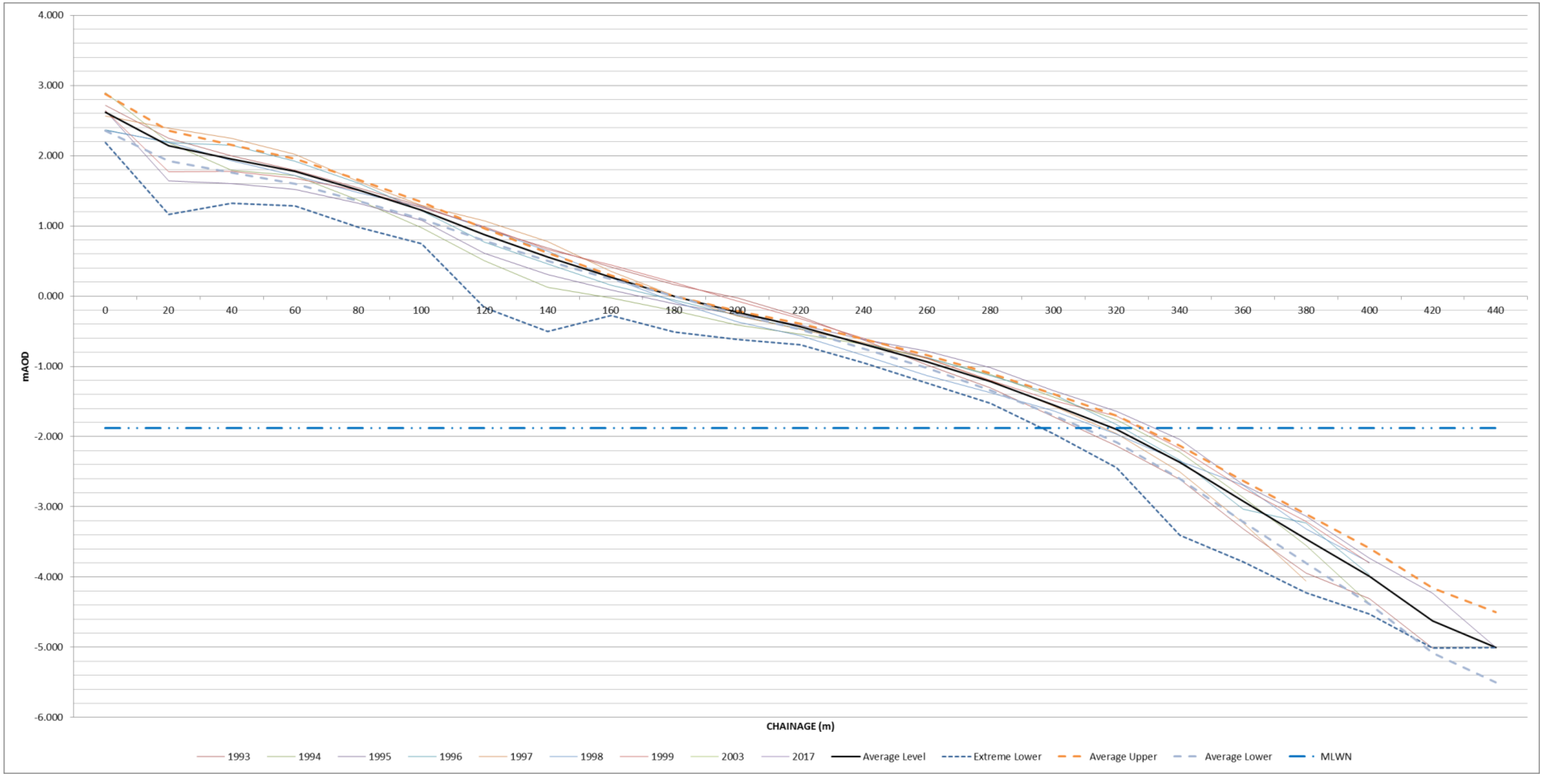


Figure I-52: Annual change of historic beach profiles, compared with extreme averages – HR5

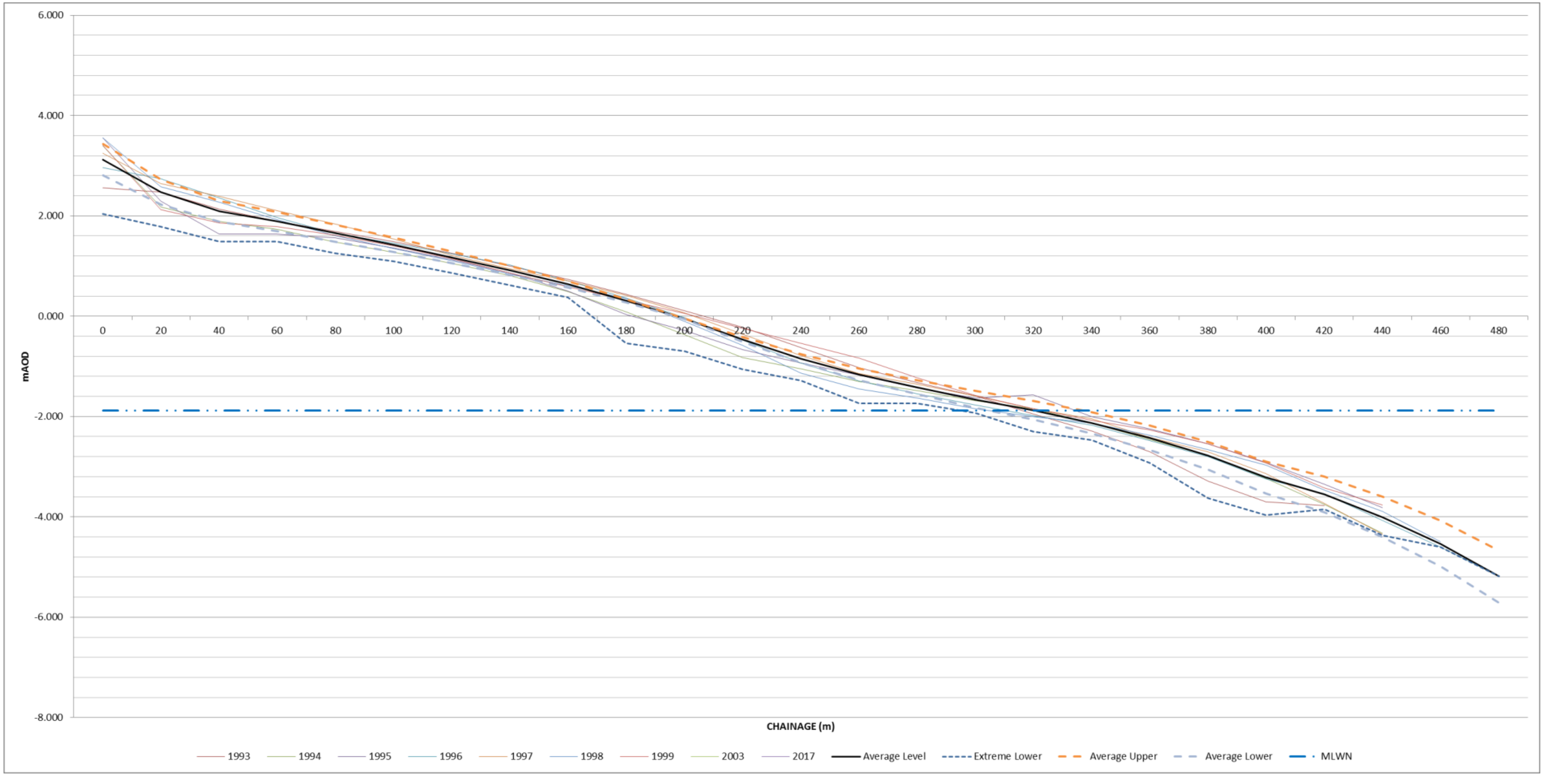


Figure I-53: Annual change of historic beach profiles, compared with extreme averages – HR6

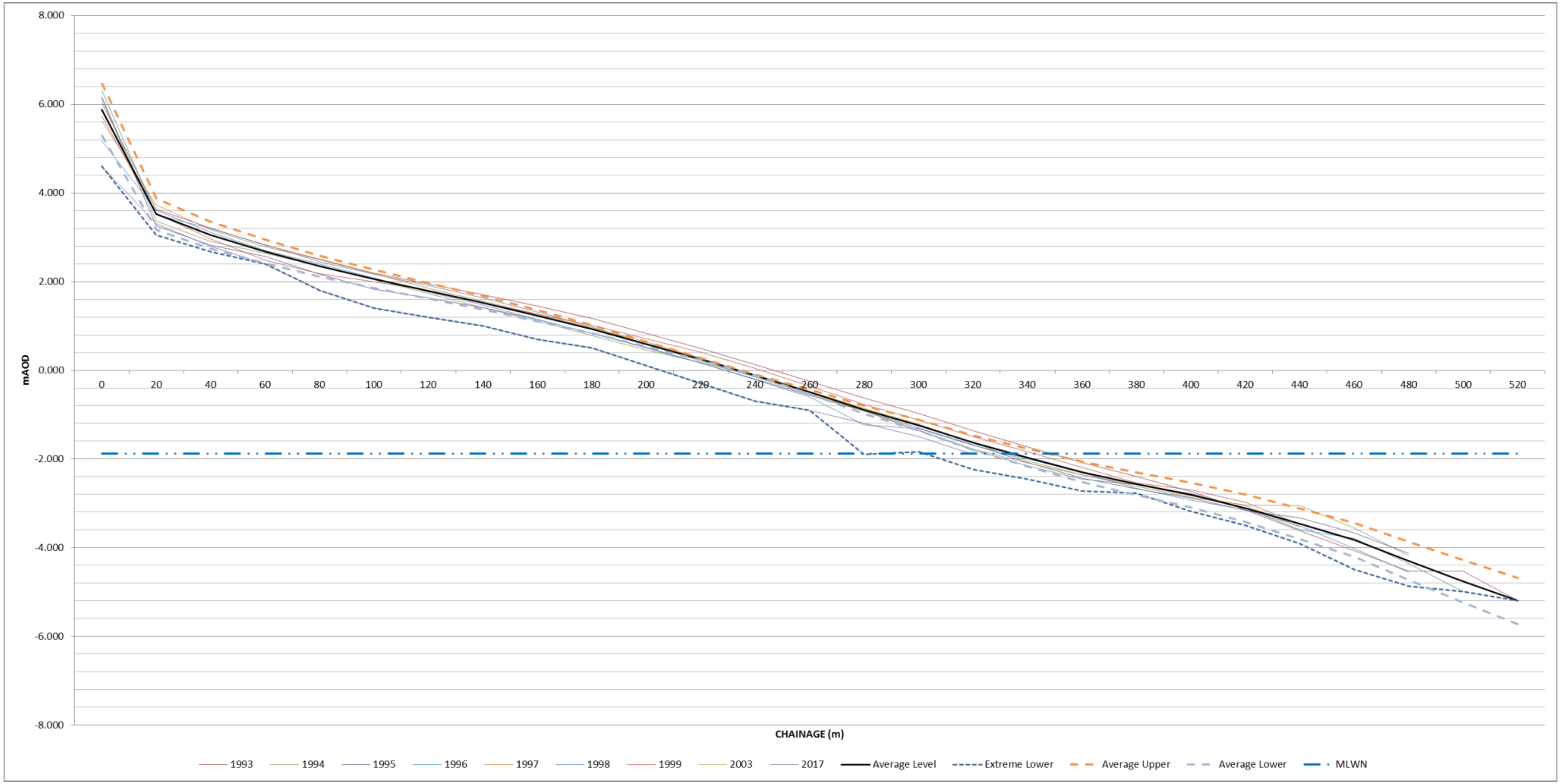
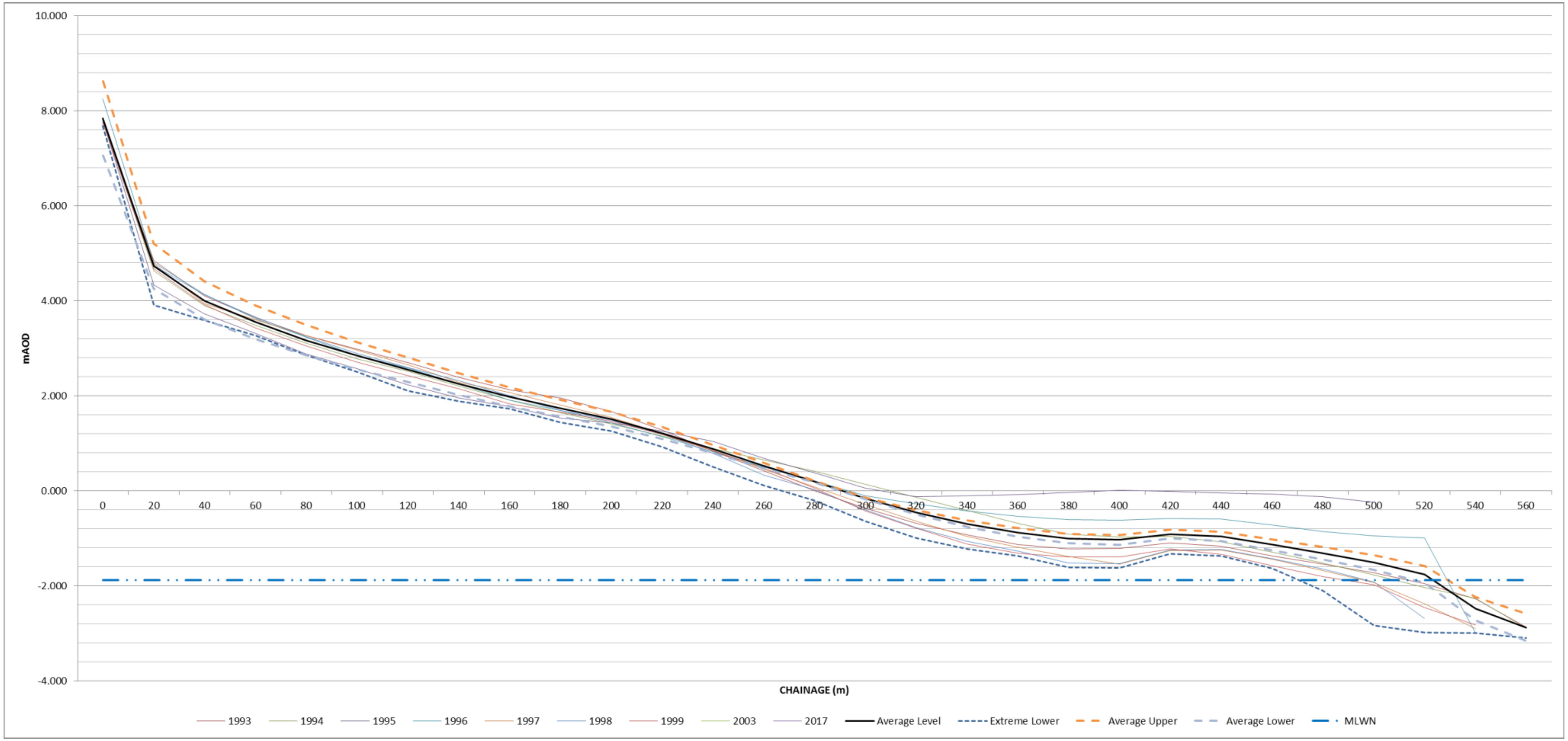


Figure I-54: Annual change of historic beach profiles, compared with extreme averages – HR7



I.2.2.2.3 St Brelade's Bay

All the results for St Brelade's Bay (Figure I-55 to Figure I-58) show the relative stability of St Brelade's Bay profiles with the clustering of the profiles and few departures from the average range.

