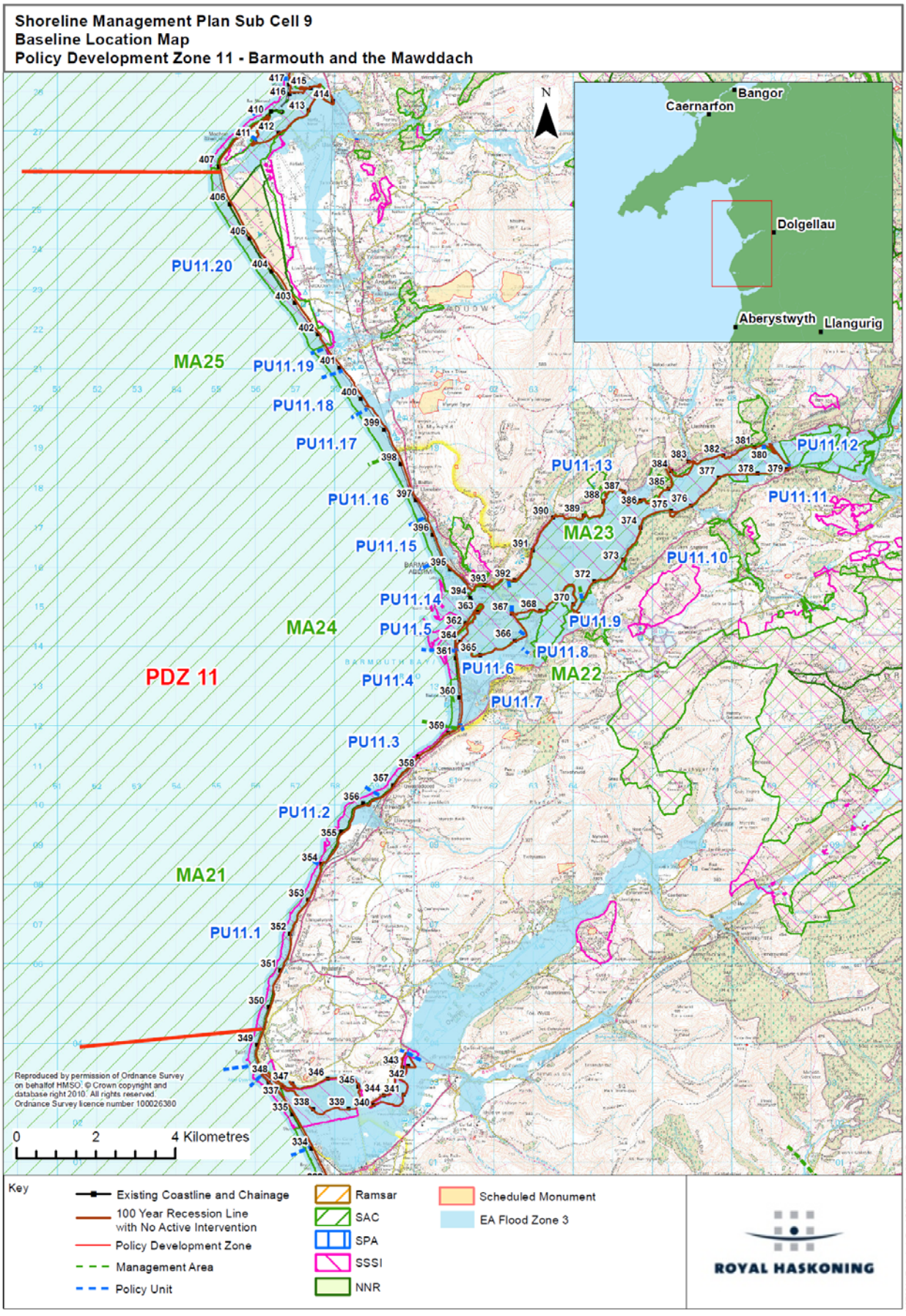
PDZ11. BARMOUTH AND THE MAWDDACH:

Abermaw/Barmouth

Tonfanau to Traeth Dyffryn

CONTENTS


Shoreline Management Plan Sub Cell 9
Baseline Location Map
Policy Development Zone 11 - Barmouth and the Mawddach
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Definitions of Scenarios Considered in Policy Development

This section defines the various scenarios that are used throughout the discussion of the Policy Development Zone.

Sea Level Rise
It is recognised that there is a continuing uncertainty with respect to Sea Level Rise (SLR). Taking different SLR scenarios may affect the scale of impact or the timing of some changes, either in terms of sustainable management or in terms of impacts. In the discussion below of the baseline and alternative management scenarios, the Defra guidance on SLR has been generally been used. Where, in any specific area, the impact of SLR is felt to be significant and may change the context of management this discussion is held within a separate box, relevant to that section of text.

Management scenarios;

Unconstrained Scenario
Under this scenario, the behaviour of the coast is considered as if there were no man made defences, effectively if they were suddenly not there. Although recognised to be a totally theoretical scenario it does provide a better understanding of how we are influencing the coastal behaviour and therefore the stresses and broader scale impact that are introduced. This assists in assessing first how the coast might wish to change, but also in defining the limits of interaction which the SMP should be considering.

Baseline Scenarios

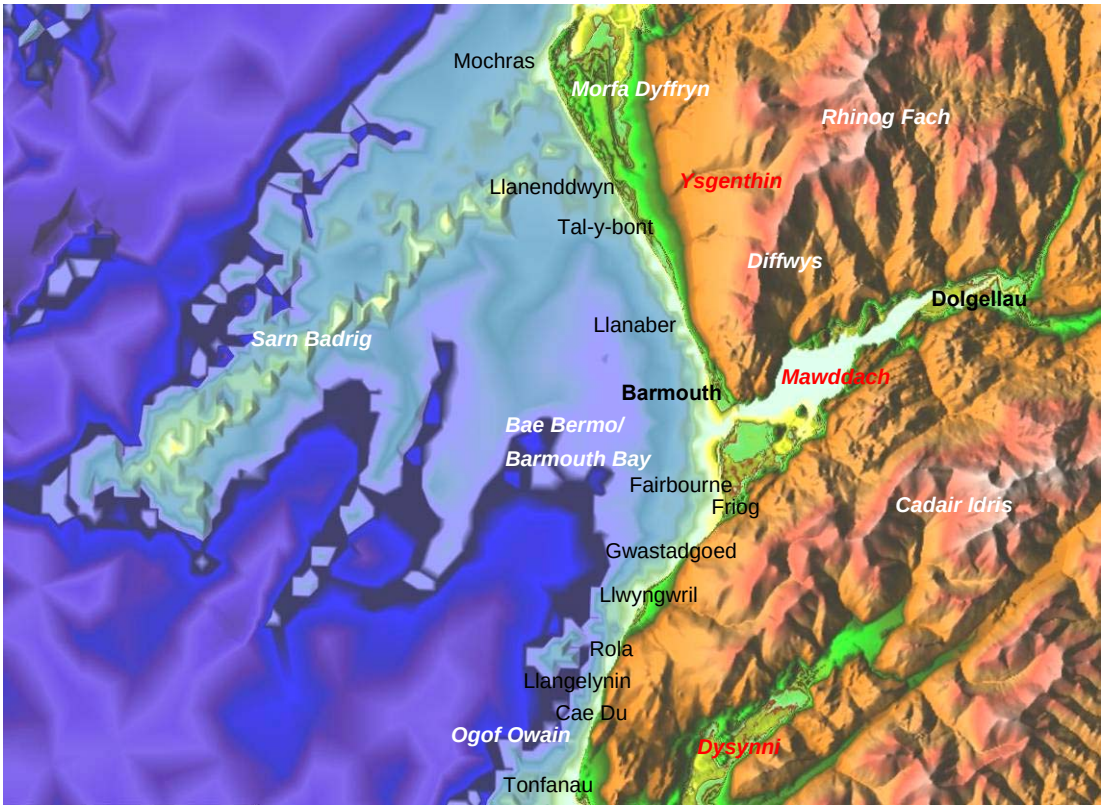
- ***No Active Intervention (NAI) – Scenario 1****, where* there would be no further work to maintain or replace defences. At the end of their residual life, structures would fail. There would be no raising of defences to improve standards of protection.
- ***With Present Management (WPM)– Scenario* 2**. This scenario applies the policies set in the SMP1 or, where relevant, takes updated or clarified policies, if subsequent work has been undertaken e.g. studies or strategies. In many locations, the approach to management defined by SMP1 only covers a 50 year period. Where this is so, the intent of how the coast is being managed has been assumed to apply into the future. It should be noted that WPM does not necessarily imply a Hold The Line approach throughout the zone, in many areas present management may be for a No Active Intervention approach or one of Managed Realignment.

The aim of the No Active Intervention is to identify what is at risk if defences were not maintained. In a similar way, With Present Management aims to examine how the coast may develop, identifying where there are benefits in this management approach or where there may be issues arising in the future.

At the end of this sub-section a brief summary and comparison of the economic risk for each of the baseline scenarios is provided, based on the MDSF analysis undertaken during the SMP (including other study findings where relevant). The baseline scenarios are also assessed in terms of how they address the overall objectives for the Zone. This comparison between the baseline scenarios sets the scene for discussing possible alternative management scenarios which better address all the issues. This discussion is provided in the subsequent sub-section.

1 Local Description

The zone is very much defined by the two mountainous ridges running through to the coast either side of Mawddach Estuary; the Cadair Idris ridge between the Dysynni and the Mawddach to the south forming the southern shoulder of the zone and the high mass of Diffwys and Rhinog Fach to the north, behind Barmouth and Morfa Dyffryn.



The whole of the area including much of the Mawddach, the southern cliff line and Morfa Dyffryn are included within the Pen Llyn a`r Sarnau/ **Llŷn Peninsula** and the Sarnau SAC.

The main railway runs close to the shoreline along the whole of the southern cliff line, running very close to the crest of the cliff particularly just north of Tonfanau through to the hard rock outcrop of Ogof Owain, to the south of Cae Du, just south of Llangelynnin and between Llangelynnin and Rola, north of Llwyngwril and then along the Friog Cliffs through to the Mawddach, where it runs behind Fairbourne, across the trestle bridge to Barmouth. The main road, connecting the villages of this southern shoreline, joins the coast behind the railway at Cae Du and runs behind the railway along steeply rising cliff line through to Friog, where it then runs set back from the southern shore of the Mawddach to Penmaenpool, to join the main A470 at Dolgellau.

The shoreline of this southern section comprises a hard well-compacted, boulder strewn lower foreshore, overlain with large areas of coarse sand and shingle. The upper beach and backshore varies between lengths of shingle upper beach to lengths of exposed clay cliff and hard rock outcrops. The harder rock and the level of the foreshore very much dictates the nature and level of the backshore, with the wider platform of lower lying glacial infill occupying the valley of the Afon Gwril to the south of Llwyngwril and forming the substantial shingle fronted promontory on the shoreline at Borth Wen.

The various villages and properties are set behind the railway line and as such it is the railway that is in places at most immediate risk from erosion. The two largest of the several caravan parks along this frontage are on the low lying land of Borth Wen

North of Borth Wen and Llwyngwril, the coastal slope runs steeply down to the narrow boulder foreshore. The railway and road are cut into this steep slope. The road remains to the edge of hill side as the foreshore sweeps around to form the Ro Wen spit across the southern half of the Mawddach Estuary.

Friog is a small collection of properties at the root of the Ro Wen, together with a small caravan park. Properties continue just to the rear of the defended shingle ridge making up the frontage, with the main development of Fairbourne within the centre of the low lying defended area behind the spit. The railway line runs to the back of the main part of the village, enclosing upper areas of marsh between it and the steep hill side to the south, with two major streams running from the steep hill side down beneath the railway into the intensive drainage system of the low lying land around Fairbourne. The railway runs through to the ridge of rock islands: Fegla Fawr and Fegla Fach, and it is from the seaward side of Fegal Fawr that the railway and foot bridge run across the estuary to Barmouth.

The older village of Friog is the rear of the railway line. Early maps of the area at the time when the railway was constructed show a few properties along the minor road out to the Ro Wen. This forms the old core of Fairbourne. Development at Fairbourne has increased significantly over the last century and now there are some 400 properties making up the village. The road through the village now continues along the back of the Ro Wen, following the spit as it curves

sharply east into the estuary. There is a narrow gauge railway that runs as an important tourist attraction from the mainline station to the far head of the Ro Wen, where there is a ferry service over to Barmouth. The wide sandy foreshore, shingle bank and dunes to the end of Ro Wen all from part of the SAC and SSSI covering the Mawddach and the anti-invasion concrete dragon teeth along the crest of the shore are designated a SAM. These all add to the attraction and interest of the frontage for tourism, together with the views across to Barmouth and up the Mawddach valley.

Main span of the Mawddach Railway Bridge

The two rock islands within the mouth of the estuary partially enclose an area of bog and farmland (SSSI and SAC). This is backed by the old railway line, now part of the Mawddach Trail, maintained by Snowdonia National Park, which runs all the way along the southern side of the estuary through to Dolgellau. There is a row of properties at the estuary edge of Fegla Fawr and properties and Holiday Centre along the ridge and on Fegla Fach. They enclose bog behind, and together with the low lying area of Fairbourne, forms one of the largest areas of reclaimed normal tide flood plain in the estuary; the other areas being much further upstream at Penmaenpool.

Over much of the southern side of the estuary, the steep coastal slope runs down to the estuary foreshore, with the old railway line running along the lower part of the slope. Much of the foreshore is quite sandy with often only a veneer of saltmarsh over the higher sand banks at the edge of the estuary. There are quite large areas of saltmarsh in the Penmaenpool area, although also areas of reclamation.

The broader lower estuary valley narrows substantially upstream with, much of the valley heavily infilled with sediment. The relatively wide but shallow channels meander across this flat plain of sediment. It is at Penmaenpool that the channel is really confined by the encroaching in-fill and saltmarsh. This natural constraint has been reinforced by the reclamation and most significantly by the development of the road linking across from north to south. Penmaenpool village is in part built along the higher main road and in part down behind the defence of the old railway line along the southern edge of the estuary. The toll bridge and road form this lower level and are an important local access across the estuary.

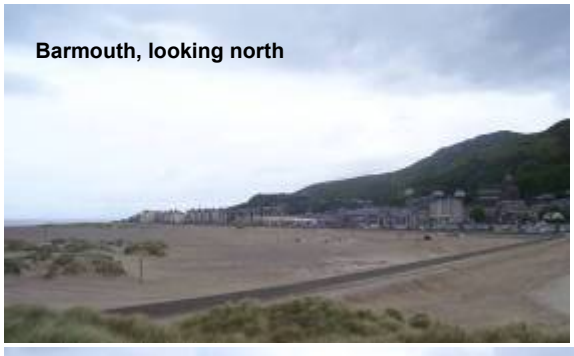
Upper area of the Mawddach

Upstream of the bridge, the in-filled valley floor widens slightly where the Afon Mawddach and the Afon Wnion meet, although the channel of the estuary continues to narrow. Normal tidal limit on the Afon Mawddach is just upstream of the confluence of the two rivers, just upstream of the main A470 road bridge. Similarly, the normal tidal limit of the Wnion is just upstream of the confluence. More extreme water levels could extend some 2km further up the steep sided flat bottomed valley of the Afon Mawddach but only just within entrance to the narrow valley of the Wnion.