Figure I-55: Annual change of historic beach profiles, compared with extreme averages – HR8

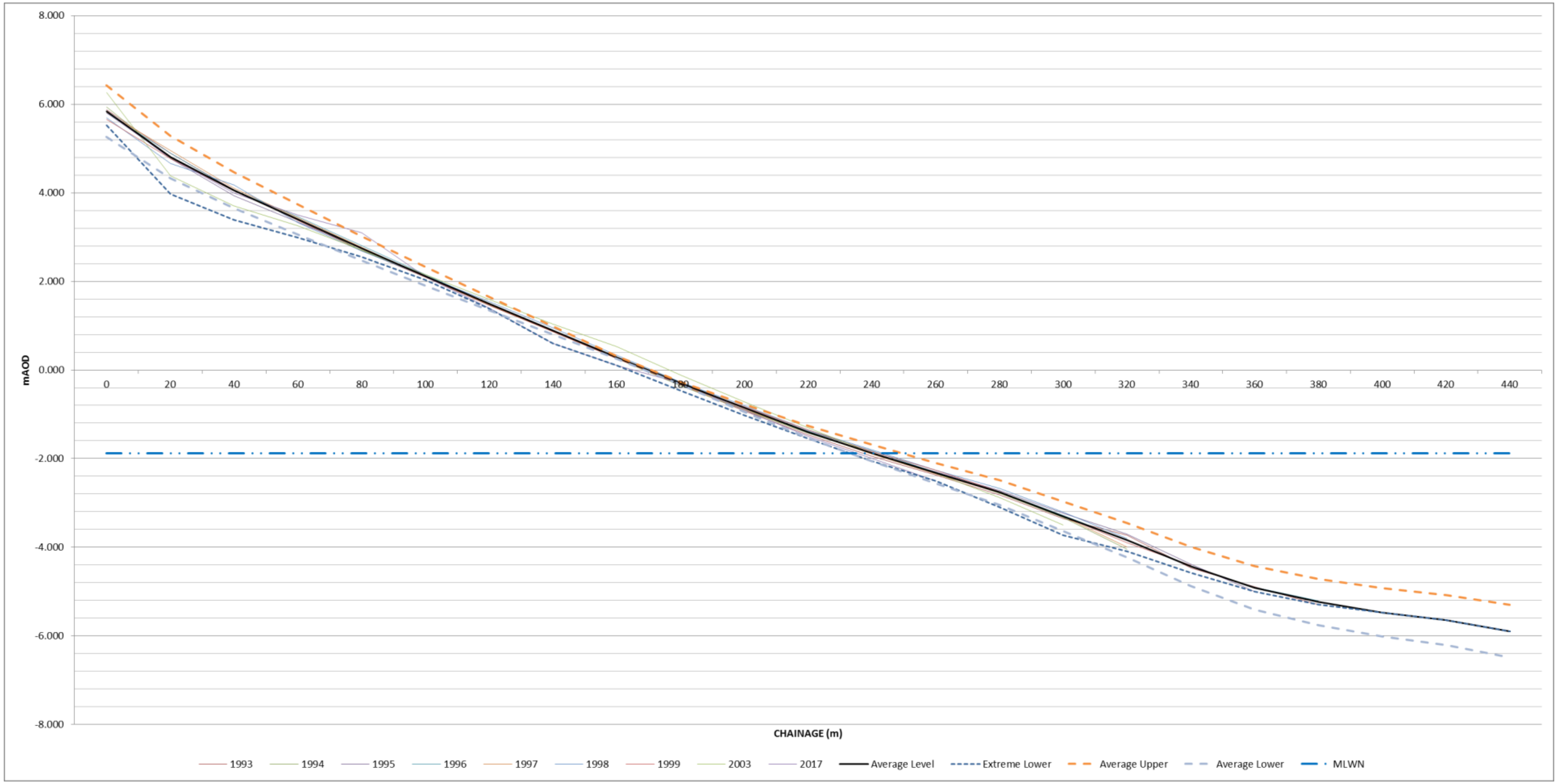


Figure I-56: Annual change of historic beach profiles, compared with extreme averages – HR9

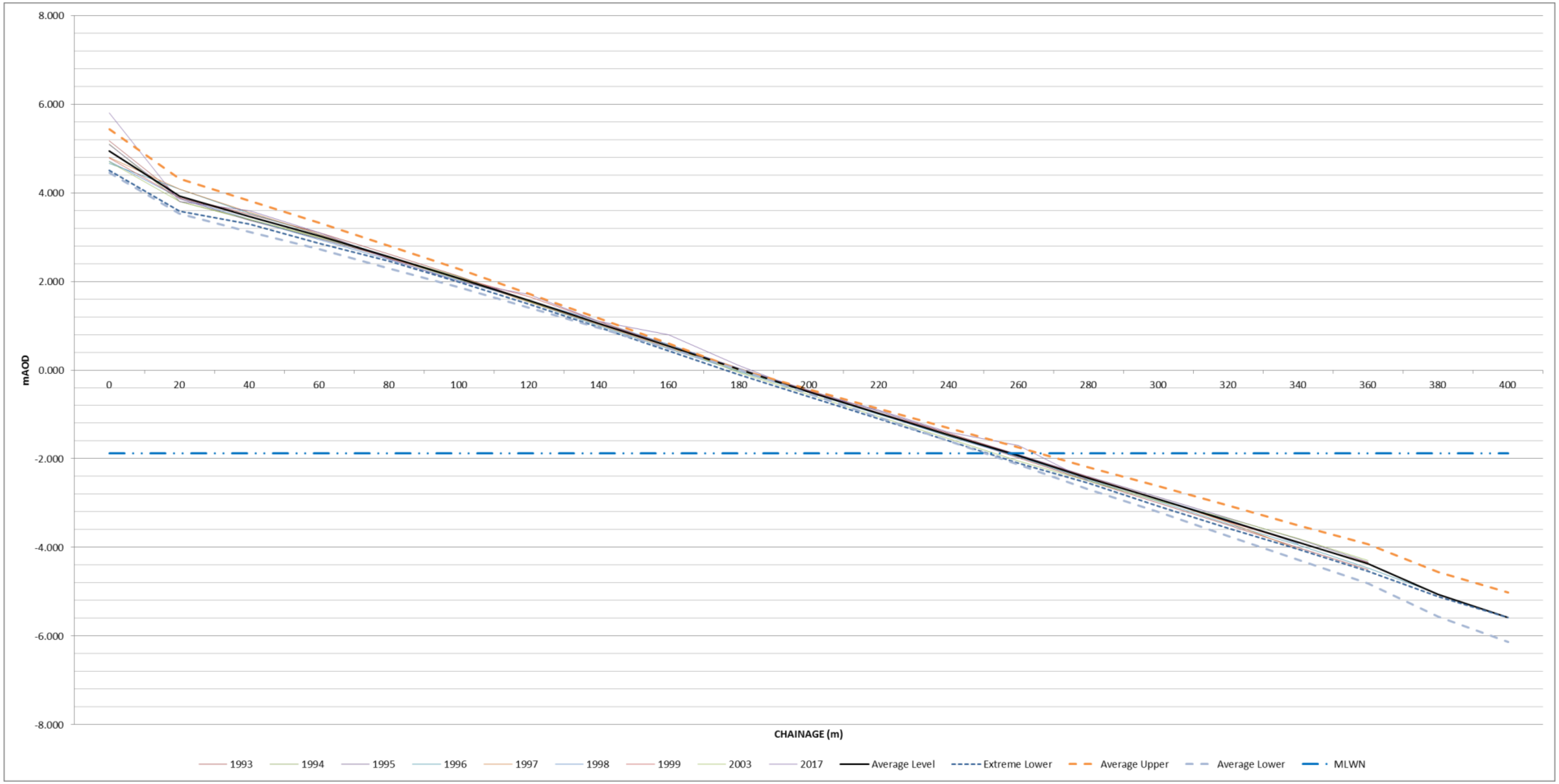


Figure I-57: Annual change of historic beach profiles, compared with extreme averages – HR10

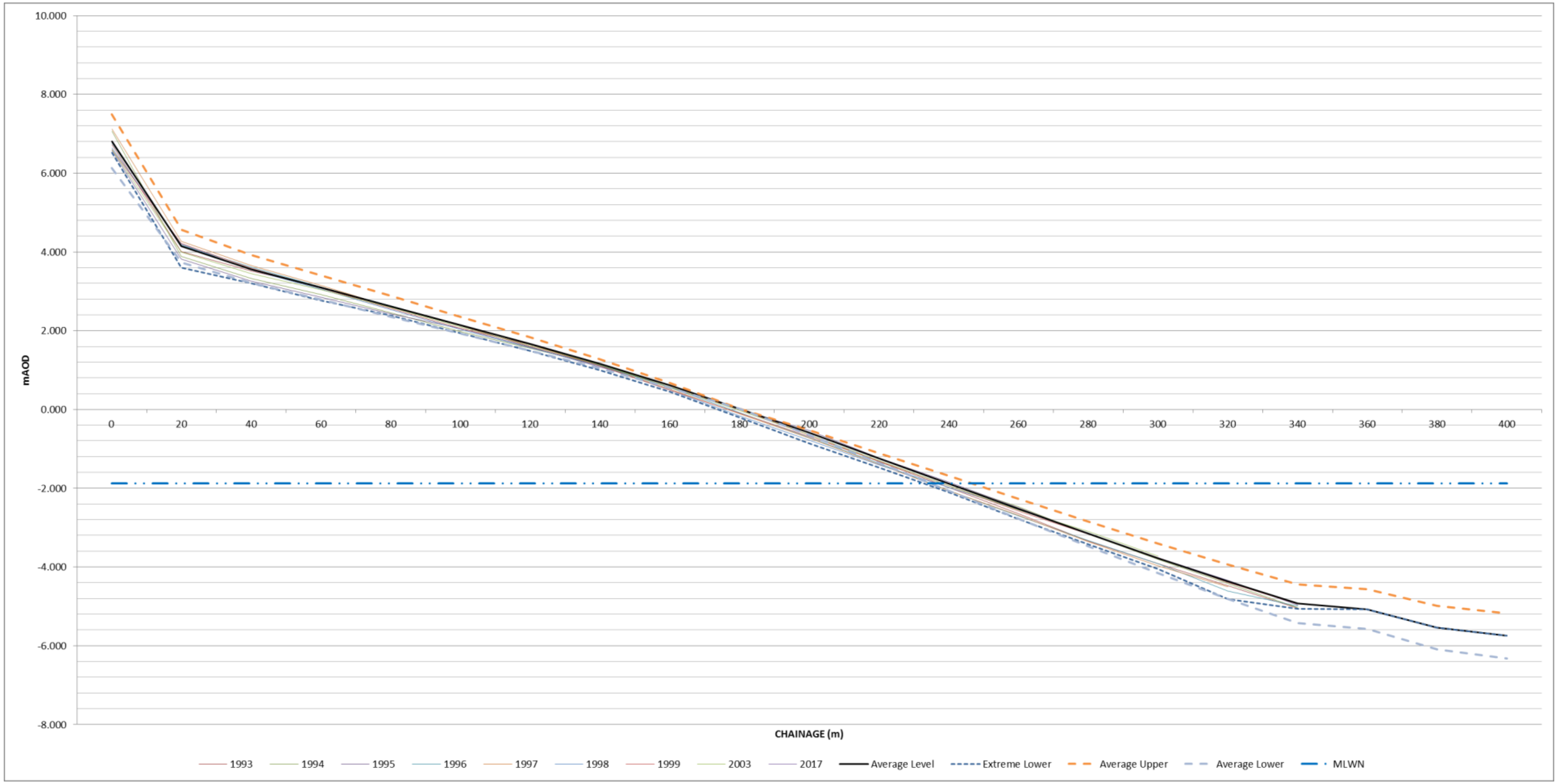
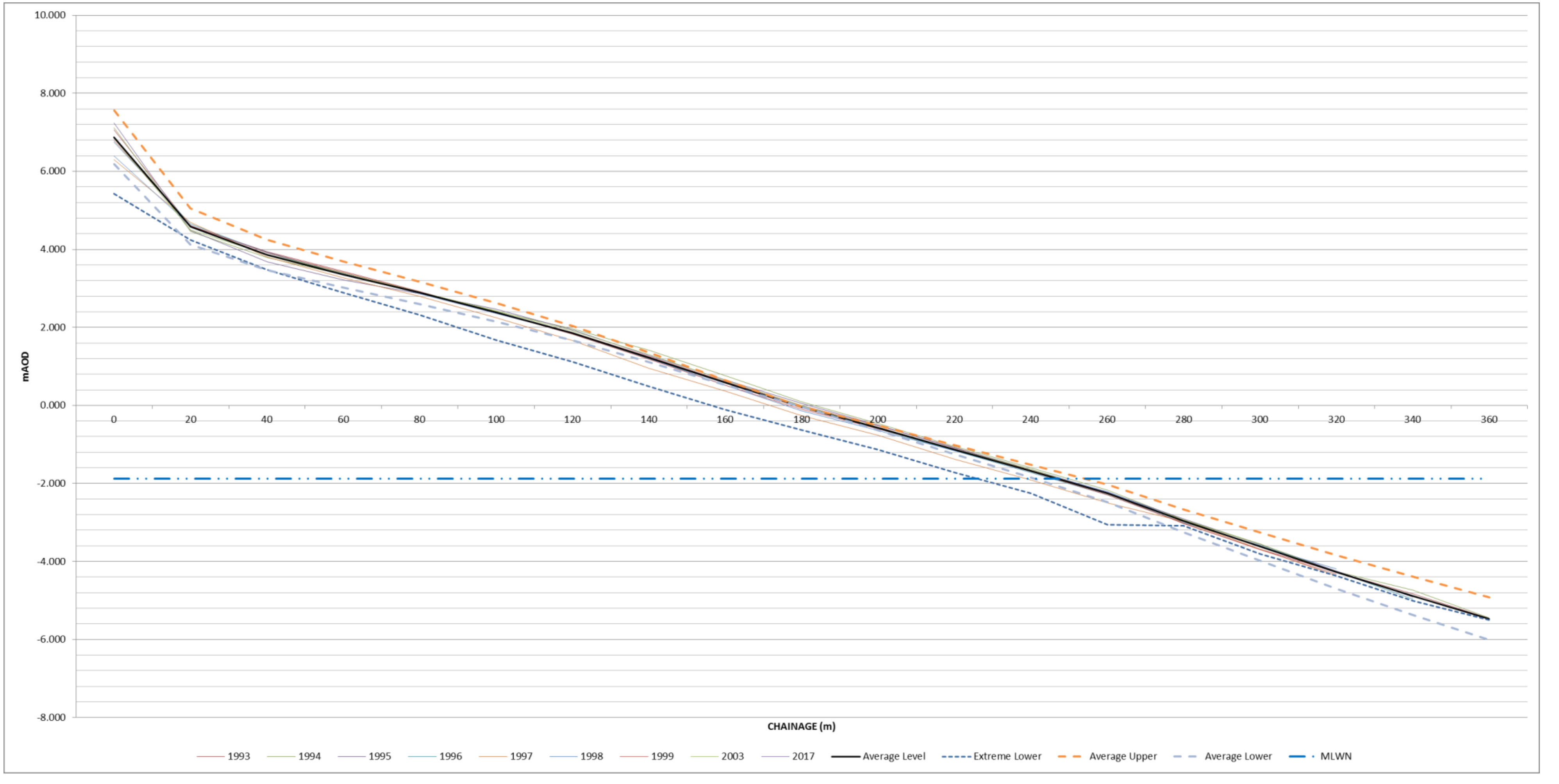


Figure I-58: Annual change of historic beach profiles, compared with extreme averages – HR11



I.2.2.2.4 St Aubin’s Bay

The results for St Aubin’s Bay in Figure I-59 to Figure I-62 are very similar to the average results shown in Figure I-28 to Figure I-31. The figures again show the overall narrow change in elevation despite some profiles showing oscillating elevations from year to year and also the previously mentioned ‘spikes’ in surveys, possibly around rock outcrops. The graphs show few profiles or portions of profiles outside the average range; more extreme portions of profiles are most visible on HR15.