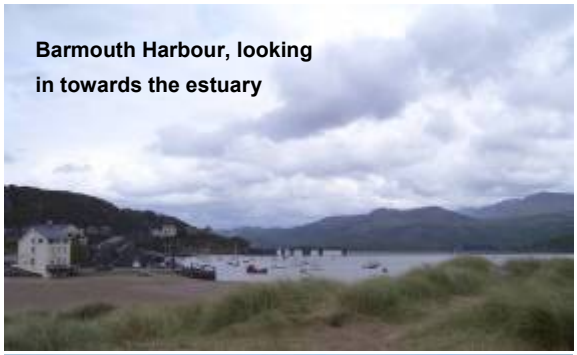
Along the north side of the estuary there are several villages set back on the steep northern slopes, with the main road connecting between them. Only locally does the road run close to the estuary at a low level. This is typically where the streams flow down to the estuary at: Pen-y-bryn; where Afon Cwm-mynach flows into the estuary opposite Penmaenpool, at Bontddu; on the Afon Cwm-llechen, at Caerdeon and at Cutiau; on the Afon Dwynant, where a relatively long stretch of the road is already at risk from occasional flooding..

Barmouth, Railway Bridge

The northern headland at the entrance to the estuary tends to narrow the valley, squeezing the valley mouth between the hard ridge that runs behind Barmouth and the Fegla Islands on the southern side. The railway, over much of its length across the estuary, is built as a low level causeway across the saltmarsh in the lee of Fegla Fawr. The Trestle bridge extends from the causeway over to Barmouth. This bridge was reinforced during 1980/1981 by the placement of Reno mattresses to the trestle bases. This further constrains the entrance, with the main channel being held at the northern end where the railway bridge connects to a small rock promontory. The old Barmouth Life Boat Station was located on the seaward side of the promontory. The new RNLI station is now further north.



Barmouth, looking north



Barmouth Harbour, looking in towards the estuary

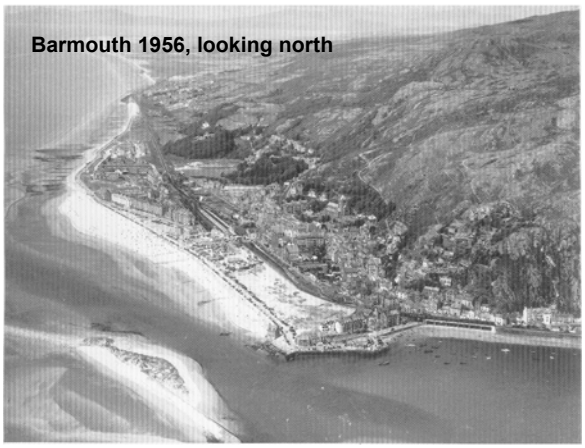
Barmouth Harbour, looking seaward

The older development of Barmouth is along the steeply rising coastal slope along the open coast north of the estuary. The promenade has been developed along the lower lying backshore. At the entrance to the estuary, just in front of the southern most point of the town is the island of Ynys y Brawd. This outcrop extends as well compacted glacial deposits in a southwesterly direction to the Y Perch as a hard ridge constraining the mouth of the estuary between here and the ridge of dune and shingle making up the northern end of the Ro Wen.

The North Channel used to run between the southern end Barmouth headland, and Ynys y Brawd. This was closed off and a new concrete causeway built out to the island. There is now a developing dune system around the island with an extensive build up of sand beach in front of the southern part of the town.

The higher ground of Ynys y Brawd has been extended out into the estuary to form the seaward protection to Barmouth Harbour. The main harbour area is formed in a slight bay with the railway line running at a relatively high level behind much of the harbour and the main quay and harbour buildings built on a rock headland. There are several listed buildings around and to the back of the harbour.

The Barmouth seafront has been developed out from the toe of the old coastal slope over the flatter, lower lying coastal land at the mouth of the estuary. This development extends in a north westerly direction for about 1km north of the harbour, before curving back towards the rear coastal slope some 2km north at Llanaber.


Barmouth 1956, looking north

The lower lying plain contains much of the more modern development of the town, with the car parks, hotels, the bus station and the main promenade. The frontage is vital for the main tourism of the area, with access to the important sandy beach, and contains the main area for commercial development. The railway line runs to the back of this lower lying land. The northern strip of land is primarily residential properties. A stream runs down to the coast at this northern end and is piped under the promenade and over the foreshore. The stream is in quite a wide valley and significant parts of this valley are within the coastal flood plain, behind a slight ridge at the shoreline.

The coast curves northward towards Llanaber Point, where the high ground runs to the shoreline. The railway runs to the toe of the coastal slope and is heavily defended at this natural headland.

North of Llanaber, the more gently rising coastal slope sets back behind a widening coastal marshland plain. The railway line runs at the back of this flat area of land. The coast swings slightly to the northwest through to the slight higher ridge of land in front of Talybont and immediately north of this ridge is the Afon Ysgethin. From Talybont north the coast continues to lie in a north westerly direction to Mochras, with the steeper relic coastline falling away in a more northerly direction. The area between the shoreline and the back coastal slope is filled by the large sand dune system of the Morfa Dyffryn.


Looking south from the Afon Ysgethin

Much of the low lying marsh area, north of Llanaber, is agricultural pasture land, with the Ceunant Egryn and various other small streams running down through the marsh. The only property and development in the low lying land is the large caravan park behind the railway line just north of Llanaber and Sunnysands Caravan and Holiday Park developed right to the shoreline on an area of slightly raised ground some 2.5km north of Llanaber. A small road cuts across the low lying land to the back of this site and, where it crosses the railway line, there are a few

properties. The Holiday Park is defended by a recently improved rock revetment to the back of the sandy beach. The adjacent section of the coast to the south is protected by a thin, low shingle ridge which has been managed as a defence. To the north of the Holiday Park, there is a more substantial shingle bank. This bank used to continue to beach road but the northern end has been heavily modified by a revetment in front of the Islawrffordd Caravan Park. To the north of Beach Road is a substantial rock revetment protecting the Barmouth Bay Holiday Park. These defences are run along the face of the exposed face of the ridge of higher ground running to the shoreline to the south of the Ysgethin.

The various holiday parks have been identified as very important to the area, providing a significant amount of holiday accommodation that supports the tourist industry. This also supports local services in the local villages and creates employment in the area.


Morfa Dyffryn

The Ysgethin forms a small estuary behind a shingle spit north of the Talybont headland. This is covered by an SSSI designation. The Dyffryn and Harlech dune system is designated as part of the Morfa Harlech and Morfa Dyffryn SAC.