Figure I-59: Annual change of historic beach profiles, compared with extreme averages – HR12

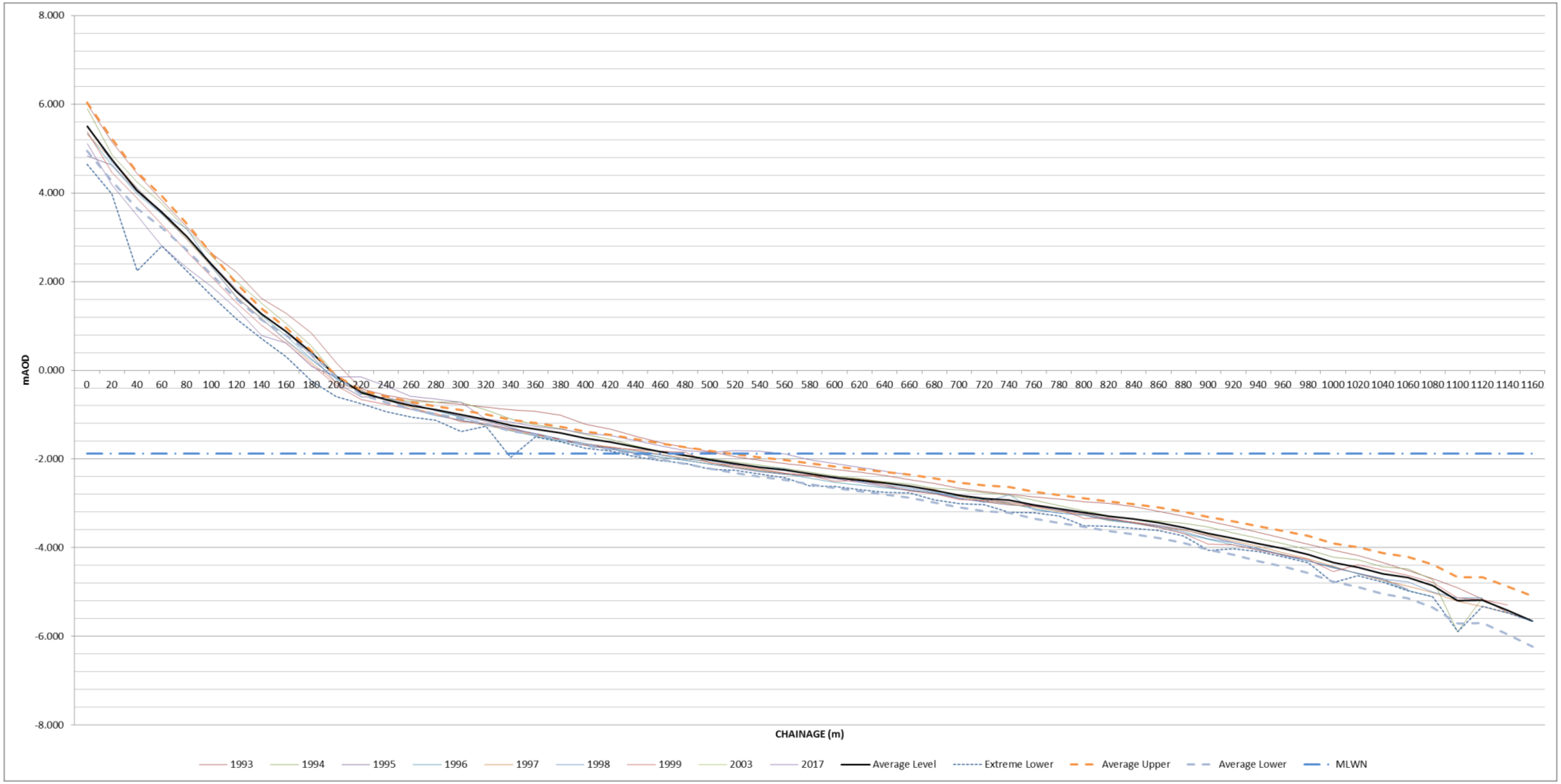


Figure I-60: Annual change of historic beach profiles, compared with extreme averages – HR13

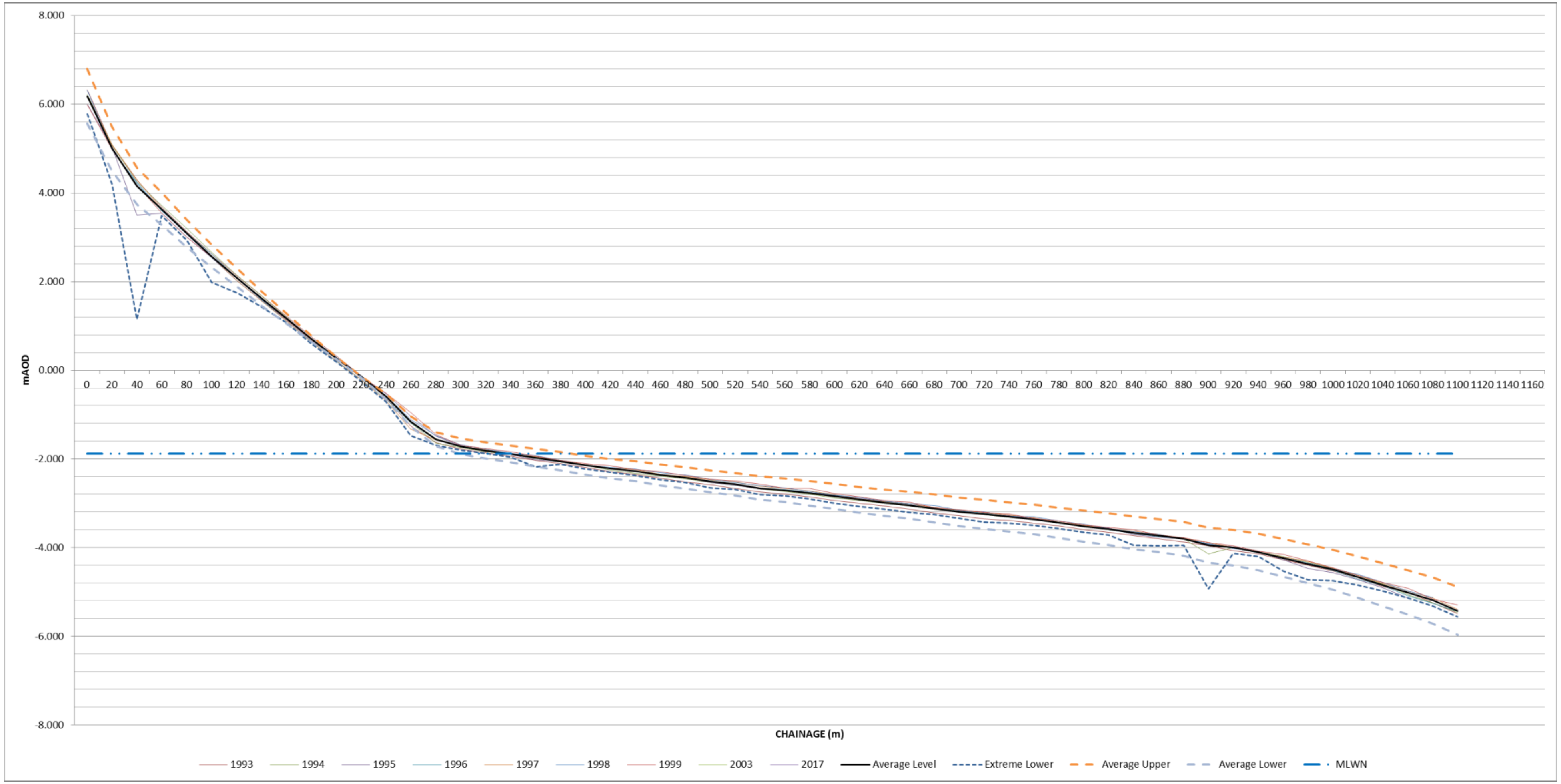


Figure I-61: Annual change of historic beach profiles, compared with extreme averages – HR14

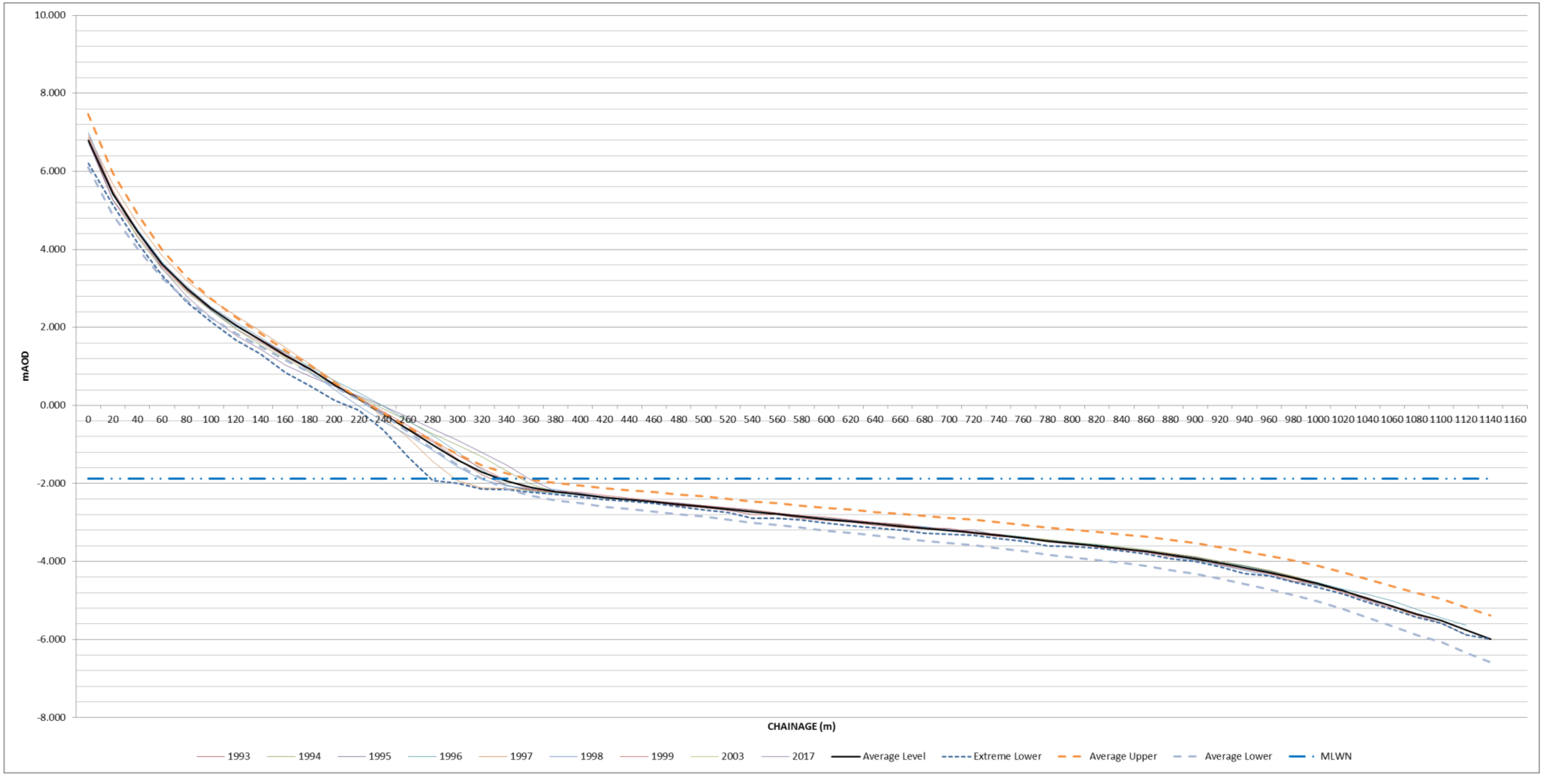
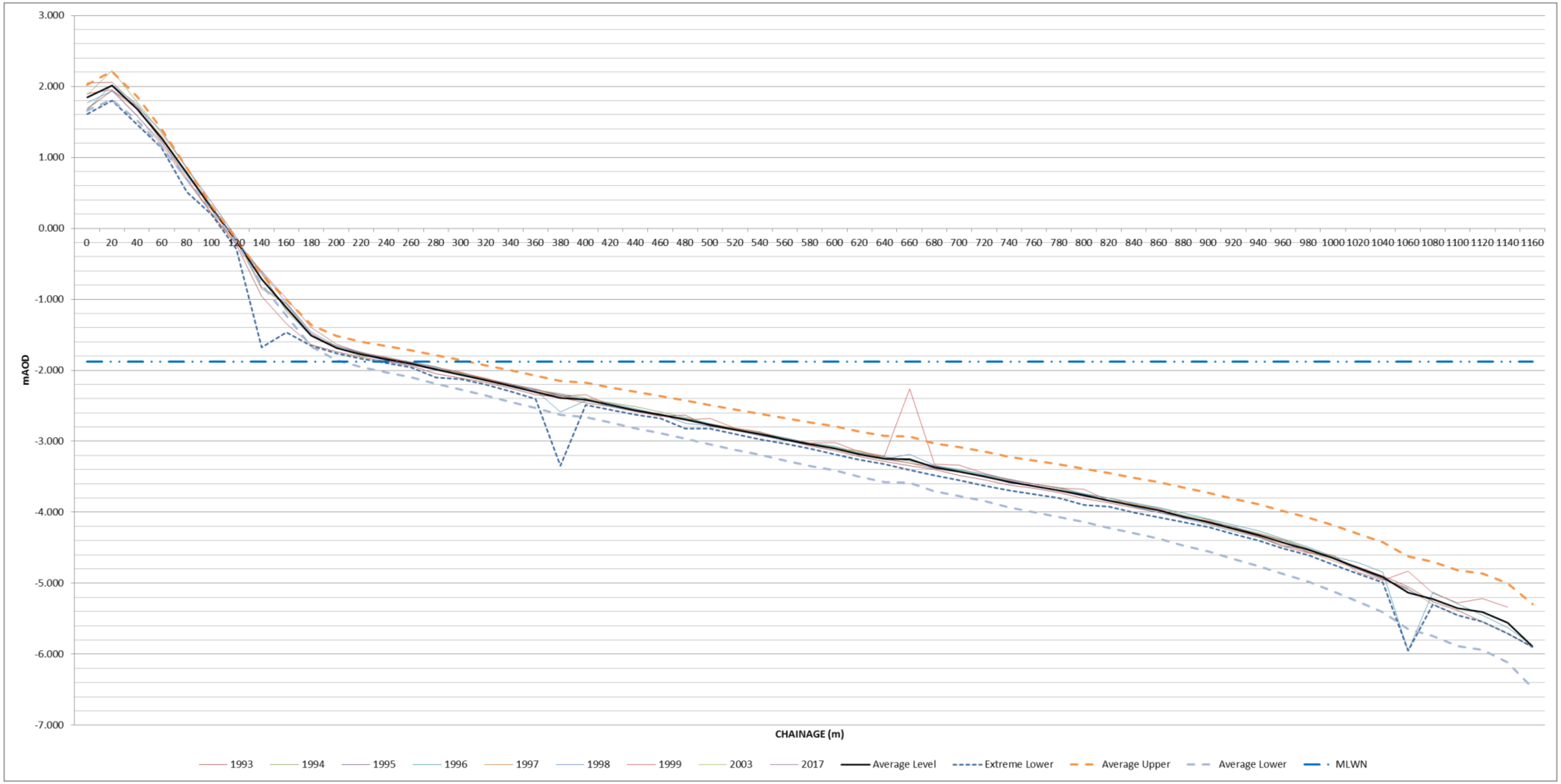