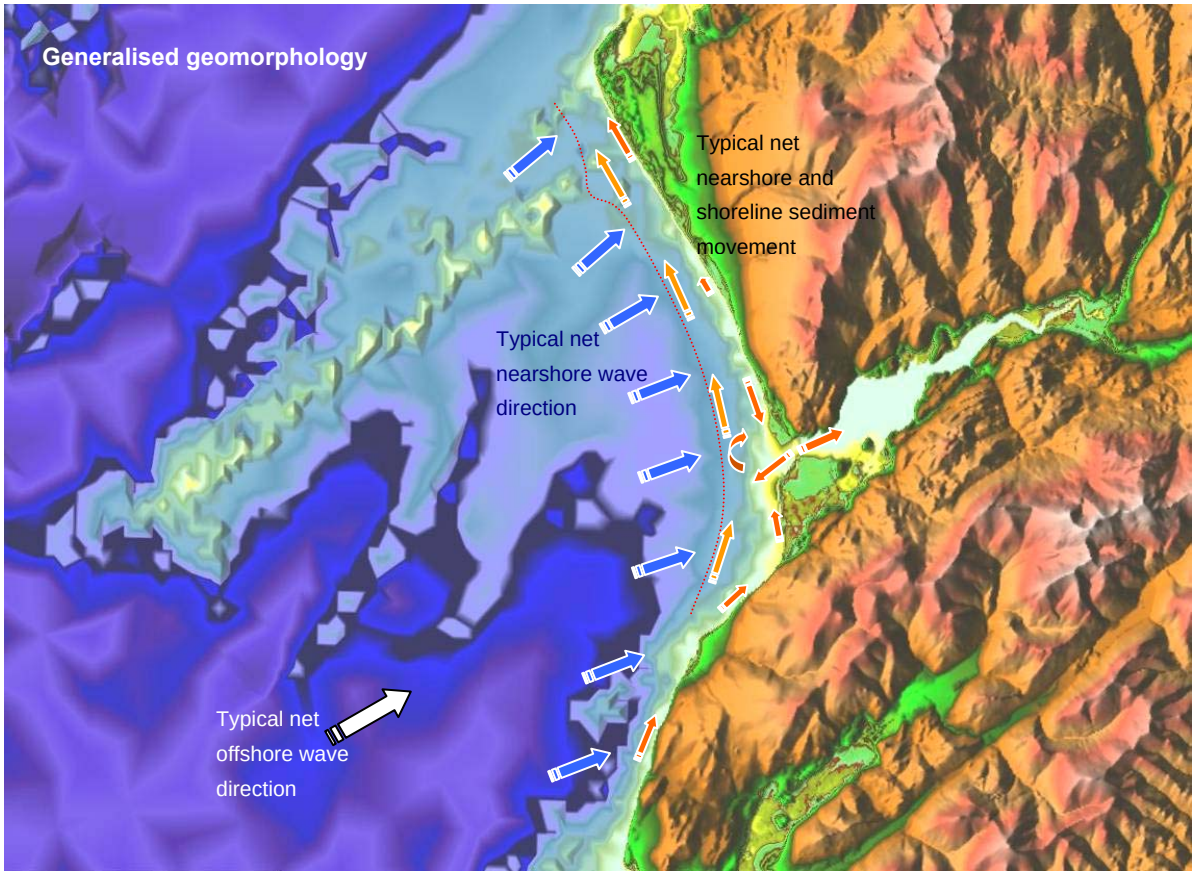
At the northern end of Morfa Dyffryn, behind the dunes is an old airfield. Re-opening the airfield has been considered as providing potentially important access to this quite remote area of the coast, and providing a source of employment opportunities.

2 Coastal Processes

The offshore wave climate is dominated by energy from the southwest to west, varying slightly over the zone from south to north, as discussed in the introduction to the whole coastal area. The zone at the lager scale is contained by the rock headland running down from Cadair Idris in the south and by the Sarn Badrig, running back to Mochras in the north. The Mawddach, strongly constrained by the hard underlying geology, acts to influence the coastal shape where the soft shoreline meets the hard geology of the southern ridge of high ground. The Mawddach has accreted substantially since the last glaciation and this is seen in the very flat sandy intertidal area through which runs the relatively shallow channels of the estuary. The deepest section of the channel is at the entrance between the Ro Wen and Ynys y Brawd. This very straight channel tends to form a jet of flow from the estuary that extends out nearly 1.5km from the narrows. This has allowed the formation of the North Bank extending out on the Barmouth side and the smaller bank at the knuckle of the Ro Wen. The Ro Wen frontage is held forward of the coast to the north, creating a step in the alignment of the shore.

Some sediment modelling has been undertaken of sediment movement along the shore north of Llanaber. This has indicated a strong northerly transport, although from inspection of the upper shore, the transport along the shingle ridge may be much weaker. Along the Morfa Dyffryn frontage, there has evidently being a history of northerly drift but this frontage is now seen as being quite well aligned to the net west south west wave energy. The main change along this frontage is the slow erosion of Mochras, allowing sediment to escape form Morfa Dyffryn to move north into the next zone.

The general geomorphological behaviour of the zone is shown on the plot below based on the limited modelling and additional evidence provided from consultation.



From this assessment it would be seem that in general there is sediment movement into the main bay area, particularly in the southern area by the estuary. This is consistent with the capacity for the estuary to infill. For this to materialise at the shoreline there needs to be adequate width in the upper beach area, such as has occurred at Morfa Dyffryn and at Barmouth. Furthermore, there would appear to be a general drift to the north over the lower foreshore, as evidenced by the shape of the outer banks of the estuary and by the lower shore ridges further north, but that at the upper shoreline the drift is more variable and, particularly north of Llanaber, very weak. The southerly drift along the Barmouth frontage is evidenced by the growth of the beach to the south .


Rola – taken from SMP1

Along the most westerly face of the southern cliffed frontage, the high well, consolidated platform is littering of boulders and rock outcrops. This tends to reduce sediment drift at the upper shore.The thin shingle upper beach does provide some sediment to the system. However, where there are areas of higher foreshore and over sections between rock promontories, the upper beach can be quite stable, reducing longshore drift.

There is a large shingle beach Fronting Llwyngwril at Borth Wen. This is partially held by the higher foreshore. However, this area also marks a reorientation in the shoreline and the accumulation of sediment is seen as being a result of different drift rates along the shoreline (higher drift from the frontage to the southwest and lower drift to the northeast). This results in shingle being stored in this area. Despite, or in fact, because of the greater obliquity of the waves along Friog Cliffs, sediment transport reduces along this frontage. However, this whole frontage is still an important, but limited, supply to the Ro Wen. There is current evidence from monitoring that the beach at the root of Ro Wen is narrowing.

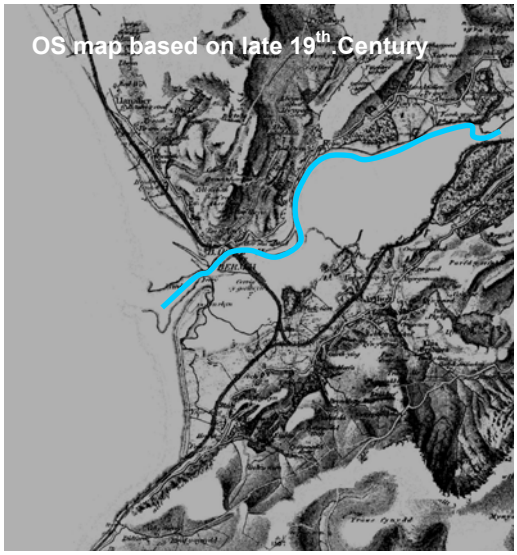

Ro Wen 1990

The main pressure on Ro Wen is for the coast to roll back inland. This pressure will increase with sea level rise. Sediment tends to be taken north and at the northern end the influence of the estuary channel draws the coast out allowing sediment accretion at the point or knuckle of the spit. This is possibly reinforced by a harder underlying foreshore. The exposed cobbles at the toe of the upper beach suggest this may be well compacted glacial deposit. This would help explain why the mouth of the estuary tends to be fixed on this southern side.

Sediment is taken into the estuary on the flood tide and probably during more significant wave action along the lower foreshore of the Ro Wen Spit. However the strong ebb flows, constrained on the opposite bank by the hard engineering of Ynys y Brawd, stop further northward development of the spit, giving it its curiously straight or slightly embayed alignment. It is only at the head of the spit that one gets a more traditional recurved head. Even here the alignment and constraint (both natural and man made) of the estuary entrance results in sediment being carried into the

quiescent area behind Fairbourne and Ro Wen, forming the large sand banks in this area.

The whole estuary mouth is quite unusual. The natural width of the mouth is limited naturally by the ridge of islands on the southern side and the estuary assessment (appendix F) highlights the constrained nature of the estuary with significant control imposed by the hard geology at several points. The map below is based on the earliest 1 inch to the mile Ordinance Survey. The blue line highlights the position recorded for the main channel. The adjacent air photograph highlights the more recent position of the main channels. It is recognised that the channels within the inner part of the estuary have changed significantly over recorded history and will continue to do so.



However, the following points may be made and are considered valid at the high level.

- The island ridge to the south of the estuary had clearly allowed significant accretion both behind the islands and probably behind Ro Wen, limiting the otherwise much larger estuary mouth.
- There has been significant growth of saltmarsh in the bay within the northern side of the estuary at Cutiau. The main channel is shown very clearly on the map with streams from the south side of the estuary cutting across the full width of the estuary to join the main channel on the northern side. Given that the railway line had only been built quite recently (the bridge opened in 1867) at the time of the map, it seems likely that the old channel may have been to the north prior to the constriction of the bridge. It is uncertain, therefore, to what degree the railway bridge has affected the inner estuary behaviour and how much has been the natural accretion within the estuary. There is an indication that the northern gap may have directed flows more across the estuary on the flood but also, possibly, that the constraint imposed by the gap may have resulted in higher tidal flows to spill more generally over the more central area, potentially creating the opportunity for the southern channel past Fegla Island .
- The channel has adopted a far more central line through the estuary. However, with this change the main channel has divided into what appears to be a flood channel and an ebb channel, based on the form of the sand banks. The evidence for an ebb dominance on the southern channel is also seen in the sediment over-wash, over the lower bank, beneath the trestles of the bridge.
- There is evidence that the Ro Wen spit has extended and indeed on the air photograph the old head of the spit is indicated to be possibly 200m back from its current position since 1990. This would suggest that there are now strong flood flows

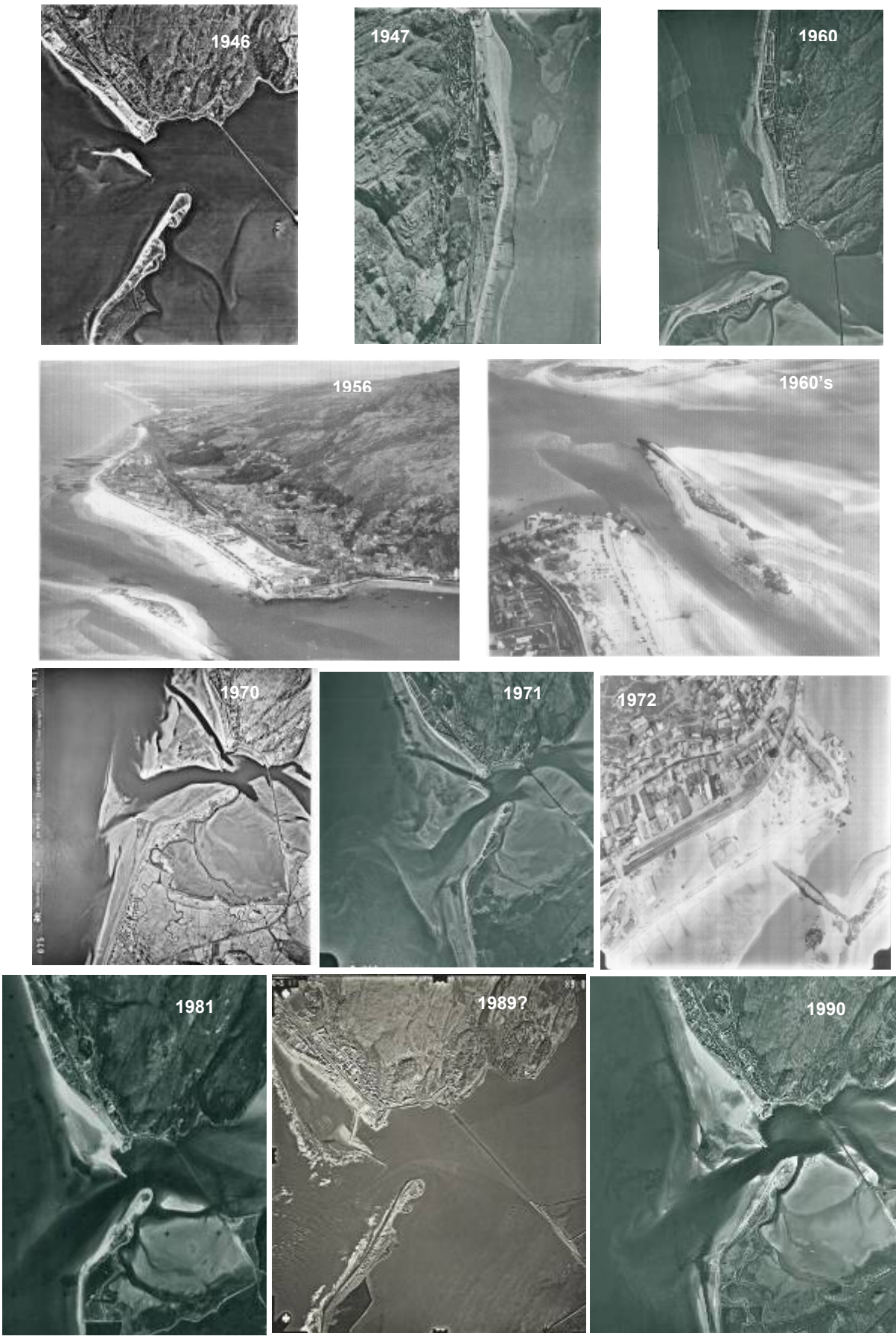
to the south of the channel. The shape of the Ro Wen spit has also changed from a convex shape to the concaved shape now seen. This is seems to be linked to the increased ebb flow within the main channel.

- While the main channel between Ro Wen and Ynys y Brawd appears to have remained relatively fixed, the ebb flow may now set more firmly against the Barmouth side. There is some suggestion from the map that there was less of a bay developed behind Ynys y Brawd. The construction of the railway bridge may have increased scour of this bay.
- The old North Channel behind Ynys y Brawd is evident on the old map, but the shape of the channel suggests that this may have been more of a drainage channel from the back of the higher sand ridge in front of Barmouth. Older charts do clearly show the presence of the old North Channel. The fact that this channel is shown as being quite narrow on the map suggests that it was possibly closing. The further development of the channel may have been a response to the change in direction of the ebb flow from the estuary. This point is discussed further below.