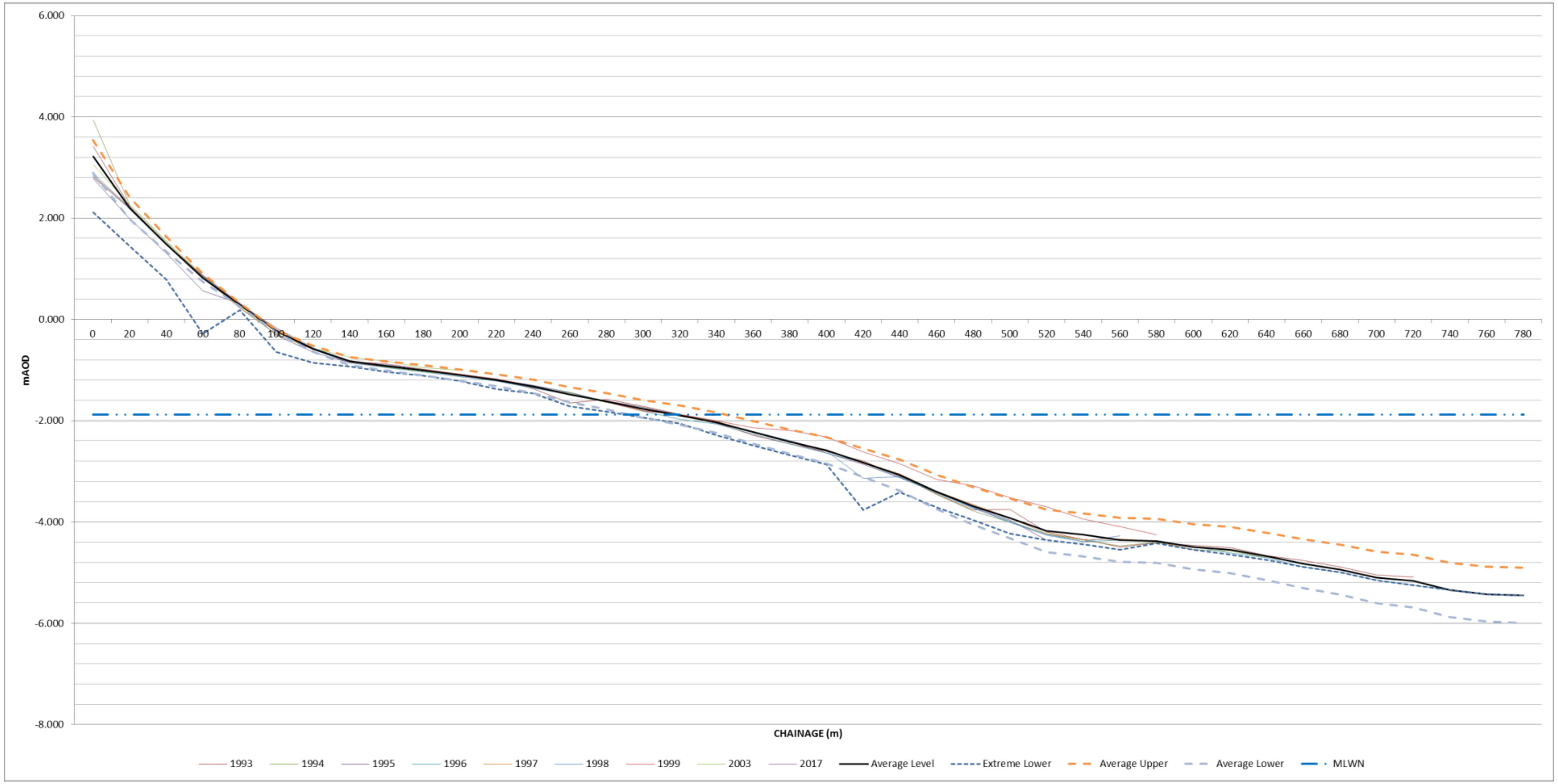
Figure I-62: Annual change of historic beach profiles, compared with extreme averages – HR15



I.2.2.2.5 St Helier

The results in Figure I-63 for St Helier indicate few portions of the profiles outside the average range.

Figure I-63: Annual change of historic beach profiles, compared with extreme averages – HR16



I.2.2.2.6 St Clement

The results for St Clement are shown in Figure I-64 to Figure I-69. Whilst there is a relative spread (less clustering) in profile lines for some locations, e.g. HR17 and HR21, most profiles are still within 10% of the average beach level. The extreme lower profile is represented by the 2017 DTM results, which is a common feature in the dataset.

Figure I-64: Annual change of historic beach profiles, compared with extreme averages – HR17

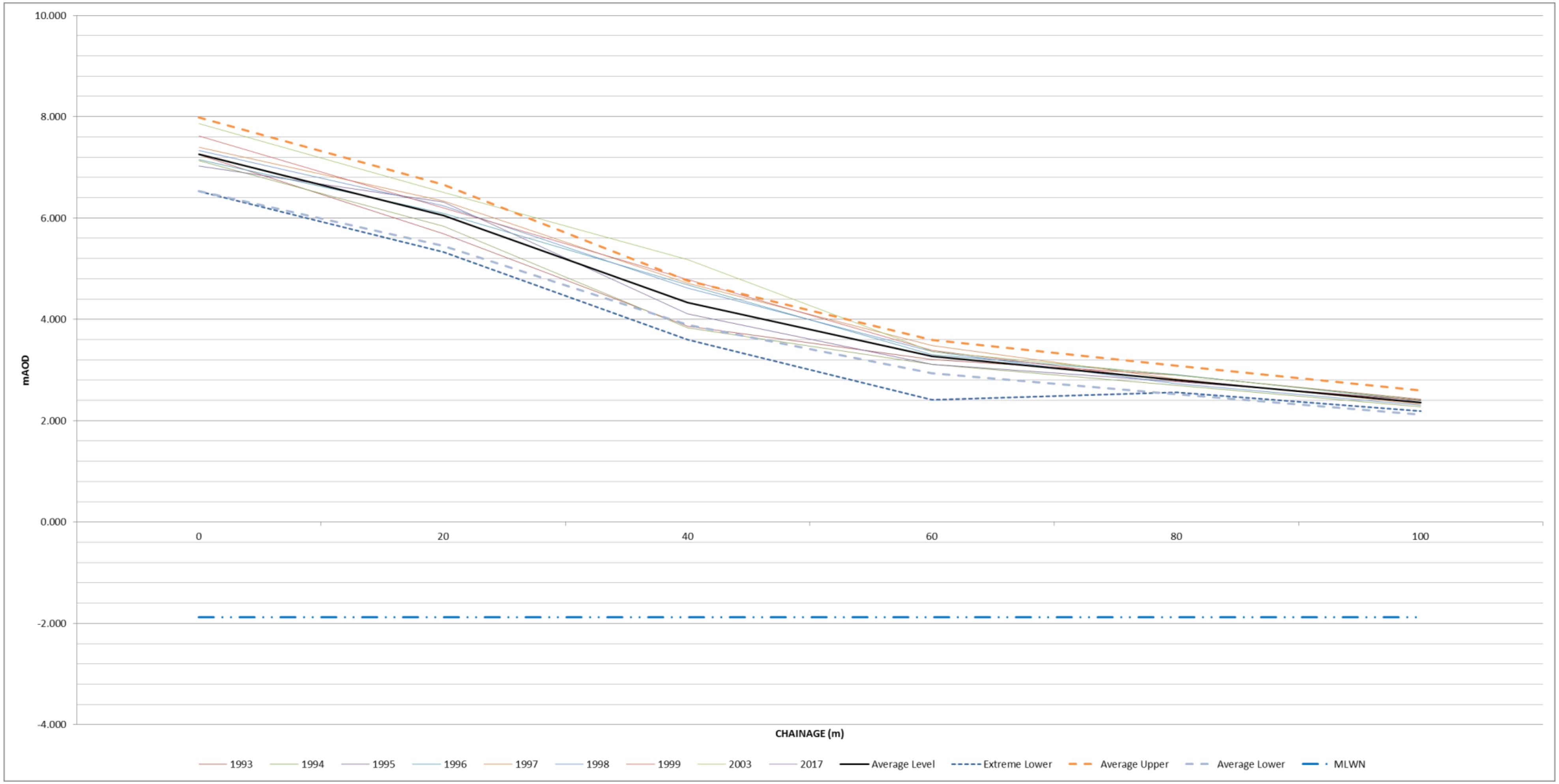


Figure I-65: Annual change of historic beach profiles, compared with extreme averages – HR18

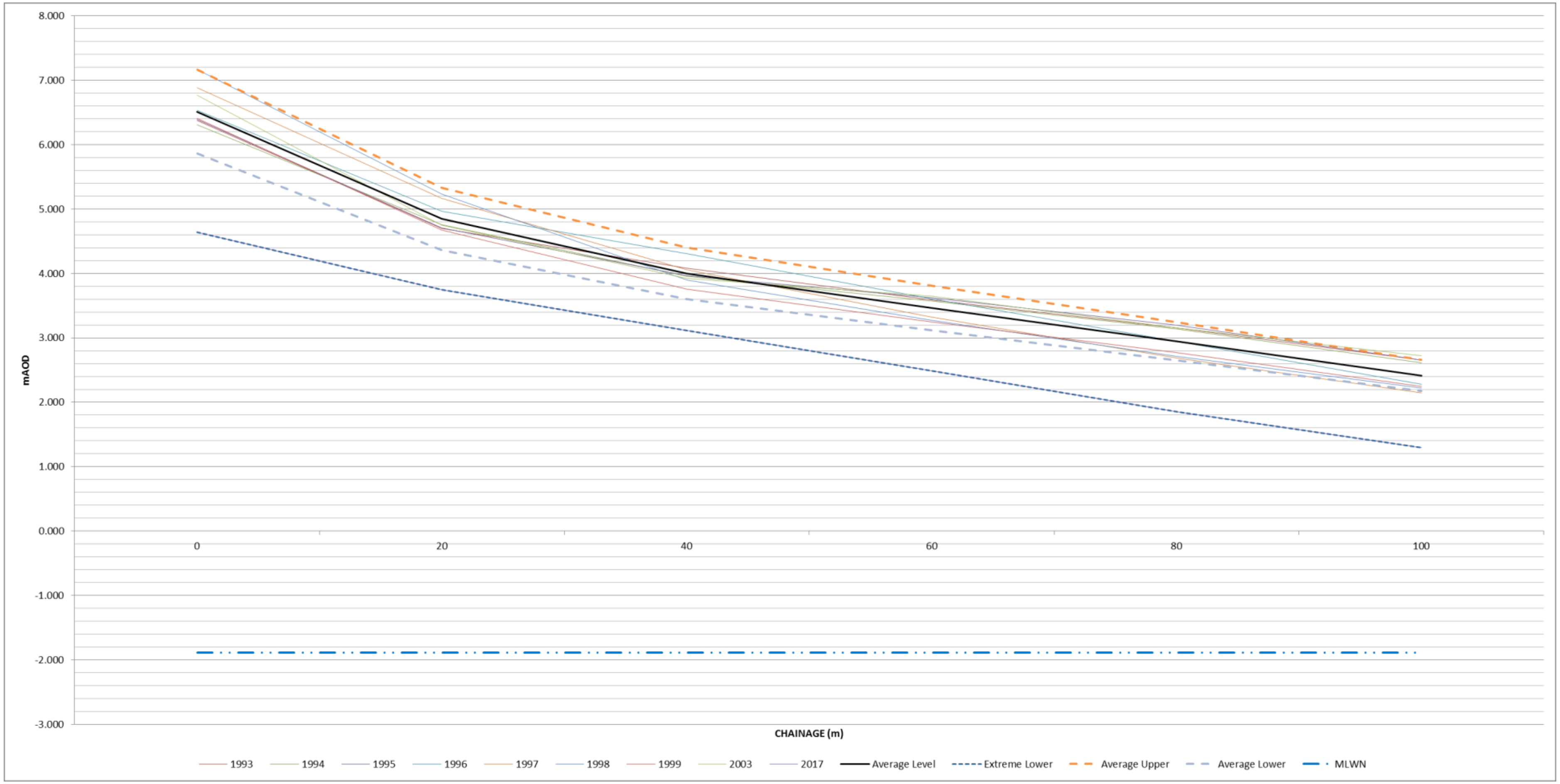


Figure I-66: Annual change of historic beach profiles, compared with extreme averages – HR19