A series of air photographs have been collated in the following plate setting out the development around the mouth of the Mawddach. Some care has to be taken in comparing these photographs due to the difference in tide level shown. This is particular the case in interpreting the position of the low water channels. However, the following assessment can be made.

- During the 1940's the North Channel was a very dominant feature. It is suggested that the channel was possibly reinforced and revitalised due to the reorientation of upper tidal ebb flows as a result of the construction of the bridge. With the main channel moving over to the southern side of the estuary, there would be a northward flow on the upper part of the tide in towards the area of the harbour.
- The 1960's photographs show a tendency for the North Channel to be moved away from the shoreline at the apex along the Barmouth frontage and these photographs also show how the channel is having to cut through the natural low water bar of the beach.
- The 1970 photograph shows that the channel has narrowed and tended, at its seaward end, to move further south, suggesting again the pressure from sediment building against the shore and the southerly drift over the upper beach may have been attempting to close this channel. The plume of sediment in the area of the harbour is a further indication that there was an increasing amount of sediment along the southern Barmouth sea front. This created a flood delta within the area of the harbour.
- In the early 1970's, the channel was artificially closed. The response of the shoreline to the north was, initially to form a low water berm with almost a lagoon behind, but then for this lagoon to rapidly infill with sand. This is further evidence of the larger scale capacity for the coast to make use of width to build beaches.
- The closure of the North Channel appears to have strengthened the main south channel, resulting in the elongated ebb tidal banks to extend further into the nearshore regime.

It is difficult to conclude that the artificial closure of the channel did more than pre-empt a process that was already occurring. Certainly there is little evidence to suggest that in closing the channel and allowing sediment to build against the Barmouth sea front, that this has had any significant impact on sediment supply to the north. From the photograph of 1956, compared to more recent photographs, the indication is that the beach to the northern end of Barmouth has actually benefited from the development of the larger nose of sediment at the apex in the shoreline.



Entrance to Mawddach Estuary. Note: the date of the photograph shown as 1989 is uncertain.

Further north along the shoreline, Llanaber point is clearly under significant pressure. However, this point is seen as being a significant control point in holding the shape of the coast both to the south and to the north.

While the modelling of the shoreline to the north of Llanaber indicates a very high drift (in the order of 300,000 m^3/yr) this is belied by the behaviour of the shingle bank in relation to the interaction with the defences at Sunnysands. There is no build up of shingle against the southern side of the rock revetment and to the north of the revetment no significant down drift erosion. What is very evident, however, is that the shoreline is eroding back and that the defences at Sunnysands and at Islawffordd are and will continue to come under significantly greater pressure, with the potential further loss of sand in front. The erosion of the beach is clearly shown in the exposure of the underlying peat.

POTENTIAL BASELINE EROSION RATES

In assessing erosion and recession in the future, allowance has been made for sea level rise and this is discussed in Appendix C. This is also discussed briefly in following the table.

Over the mainly soft coast central and northern sections of coast, sea level rise (SLR) will be a significant factor in future development of the shoreline. Over where there is current erosion, the rate of erosion is likely to increase with SLR. This might be by a factor of 1.7 to 2.5 times the existing base erosion rate over the 100 years. Where there are more stable features, such as the dune frontage to the north there would be a natural roll back of the beach potentially in the order of 10m to 40m, depending on the nature of beach and the coast behind. As beaches, protecting relatively stable coastal slopes, erode or roll back, this could result in re-activating landslides and slope instability.

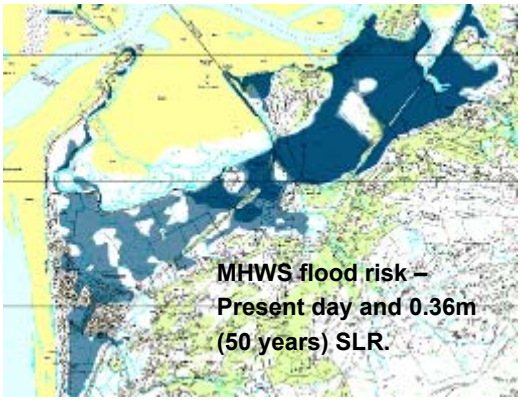
Location	NAI Base Rate (m/yr)	Notes	100yr. Erosion range (m)
Rola	0.1	Slow erosion of cliff	10 - 20
Borthwen	0.2	Roll back of shingle ridge very sensitive to SLR	30 - 80
Fairbourne	0.2 – 0.3	Roll back of shingle ridge very sensitive to SLR	30 - 100
Ro Wen	0.05 – 0.1	Influenced by estuary channel	15 - 50
Barmouth S	0.05	Defended area recently accreting	20 - 40
Barmouth N	0.2 – 0.4	Defended but historically reducing beach levels	30 - 120
Llanaber	0.2	Heavily defended with no longer term record	40 - 100
Egryn Marsh	0.5	Managed shingle ridge	50 - 120
Tal y Bont	0.3	Defended shingle ridge backed by cliff	30 - 100
Morfa Dyffryn	0.2 – 0.3	Natural shingle and dune frontage	30 - 100

Base rates have been assessed from monitoring and historical data. The range of potential erosion is assessed in terms of variation from the base rate and sensitivity in potential sea level rise. Further detail on erosion rates together with erosion maps are provided in Appendix C.

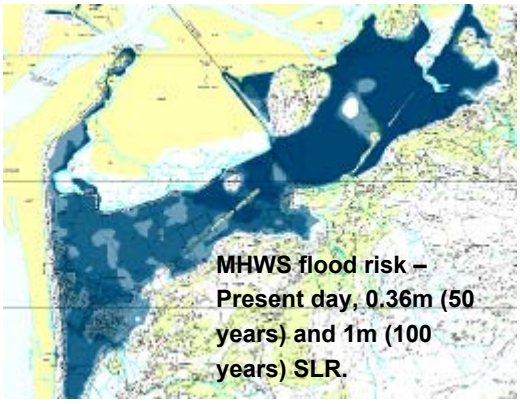
FLOODING

At Llwyngwril, and more with respect to the low lying area of Borth Wen, there is local flood risk to the Caravan Park and to local areas of the low lying land to the south. There may be some tidal locking of the Afon Gwril. With sea level rise this local flooding would increase. However, it is only under extreme events; even with 1m sea level rise that the more extensive area to the south of Borth Wen, in the area of the old rifle range, that large areas of the low lying land are affected. This is an area that is quite extensively drained and with sea level rise there is a greater risk of tidal locking.

Flood risk is a significant issue with respect to the low lying land behind the Ro Wen. At present the general land level around Fairbourne is just above MHWS. With anticipated sea level rise over the next 50 years it would be expected that significant areas would be below normal tide levels. Over 100 years the whole area would be below MHWS. This is shown in the following plots. This would have a significant impact on ground water levels and the ability to drain the area.



MHWS flood risk – Present day and 0.36m (50 years) SLR.



MHWS flood risk – Present day, 0.36m (50 years) and 1m (100 years) SLR.

Impact of different Sea Level Rise Scenarios

With higher rates of sea level rise the whole area around Fairbourne would be below normal tidal levels within 45 years. Over the 100 years with 2m SLR the area would be typically 1.5m below normal tidal levels.

Further upstream within the estuary areas particularly around Penmaenpool are at significant flood risk. Large areas of the upper estuary around the confluence of the Mawddach and Wnion are at risk of flooding on extreme conditions at present. Much of this area would be below MHWS under 1m sea level rise. Normal tide level would extend further up the Mawddach valley. However, even under this increase in water level, normal tides would not affect directly areas around Dolgellau. Higher tide levels will impact on fluvial flooding due to tidal locking.