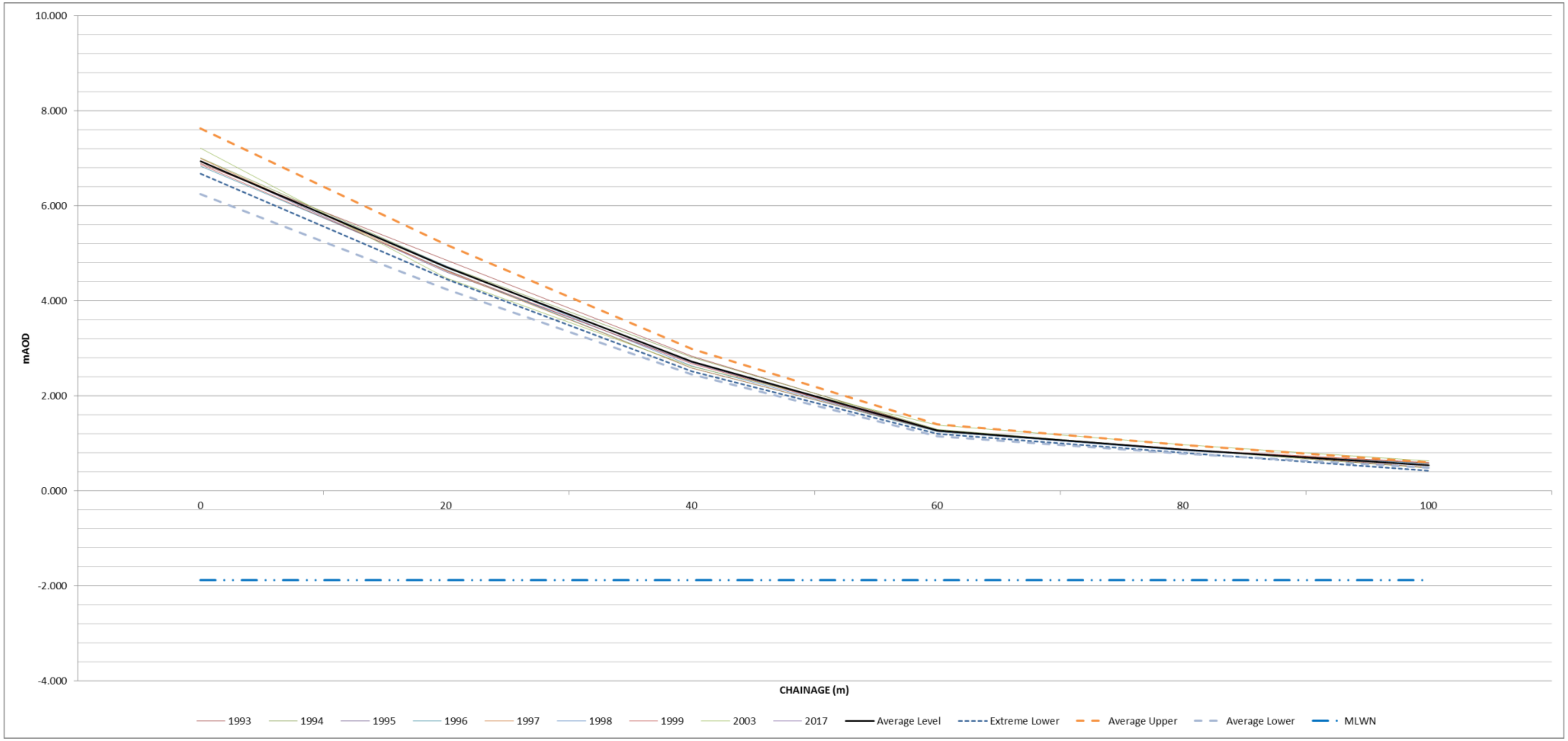


Figure I-67: Annual change of historic beach profiles, compared with extreme averages – HR20

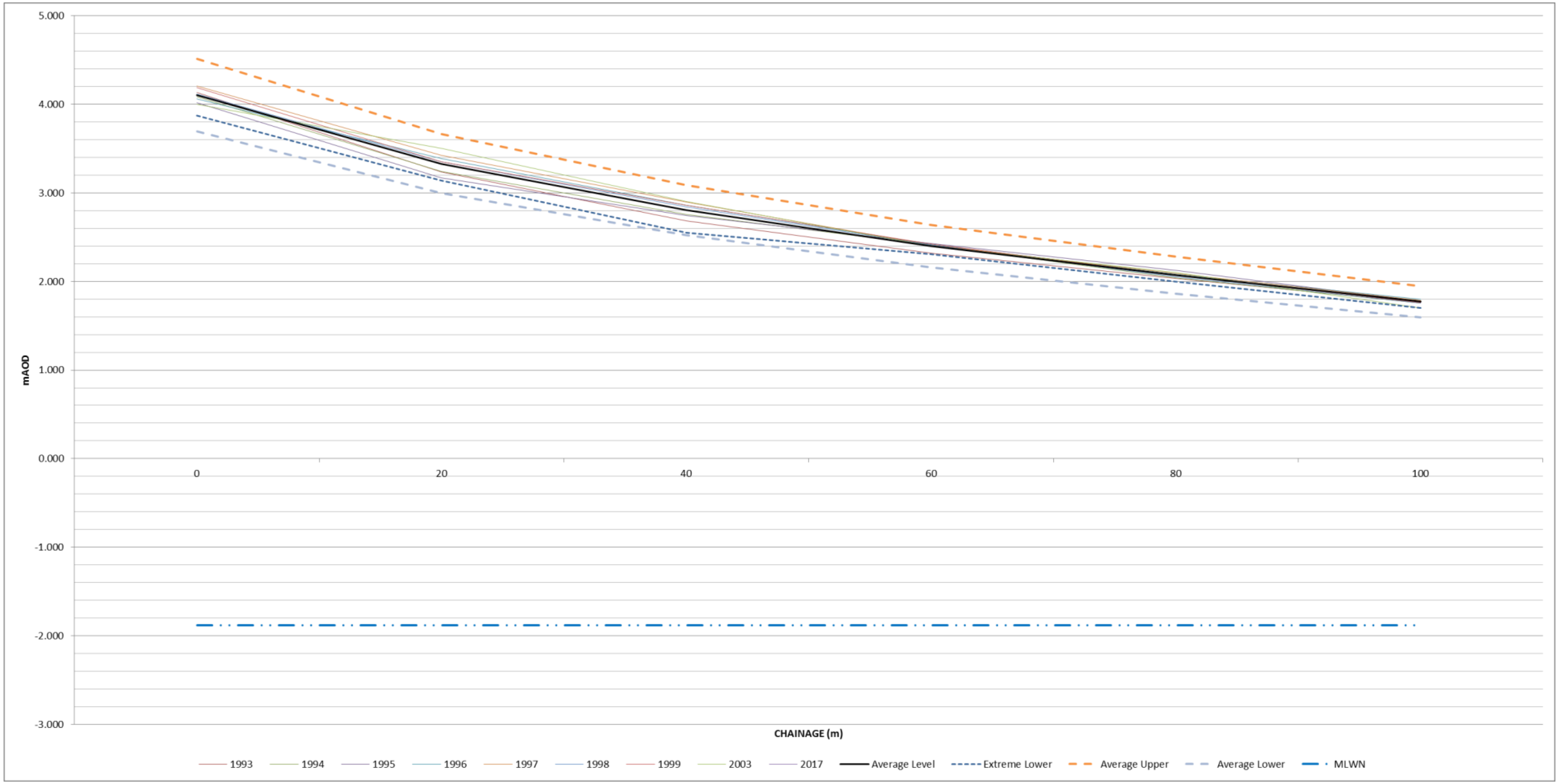


Figure I-68: Annual change of historic beach profiles, compared with extreme averages – HR21

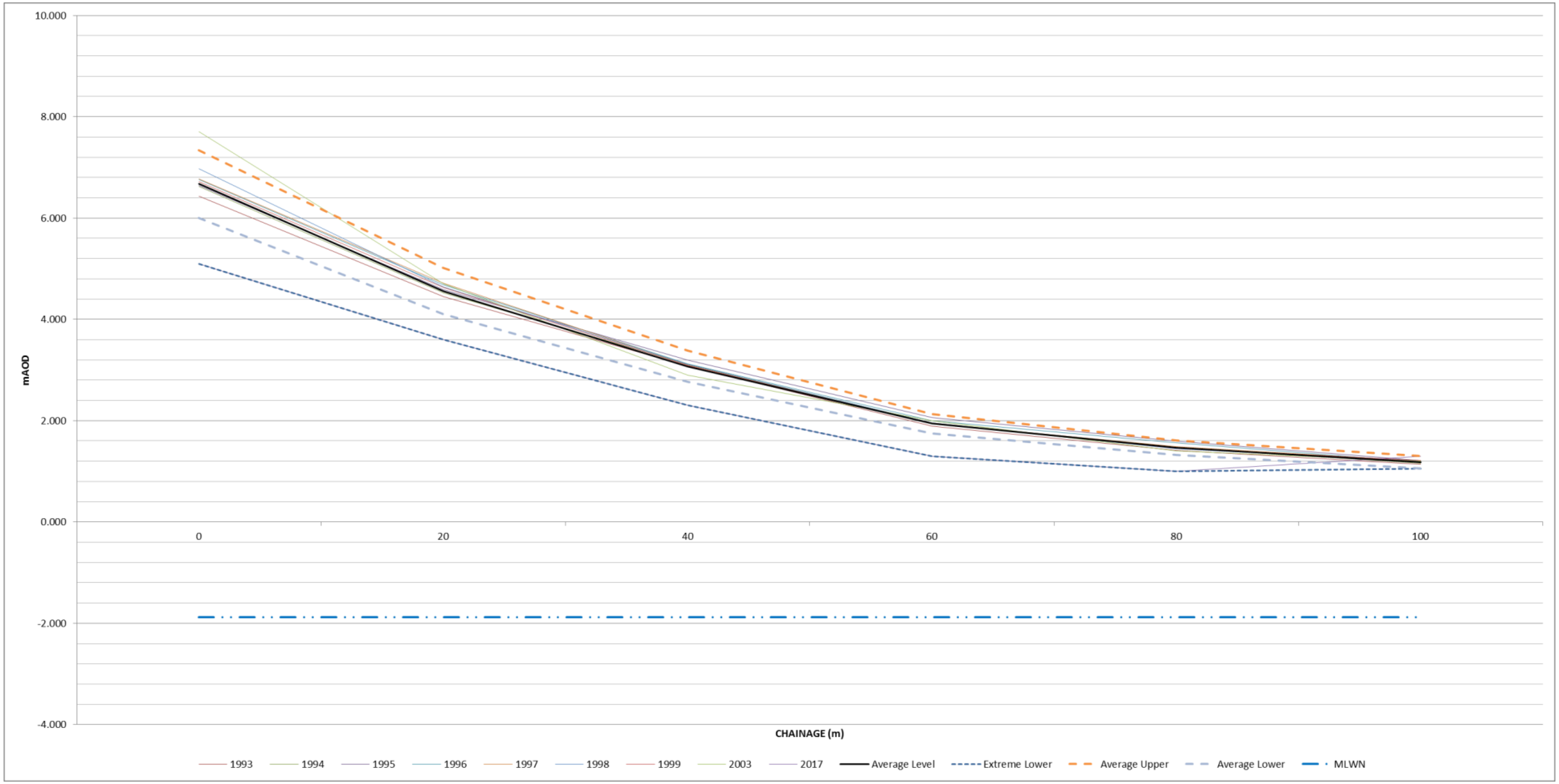
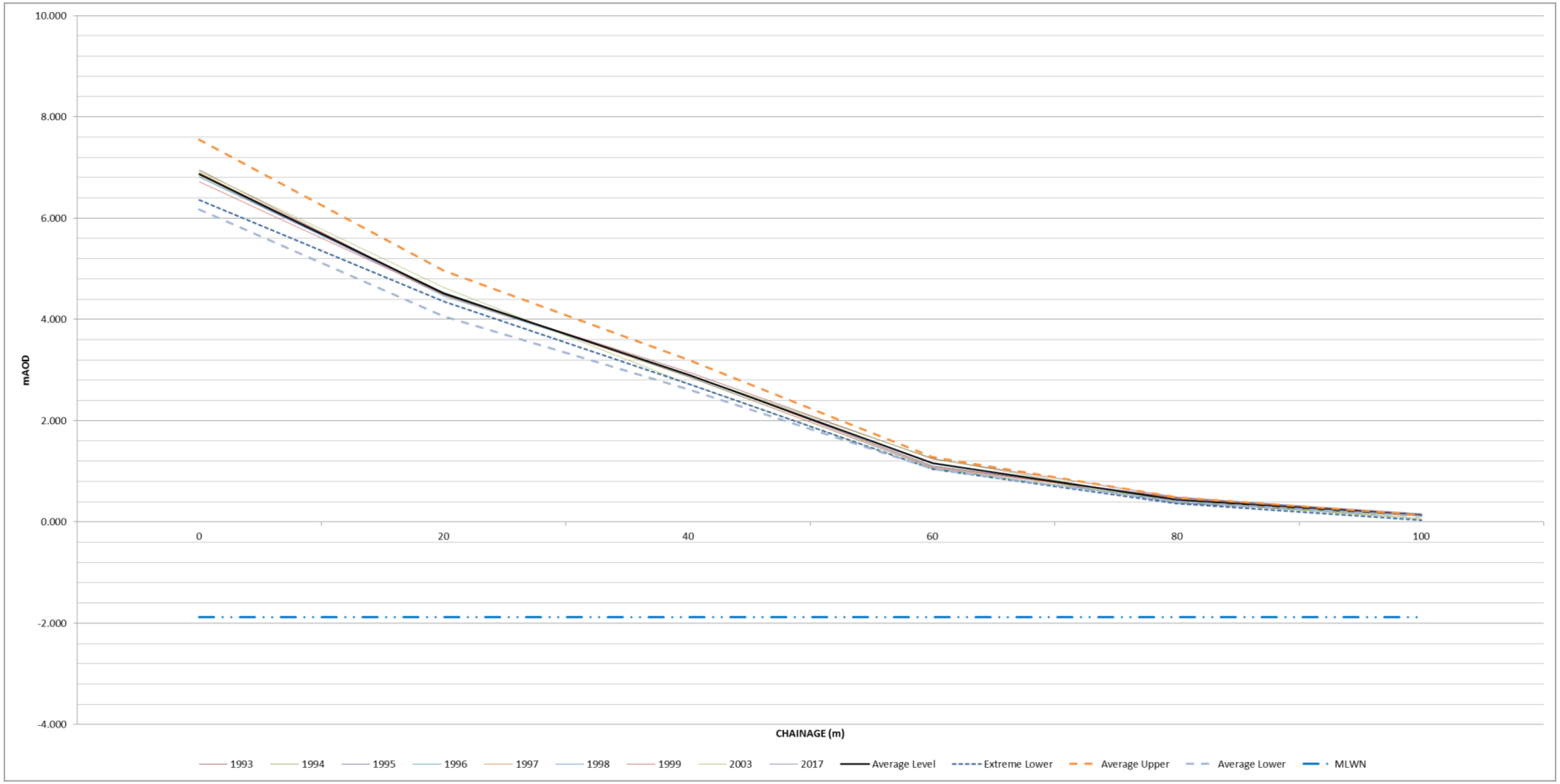


Figure I-69: Annual change of historic beach profiles, compared with extreme averages – HR22



I.2.2.3 Future Beach Elevation Change for each Epoch

AECOM used the results for the extreme changes (taking a conservative approach) and applied the duration of each epoch (20, 50 and 100 years), in order to predict potential levels of beach elevation change along the chainage of the profile for each epoch.