Some properties in Barmouth have basements. It was indentified during consultation that some properties require pumping to keep these dry and this would increase with sea level rise. Part of the northern end of the town is at flood risk at present, with the 1:1000 year flood risk area extending inland at Heol-y-Sarn through to the football ground. Areas around Heol-y-Sarn could be below normal tide level with 1m sea level rise.

At present there is a flood risk from water levels in excess of the 1:10 year event to the low lying land north of Llanaber. This includes land behind the Sunnysands Holiday Park. With sea level rise, clearly the risk increases, however, the land is unlikely to be subject to normal tidal flooding even under a 1m sea level rise.

Impact of different Sea Level Rise Scenarios

Over the 100 years with 2m SLR, normal tidal flooding would include much of the low lying land to the north of Llanaber. This would extend behind the holiday park and under extreme events the holiday park itself would be at risk.

There is a large flood risk area behind the Morfa Dyffryn dune system. This is at risk from flooding from the Artro Estuary. This risk extends to cover parts of the Llanbedr village and the northern part of the airfield. The area is only extended slightly as a result of sea level rise, extending somewhat further across the airfield under extreme events with 1m sea level rise. Even with anticipated erosion over the next 100 years, the front dunes would still provide a barrier in terms of flooding from the Morfa Dyffryn side. As such this flood area is considered within the following policy development zone (PDZ12).

EXISTING DEFENCES

Over the southern cliff section of the zone, defences are quite localised at Tonfanau, to the south western area of the Borthwen frontage and more extensively along the Friog cliff, with the seawall built into and along the rock cliff.

The crest of the shingle ridge along Ro Wen was reinforced by a concrete crest wall in 1982. There is an embankment running from the knuckle of Ro Wen back to the railway at Fegla Fawr and the railway embankment and road separates the area of Fairbourne from the defended marsh behind Fegal Fawr and Fegla Fach. There are works linking the two islands and between Fegla Bach and Arthog. There is also a short section of defence in front of Mawddach Terrace.

Arthog is defended in part by the enclosure between the islands but also by the embankment formed by the old railway line to the east. Locally along the whole southern side of the estuary the old railway embankment encloses small areas of marsh with a more extensive enclosure just to the west of Penmaenpool. The lower part of Penmaenpool is defended by a short section of revetment.

Further upstream of Penmaenpool, on the southern bank, there is a length of embankment enclosing land around Yr Ynys, with the old railway embankment acting as a defence behind. Over the northern side of the estuary there are local embankments along the edge of the marsh.

Opposite Penmaenpool, there are embankments enclosing land either side of the Toll road and extending along the banks of the Afon Cwm-mynach. There are local embankments Bontddu, at Farchynys and at Cutiau, protecting and retaining the road.

There are various sections of seawall along the road at Porth Aberamffra and around to the area of the harbour. There is the new causeway to Ynys y Brawd and works extending the island that act as protection to the harbour. Along the whole length of the Barmouth seafront there is a seawall with timber groynes. North of the sea wall is a length of shingle bank, which extends through to the railway seawall and rock revetment around Llanaber Point.

Much of the frontage to the north of Llanaber is semi-natural shoreline. The shingle ridge immediately north of Llanaber is maintained as a flood defence. There is a major rock revetment in front of Sunnysands Holiday Park and there is a tipped rubble revetment in front of the Islawffordd and Barmouth Bay Holiday Centres.

North of the Afon Ysgethin are natural dunes.

Over the southern cliffs line, in the absence of defences and with the natural erosion of the clay cliffs there would be slow and continuing erosion. The principle asset at risk would be the railway line, although at Gors Wen there could be increased flood risk to the caravan park. The erosion of the cliff line would tend to increase the slight embayments formed between harder sections of cliff. There would also be some increased erosion rates with sea level rise as the harder areas of foreshore are submerged. The overall shape of the coast would not change significantly. There would be slightly increased drift feeding to Ro Wen, but this would be naturally limited by the development of the slight embayments.

In the absence of defences at Ro Wen, behind Fairbourne and between the Fegla Islands, the whole area would be subject to regular tidal inundation. This would result in loss of Fairbourne. The area would tend to revert to natural marsh and based on past behaviour of the estuary the area may well accrete in line with sea level rise. The open coast section of Ro Wen would attempt to roll back. It is uncertain whether there would be a breach in the shoreline, but even if there were it seems unlikely that the estuary would form a new entrance channel. As such the present entrance channel would still impose a control on coastal development and, even if the knuckle of Ro Wen retreated this is still likely to remain as a significant headland.

As Ynys Brawd becomes more exposed and the hard ridge is submerged with sea level rise there could be the development of a north spit into the estuary. As sea level increased and the influence of the island decreased so the North Channel might re-open but as part of the wider estuary mouth. This overall process would tend to cause the return of Ro Wen to roll back further, forming a wider entrance to the south. In the absence of the railway embankment, there might be greater variation across the whole mouth of the estuary. It is unlikely, however, that the old northern channel would be re-established due to the general accretion that has taken place within the estuary.

Within the estuary there is likely to be further accretion along the edges of the estuary. At Penmaenpool, the areas now defended would revert to marsh and while there might be some local variation in channel position it seem probable that accretion would still occur.

Along the Barmouth frontage, the declining influence of Ynys Brawd would encourage movement of beach material to the south, this would place greater pressure on the apex in the frontage and this would erode back in equilibrium with the influence of the estuary in holding the shoreline forward. There would therefore be significant loss along the central section of the frontage.

Llanaber point would erode back and this would again impose pressure along the coast to the south. With the erosion along the Barmouth frontage and with the estuary tending to draw sediment into its new wider entrance, there is unlikely to be significantly greater sediment supply to the north. Llanaber Point would still act as a control point along the coast. However, as this point erodes slowly, the shoreline to the north would tend to erode back at a greater rate. There would be loss of the railway at Llanaber

This northerly section would erode but would still be controlled to a degree by the slightly higher ground at Tal-y-Bont and potentially by the weaker influence of the Afon Ysgethin. There would be significant loss in terms of the Sunnysands Holiday Park and continued slower loss to the holiday parks further north

The main control to Morfa Dyffryn is Mochras at the northern end. As this headland erodes back so the dune system would also tend to roll back.

KEY INTERACTION WITH DEFENCES

From the above assessment, in terms of the behaviour of the coast, it may be seen that there are key locations in the system where defences have a significant impact.

Although where there are defences along the southern cliffs and at to the south of the Borthwen frontage, these act more locally to stop erosion of the cliffs and, in the case of the embankment, defend against flooding. The defence of the Friog Cliffs reduces potential supply to Ro Wen, however, none of these defences really control the over all behaviour of the coastal system.

At the mouth of the estuary, the railway clearly influences the behaviour of the mouth and may have resulted in significant change further within the estuary. The other major control point is Ynys y Brawd. This feature anchors the entrance channel. While the defences around Fairbourne obviously provide a significant function in terms of flood defence, they are not seen as fundamentally influencing estuary behaviour. Similarly, the causeway to Ynys y Brawd, while being associated with and finally closing the North Channel, which in turn has influenced the way in which the estuary entrance behaves, this structure is not seen as being as significant as the island itself. The structure has stopped loss of sediment from in front of Barmouth, which would otherwise have entered the estuary system.

The defence along the Barmouth frontage is locally important in holding the shoreline forward but it is primarily the headland at Llanaber which imposes the main influence on the structure and sediment movement along the foreshore.