It should be noted that this is an indicative, coarse projection only based on past morphological behaviour; past behaviour of the beaches is not a certain indicator of future change because multiple factors will influence future change e.g. weather and sea conditions, human intervention, structural intervention etc.

The results are limited to the available data and there is a significant gap in the data record, between 2003, from the time of the last beach survey profiles were taken, to the creation of the DTM in 2017. The method for obtaining the beach elevation is also different in the case of the DTM.

The predicted changes for each profile in the different areas are shown in Table I-3 below and can be summarised as follows. It should be noted that these are elevation changes, either positive or negative; taking a conservative approach, these could be viewed as all negative i.e. lowering. This is justification, even in its own right to monitor the beach levels to observe the trends:

- Up to 2120 the average projected change is less than 5 m for all profiles. Although this sounds very considerable this equates to 5 cm per year.
- Most profiles, 15 out of 31, have projected changes of 1m or less i.e. 1 cm per year on average.
- There is a secondary group of profiles (11 no.), where projected change is 2 m or less (2 cm per year)
- Five profiles have projected changes of greater than 2 m but less than 5 m i.e. 2 – 5 cm per year.
- Three of the profiles projected to change greater than 2 m are in St Clement (HR17, HR18, HR21). With the exception of HR17, it is the 2017 beach levels that are influencing the projection, which reinforces the need to confirm the current status of the beaches. The other two are at St Ouen’s Bay (HR2 and HR4). Historic changes in HR4 are evident from the CSA (Section 2.2.3 below).
- The profiles showing between 2 and 5 m change are mostly at St Ouen’s Bay or Grouville. One of the profiles is in St Aubin’s Bay (HR12) and this has been considered in the CSA. For the St Ouen’s Bay profiles, only 1 out of the 2017 profiles (HR6) includes the 2017 DTM data i.e. they are based on more reliable on-site surveys. The PSD8 profile at Grouville has the greatest prediction for the Grouville profiles and its vulnerability has been reviewed as part of the CSA analysis.
- Profiles with less than 1 m projected change feature in all areas except for St Ouen’s Bay. Three out of the four profiles at St Aubin’s Bay feature in this banding, which reinforces the interpreted stability in this bay.

Table I-3: Average Levels of projected future beach elevation change at each Epoch

Potential Average Future Beach Elevation Change per Epoch (m)				
Beach	**Profile**	**2040**	**2070**	**2120**
Grouville	PSD1	0.248	0.619	1.238
	PSD2	0.142	0.356	0.711
	PSD3	0.271	0.678	1.356
	PSD4	0.112	0.279	0.558
	PSD5	0.134	0.334	0.669
	PSD6	0.136	0.339	0.678
	PSD7	0.190	0.475	0.950
	PSD8	0.360	0.899	1.798
	PSD9	0.286	0.715	1.430
St Ouen’s Bay	HR1	0.260	0.650	1.300
	HR2	0.735	1.838	3.675
	HR3	0.343	0.859	1.717
	HR4	0.428	1.069	2.138
	HR5	0.359	0.898	1.797
	HR6	0.390	0.975	1.950
	HR7	0.373	0.932	1.864
St Brelade’s Bay	HR8	0.174	0.435	0.871
	HR9	0.113	0.281	0.563
	HR10	0.175	0.439	0.877
	HR11	0.395	0.987	1.975
St Aubin’s Bay	HR12	0.257	0.642	1.284
	HR13	0.186	0.464	0.929
	HR14	0.148	0.371	0.742
	HR15	0.111	0.278	0.557
St Helier	HR16	0.197	0.493	0.986
St Clement	HR17	0.442	1.106	2.211
	HR18	0.903	2.259	4.517
	HR19	0.126	0.316	0.632
	HR20	0.117	0.292	0.585
	HR21	0.581	1.452	2.904
	HR22	0.146	0.364	0.728

I.2.2.4 Potential Implications for Overtopping from the Future Change Projections

The projected changes for 2040 that were considered, conservatively, as beach lowering in the overtopping analysis sensitivity run, produced the following results for the in three priority locations for maximum overtopping rate (Table I-4). The three beach profiles of interest for the priority locations are projected to have relatively low change by 2120 (all <1.3 m) by 2120.

Table I-4: Results of overtopping sensitivity from beach lowering

Priority Location	Relevant Beach Profile	Lowering to 2040 (m)	% Change in Overtopping Discharge
Priority Region 2 (St Aubin's Bay – "Le St Aubin's Bay, First Tower to West Park")	HR15	-0.15	+10
Priority Region 3 (St Aubin's Bay – "St Aubin's Bay, St Aubin's Harbour to Gunsite Slip")	HR12	-0.30	+10
Priority Region 4 (St Clement – "Bay of Fountains, Le Nez Point to Le Hocq Point")	HR19	-0.15	+5

The wave overtopping rates are shown to increase by approximately 10% in Region 2 and Region 3, whilst increasing to 5% in Region 4 on average. The beach at HR15 is lower in elevation (approximately 2 m AOD) compared to HR12 (around 5-6 m AOD) and this influences the predicted change in overtopping discharge. Owing to overtopping predicted to occur by 2040 and flooding reported in nearby Gunsite, the findings confirm the need to monitor the beach profiles in St Aubin's Bay, despite the relative stability found in the historic profiles.

I.2.2.5 Cross sectional Area of Annual Average

I.2.2.5.1 Grouville (PSD4 and PSD8)

There are two selected beach profiles at Grouville (PSD4 (Figure I-70) and PSD8 (Figure I-71)). PSD4 showed negligible net change in CSA between 1992 and 1999. A relatively small amount of overtopping discharge is projected for 2040, which means beach levels should be monitored in this location. PSD8 profile shows a lowering trend for data years 1992-1999, dropping by around 10%. As for PSD4, overtopping is projected to occur by 2040 and still water flooding occurs in 2120. This profile should also be monitored in the future.

Figure I-70: Cross sectional Area of Annual Average Profiles – PSD4

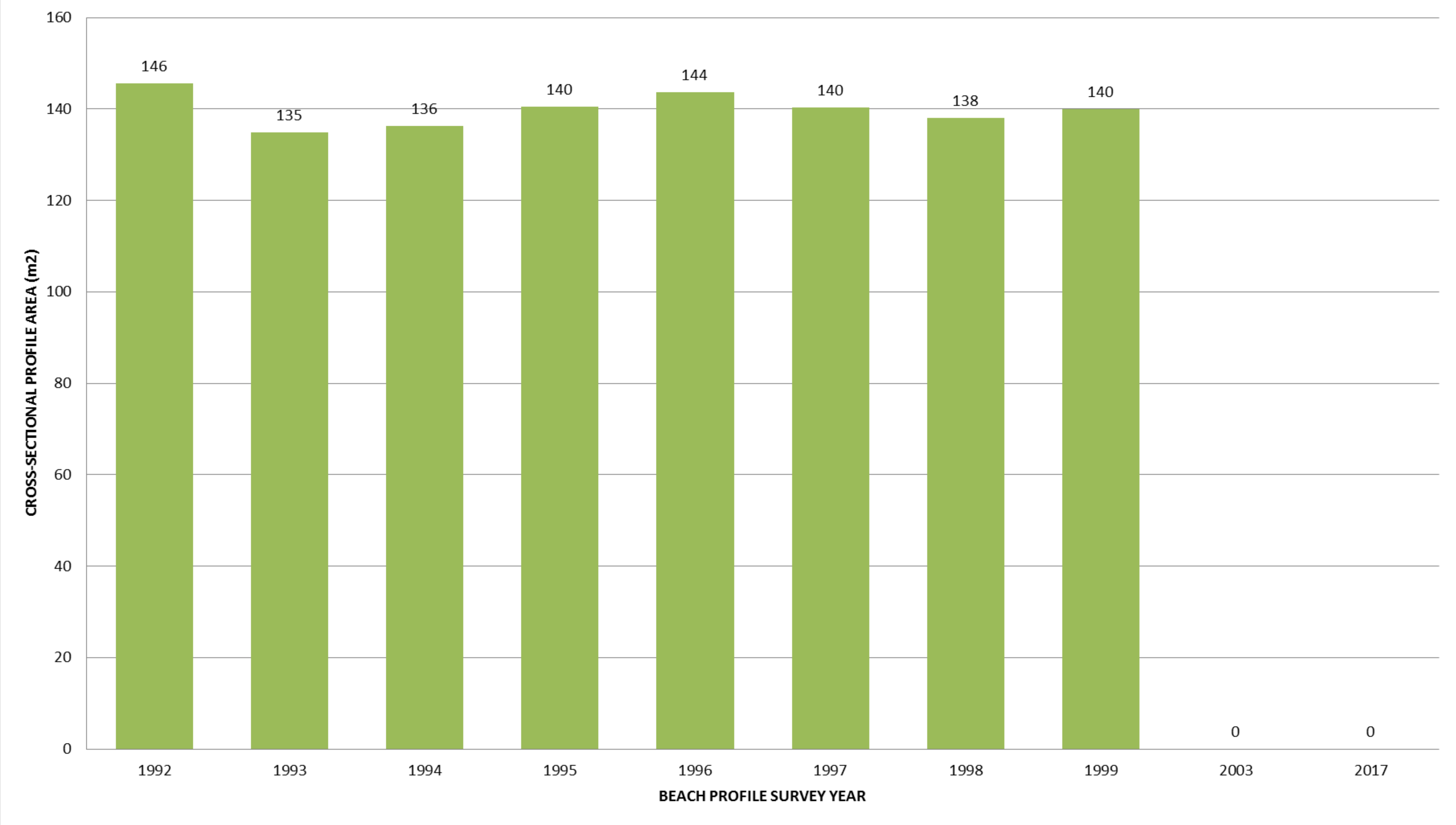
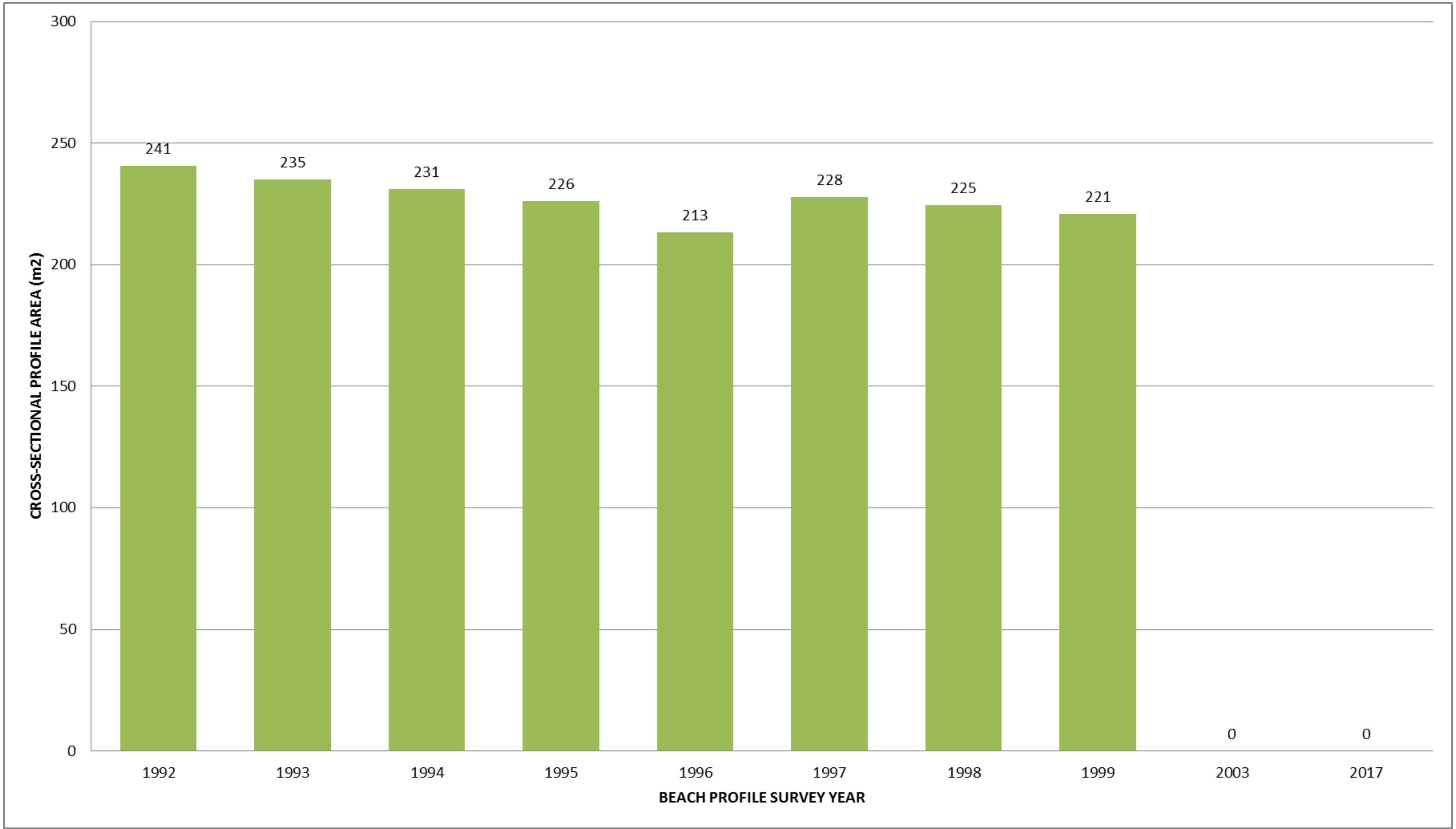


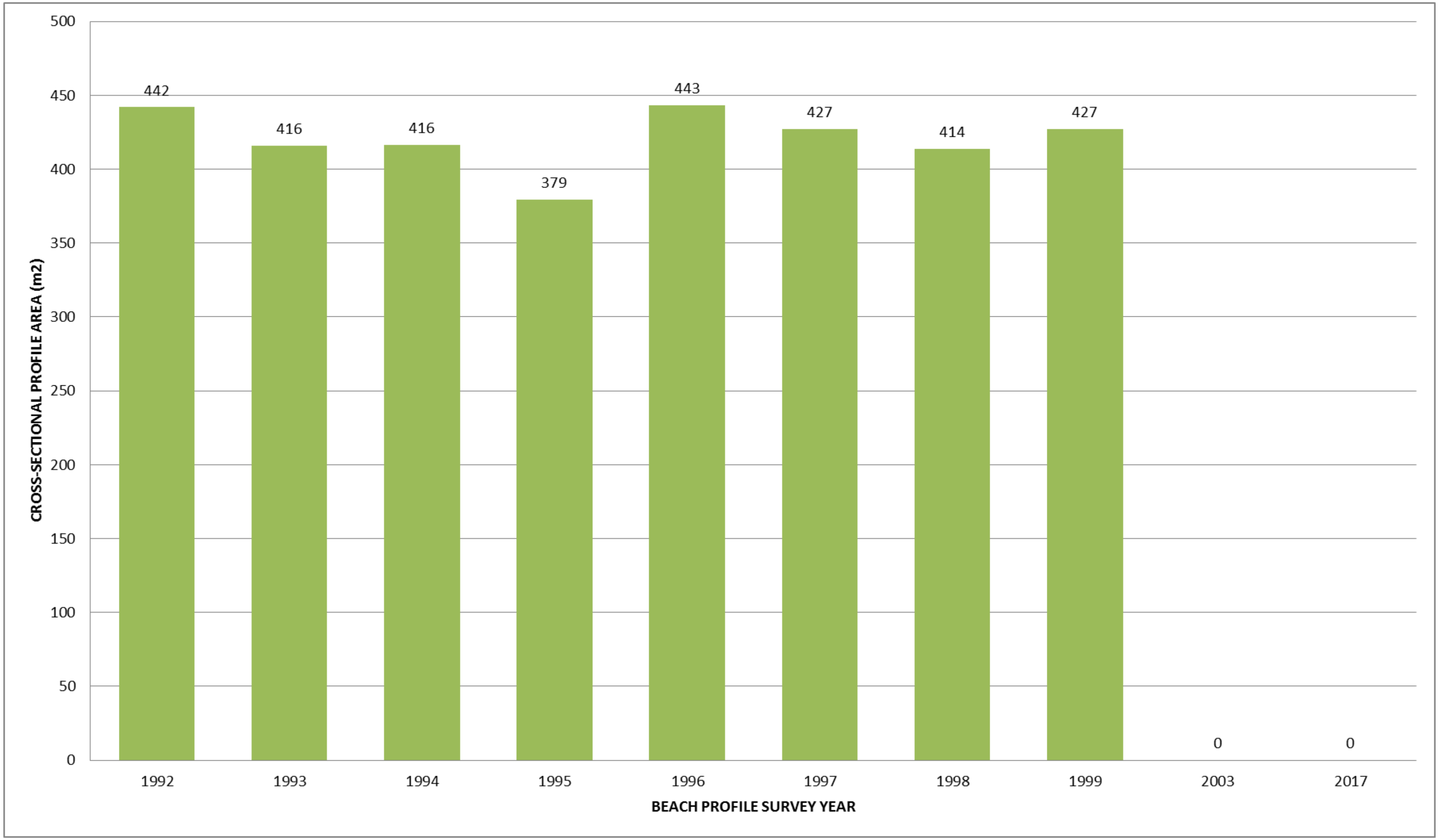
Figure I-71: Cross sectional Area of Annual Average Profiles – PSD8



I.2.2.5.2 St Ouen’s Bay

At St Ouen’s Bay, HR4 is approximately opposite The National Trust for Jersey Wetland Centre; overtopping is predicted to occur in this location by 2040, resulting in relatively small flood extents. There was little change in CSA between 1992 and 1999 (Figure I-72). However, interannual changes can be seen with a reduction between 1992 and 1995 followed by accretion in 1996 and several years of lowering again. There may be some movement and circulation of sediment in St Ouen’s Bay between different beach compartments over time. This profile and others in St Ouen’s Bay should be monitored in the future.

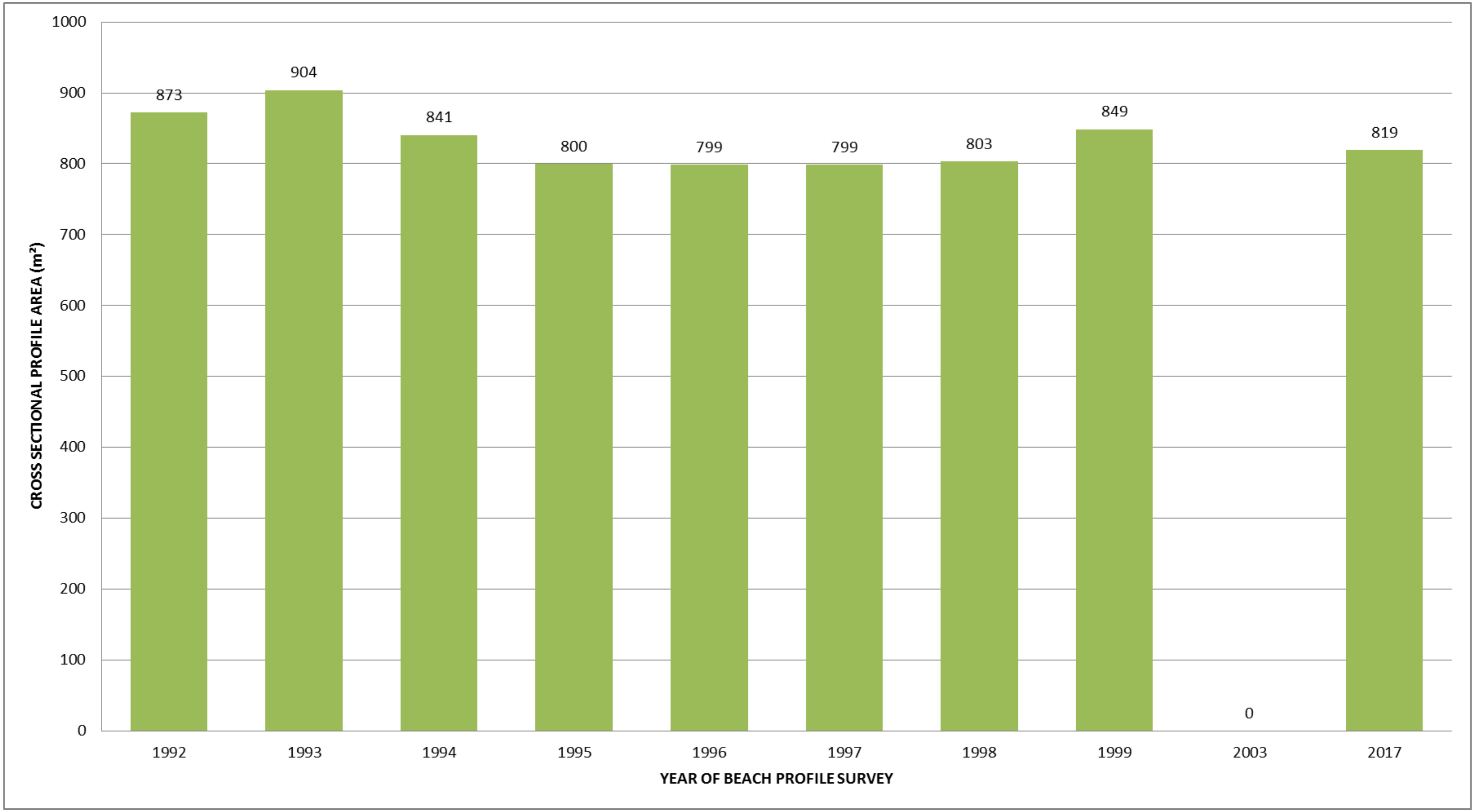
Figure I-72: Cross sectional Area of Annual Average Profiles – HR4



I.2.2.5.3 St Aubin's Bay

HR12 profile, is the nearest profile to Priority Area 3 and shows relatively little change over the beach survey years, from 1992-1999. The CSA in 2017 is very similar to 1999, which would indicate that this part of the bay is relatively stable (Figure I-73). However, owing to the overtopping and still water level projections at nearby Gunsite, it will be important to monitor beach levels are steady in the future under sea level rise.

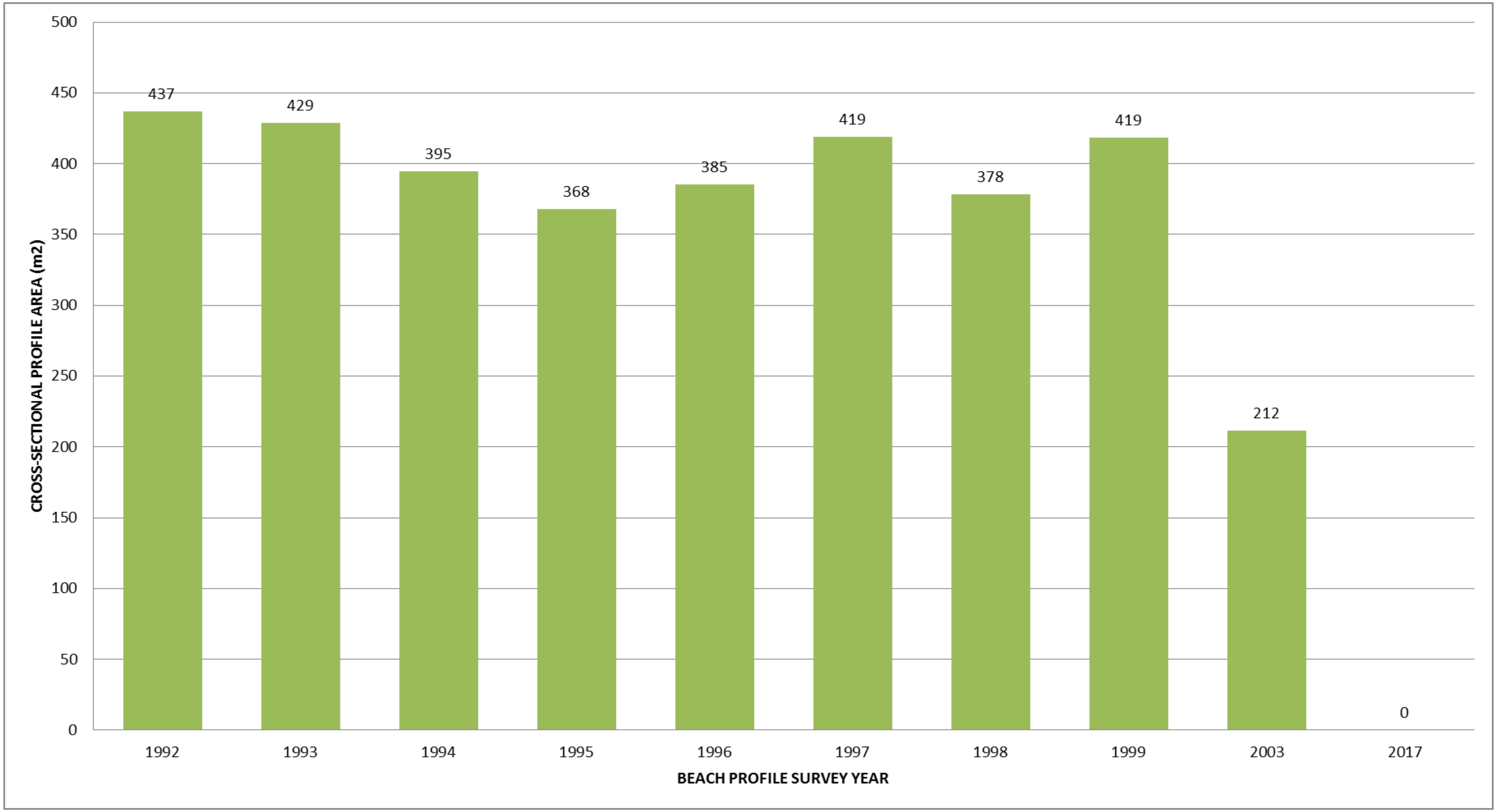
Figure I-73: Cross sectional Area of Annual Average Profiles – HR12



I.2.2.5.4 St Helier

The profile HR16 at St Helier showed a significant reduction in beach level between 1992 and 2003, amounting to approximately 50% reduction in CSA (Figure I-74). The profile is located at Havre de Pas, which is Priority Area 1 for the SMP and the beach analysis would appear to confirm why it is a priority location. The lowering in the beach may have contributed to overtopping episodes in this location in the past and this clearly needs to be monitored in the future.

Figure I-74: Cross sectional Area of Annual Average Profiles – HR16



I.2.2.5.5 Le Squez

At Le Squez, profiles HR17 (Figure I-75) and HR18 (Figure I-76) are of interest. HR17 displays an accretionary trend with the CSA increasing by approximately 12% between 1992 and 2003. The beach should be monitored to confirm its current status and how this may influence flooding projections, since overtopping and still water level flooding is predicted to occur in the future. HR18 has steady beach levels between 1992 and 2003. However, the DTM results suggest the beach lowered significantly by 2017, reducing by around 30%; this could be reasonable based on the predicted overtopping in the area for 2020. Monitoring is therefore recommended in the future.

Figure I-75: Cross sectional Area of Annual Average Profiles – HR17

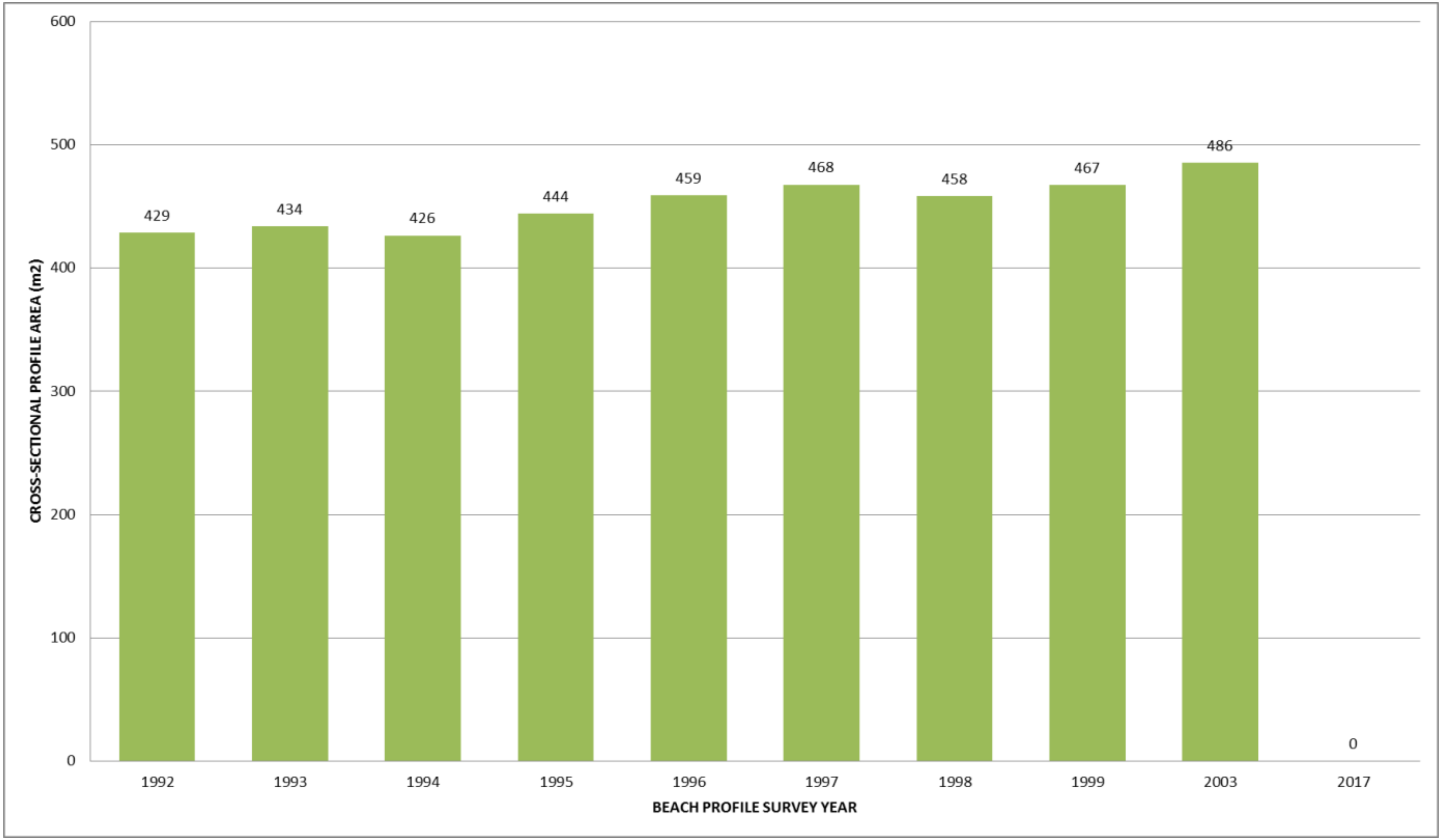
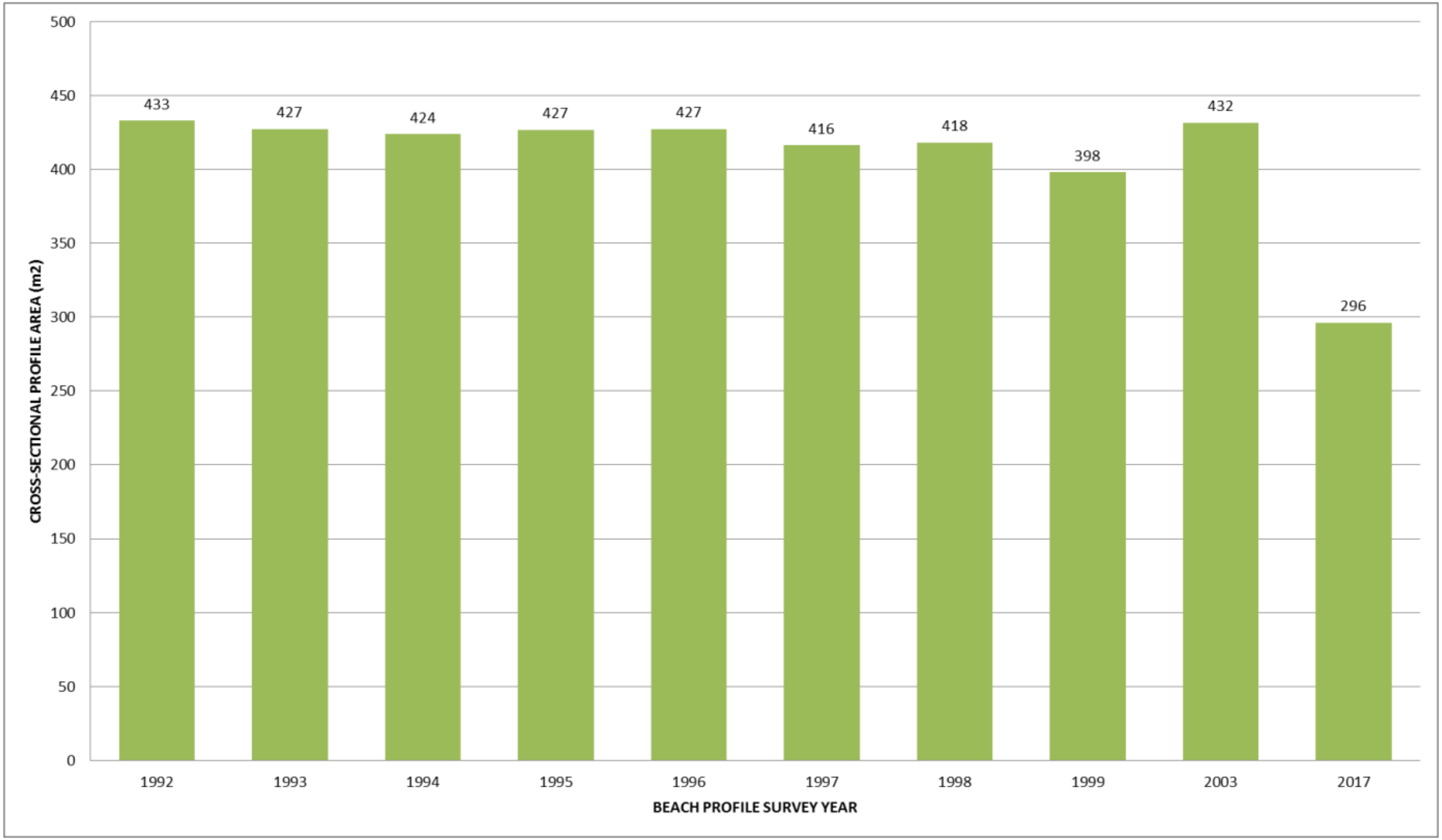


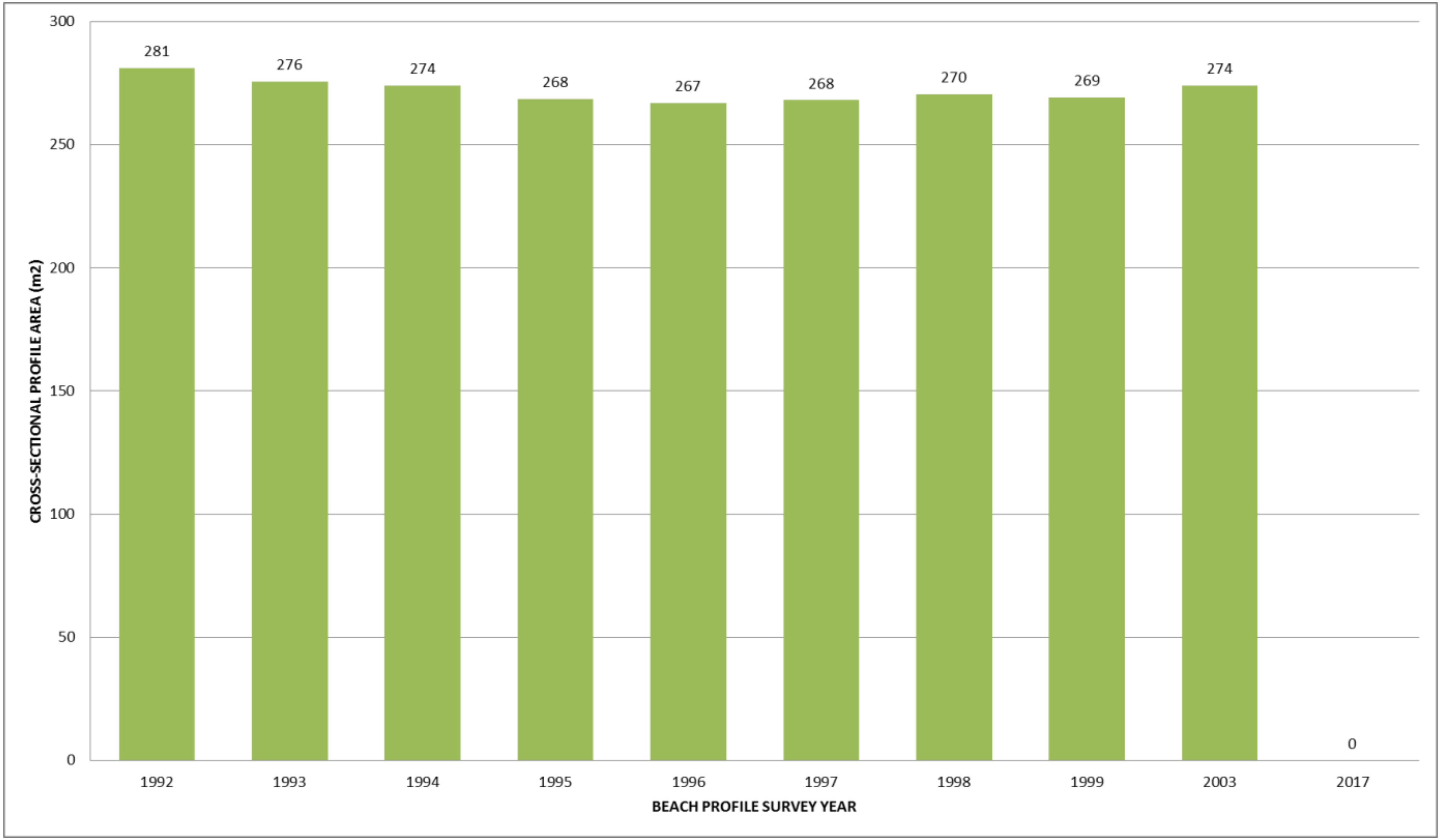
Figure I-76: Cross sectional Area of Annual Average Profiles – HR18



I.2.2.5.6 St Clement

Profile HR19 is located at St Clement and shows negligible change in beach level between 1992 and 2003 (Figure I-77). This is a Priority Area (No.4) for GoJ with small amounts of overtopping predicted by 2040 and still water levels are greater than the current crest level but the ground in the lee of the defences is raised, which should prevent flooding. Clearly, this area should be monitored in order to check these projections do not change significantly in the future.

Figure I-77: Cross sectional Area of Annual Average Profiles – HR19



I.2.2.6 Beach Volumes based on 2017 DTM

The results of the beach volumetric exercise on the DTM are presented in Table I-5 below. Beach volumes vary around the island, but purely a simple comparison between areas has been avoided because beach volume is dependent on the length of the corresponding beach profile and elevation. Some profiles are also very short and do not intersect with the MLWN contour. Interrogation of the volumes raises the following observations with respect to the profiles selected for CSA, which are italicised in the table:

- PSD4 (Grouville) – relatively small beach volume (less than 2.5m AOD elevation); this could be a factor in overtopping projections.
- PSD8 (Grouville) – relatively small beach volume but significant elevation (around 6 m AOD elevation)
- HR4 (St Ouen's Bay) – This profile has the smallest volume of all St Ouen's Bay profiles based on the 2017 data, but it is not proportionately shorter than HR1, HR2 and HR7 profiles, which have significantly larger volumes (up to a factor of 2). This helps explain why overtopping has been reported in the centre of the bay.
- HR12 (St Aubin's' Bay) – largest volume of all profiles. Therefore, structure form, crest levels and beach slope all contribute to projected overtopping.
- HR16 (St Helier) – average beach volume and elevations; this is only one factor in overtopping (historic and future projections) i.e. structure form, crest levels and beach slope.
- HR17 (Le Squez) – beach elevation is relatively high (over 7m) and average volume. This combined with structure form, crest level and beach slope are relevant factors in overtopping projections.
- HR18 (Le Squez (La Mare)) – relatively large volume with relatively high beach elevations (5m AOD). This suggests structure crest level and beach slope is more relevant factor in overtopping projections, where overtopping is projected to occur close by.
- HR19 (St Clement) – average beach volumes and relatively high elevations (7m AOD), which means that crest level and beach slope are contributory factors in overtopping and still water level projections.

Table I-5: 2017 Beach Volume Estimates based on DTM

Beach	Profile	Cross sectional Area m^2	Volume m^3
Grouville	PSD1	215	90,000
	PSD2	214	59,000
	PSD3	356	115,000
	PSD4	260	70,000
	PSD5	172	42,000
	PSD6	109	31,000
	PSD7	160	63,000
	PSD8	108	64,000
	PSD9	71	133,000
St Ouen's Bay	HR1	489	537,600
	HR2	487	613,700
	HR3	461	360,000
	HR4	354	247,000
	HR5	426	324,000
	HR6	440	463,000
	HR7	425	553,700
St Brelade's Bay	HR8	502	287,000
	HR9	520	288,000
	HR10	611	234,000
	HR11	643	236,000
St Aubin's Bay	HR12	819	1,207,600
	HR13	614	751,500
	HR14	535	654,200
	HR15	439	549,000
St Helier	HR16	295	340,000
St Clement	HR17	224	274,000
	HR18	296	480,000
	HR19	286	317,000
	HR20	322	333,000
	HR21	241	151,000
	HR22	191	108,900

I.2.3 Summary Conclusions

A review of historic beach profiles has been undertaken to assess historic changes in beach level. The historic profiles range from 1992-1999 and 2003. In most years, quarterly surveys were completed on a total of 31 beaches. The traditional surveys have been supplemented by considering beach levels obtained from an island wide DTM in 2017 in order to obtain a more recent snapshot of beach 'health' i.e. if levels have dropped since the historic surveys.

The key findings from the data are summarised as follows:

- Whilst sometimes displaying switches between erosionary and accretionary behaviour between profile years, most beaches are stable for the period 1992-2003 with profiles typically varying in elevation by 10% or less. 'Extreme' profiles and portions of profiles, i.e. exceeding 10% change are limited. In some instances, it is the 2017 DTM data that reports the most significant change.
- Results from the 2017 DTM suggest that the beach elevations may have dropped since the time of the traditional surveys from 1992-2003. However, the DTM data acquisition technique is less accurate than the traditional beach surveys and thus an element of the beach drop could be attributed to the varying techniques. A recommendation for the SMP Action Plan is that beach profile acquisition is reinstated to confirm current beach health i.e. whether beaches have lowered or not. This is important to understand the implications for coastal processes, mainly overtopping, and structural integrity, in case erosion in the upper part of the beach begins to undermine defence foundations.
- There is negligible evidence of changes in beach plan shape, which also suggests that beaches are relatively stable.
- Historic rates of elevation change (which could be increased levels resulting in accretion or lower levels from erosion) and accounting for extreme changes, equates to a range of between 1 to 5 cm per year.
- The historic rate has been projected into the future to consider the potential change for each epoch of the SMP, based on a continuation of historic / existing beach conditions. In doing this, most beaches analysed are projected to change by 1 m or less. Only a handful of profiles (5 from 31 profiles), located in St Clement and St Ouen's Bay are projected to change by up to 5 m by 2120.
- Whilst the 'extrapolation' method is limited in assessing future change, because of the lack of historic evidence of eroding beaches and the available data, it is considered that this is an appropriate methodology for the SMP to inform planning policy development. Beach monitoring is recommended in the future on an annual or biannual basis to confirm beach health and the validity of projections.
- Cross-sectional analysis of beach profiles in key areas (those that are projected to experience overtopping / an increase in overtopping) confirm that most are stable. A single profile in Grouville shows evidence of an erosionary trend that should be monitored; similarly, HR16 profile in St Helier suggests erosion is occurring and it is recommended that this is investigated.
- The position of beach profiles analysed in this study do not necessarily correspond to the defence section profile used in the overtopping analysis i.e. the nearest beach profile has been taken. When considering the effect of the beach on overtopping, other factors may be contributing to the projected overtopping, for example, beach slope, structural form and crest level. The analysis has revealed that historic evidence of overtopping and projected overtopping, although modest, at St Ouen's Bay, is possible based on HR4 beach profile volume. Beach volume analysis confirms the stability of the beach in St Aubin's Bay.
- It is recommended that beach profile analysis is undertaken via traditional beach surveying techniques (compared to use of a DTM approach) in order to provide contemporary commentary on beach levels, cross sectional areas and volumes. This should be achieved in a clear, easily repeatable manner to permit seasonal and inter year surveys to be completed and provide a constant record of beach health. Planned data acquisition should also be supplemented by responsive site measurements in the event of storm damage causing significant beach lowering; this is essential to monitor structural integrity.

I.3 References

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