Within the Mawddach, while the various defences to the edge of the estuary locally influence behaviour of the estuary, there are no major areas of reclamation which would substantially alter the estuary's tidal prism. Further upstream there are larger areas of defended land that could increase tidal prism but even here the extent of these areas is such that they seem unlikely to increase the overall tidal prism in such a manner to affect the estuaries tendency to accrete. At Penmaenpool the reclamation to the north has in effect pinned the channel against Penmaenpool. However, it is uncertain to what degree this would have been different if this area had not been defended.

In the area of the confluence, the various defences may influence tidal locking of the rivers. This needs to be examined further. There is the possibility that the defences and more probably the area around the Toll Road might actually reduce the effect of the tidal wave on more extreme surge conditions.

North of Barmouth the defences in front of Sunnysands and in front of Islawffordd do not appear to significantly interrupt long shore drift along the backshore at present. The main drift is considered to be along the lower foreshore. As the coast retreats to either side of both sections of defence, these defences will start having a more significant impact on the lower foreshore.

3 Management Scenarios

3.1 No Active Intervention – Baseline Scenario 1

The key interaction between the way in which the coast behaves and how it is managed allows this scenario to be discussed in sections:

- The southern cliffs
- The estuary entrance together with Ro Wen and Barmouth.
- The estuary
- The coast north of Llanaber.

There is recognised to be some residual linkage in terms, principally of sediment drift and supply and potentially more significance in management terms of the railway. These links are highlighted in the discussion.

The southern cliffs
The dominant feature of the frontage is the railway. This is at risk at several locations, most notably along the clay cliffs south of Ogof Owain, more locally north of Felin-Fraenan, along the section between Llangelynnin and Rola, potentially along the clay cliff section north of Llwyngwril and along the defended section of the Friog Cliffs. Under this scenario continued erosion would occur along each of these sections, with deterioration of the Friog defences over the first two epochs. During epoch 2 it is likely that sections of the railway would be lost, along with sections of the road. Under this scenario, with loss of the railway along this frontage, it seems probable that defence of the railway anywhere else along the whole area would be abandoned. This would have major consequences in term of access along the whole coast through to Porthmadog and Pwlhelli. The railway might stop at Tywyn, with no defence required across the shingle ridge of the Dysynni valley.

More locally, there would be continued roll back of the shingle ridge between Gors Wen and Borth Wen. This may expose areas of the Caravan Parks to increased flooding, although allowing natural roll back would encourage development of a berm which may then act as a defence. There would be some loss of land and caravan pitches.

There would be some increase in sediment supply to Ro Wen.

The estuary entrance together with Ro Wen and Barmouth.
The defence at the crest of Ro Wen would come under increasing pressure over epoch 2, with loss of beach in front as the shoreline attempts to roll back with sea level rise.


Ro Wen - Fairbourne

Over the next 50 years, with an anticipated sea level rise of 0.36m, the present defences would be significantly more frequently overtopped due to wave overtopping. The rear defence could be overtopped due solely to water level, such that there may be serious flooding to Fairbourne on a 1:10 year basis. Over the 100 years, overtopping to the sea wall would be at least as bad as was the case before the seawall was built in 1982 and probably significantly worse, even if the

seawall were still in place. In all probability the seawall would have been lost due to erosion sometime during epoch 3. Direct overtopping of the rear embankment would be so frequent that without maintenance it is probable that it would have breached.

Due to rising sea level, much of the village of Fairbourne would be below normal high tides within the next 50 years and under this scenario, where no action is taken in terms of flood defence, there would be significant issues in terms of surface water drainage and drainage of the two watercourses that run into the area. It is difficult to predict, without detailed investigation of the relationship between ground water and tide levels, at what point in time the village would be lost but indicatively 0.5m sea level rise might be considered crudely to be a critical threshold.

The final failure of defences, either with failure of the front line of defence or due to breach of the embankment behind would be sudden and similar to the sort of devastating flooding that occurred to communities on the East Anglian coast during the storm of 1953. The railway line and embankment to the south of Fairbourne would potentially provide some additional protection to land behind, although this embankment would be overtopped regularly with 1m sea level rise. The main road could then be flooded locally on a regular basis.

A similar pattern of diminishing standard of defence and eventual failure would occur in terms of defences between Fegla Fawr and Fegal Bach. This would result in flooding of the marsh land behind, which is already below MHWS under present day conditions. Properties between the two main islands would be lost possibly towards the end of epoch 2. The access to the two islands would be tidal. The village of Arthog would, even under a 1m sea level rise scenario, only be subject to flooding on more extreme events. There could also be damage to areas of nature conservation value in the area, including that of Arthog Bog, behind the islands, although this equally could give rise to increased areas of saltmarsh supporting a more natural estuary system.

Impact of different Sea Level Rise Scenarios

The main impact of a more rapidly rising sea level would be to bring forward the potential loss of Fairbourne by some 15 to 20 years. Under the 1m scenario over the 100 years loss might be in year 60, under a 2m sea level scenario the village might be lost in years 40 to 45.

Under a 2m scenario, there would be some increased flood risk on normal tides to the village of Arthog during epoch 3.

Under this management scenario of No Active Intervention, it is taken that the railway line, although no longer in long term use would still be present. The causeway beneath the bridge would still influence the behaviour of the entrance. The main flows would still be through the entrance channel and this would still influence and hold the knuckle of Ro Wen. Although defences around the harbour might start to fail without maintenance by epoch 3, Ynys Brawd would still hold the northern side of the estuary channel. The causeway to the island would still act to retain sediment in front of Barmouth and this would be built up as a dune. Access to the town would be lost as defence around Porth Aberamffra failed.

Defences along the Barmouth sea front might fail during epoch 2 and the defences further north would fail probably in epoch 1. There would be significant flooding in the area of Heol-y-Sarn and by epoch 3 the northern properties would be cut off on a regular basis due to tidal flooding. As the rock revetment and wall to the railway line failed and

the headland started to erode during epoch 2, the potential lands slippage would result in loss of property and potentially the road towards the end of epoch 3. This would cut the only other access to the town.

The loss of the access roads, the loss of the railway, the loss of the seafront and harbour would in effect result in the loss of Barmouth over the next 100 years.

The estuary
Under this No Active intervention scenario there would be no effort put in to maintain the various local defences around the estuary. Typically over epoch 1, without maintenance of defences, embankments start to fail. The old railway embankment would be increasingly overtopped during epoch 2 and there would be the loss of this important tourist asset. The land behind would also be subject to significantly greater flooding.

There would be failure of the revetment at Penmaenpool, possibly not until epoch 3, and some increased risk of flooding due to sea level rise. The Toll Road might be subject to tidal flooding as soon as embankments fail, even so this road might still be useable as a tidal causeway. The failure of embankments further upstream would result in some loss of agricultural land and this land would revert back to saltmarsh, with the potential for it to accrete in line with sea level rise. There is the possibility that with sea level rise and increased floodplain width, that on high surge events there may be some increased level of water reaching the confluence of the two rivers. This would need to be considered further as to the potential impact of this on tidal locking.

Along the northern bank, there is at present risk of flooding to the main road at Borthwnog, Farchynys and Cutiau. This could increase to allow flooding to occur on normal tides with sea level rise.

The coast north of Llanaber
The main process along this frontage is for roll back and erosion of the backshore. The defence at Sunnysands might fail due to deterioration, loss of beach in front and outflanking possibly during epoch 2. The initial failure is likely to be due to outflanking as the coast potentially moves back some 50m to the south and to the north. During the latter part of epoch 2 and during epoch 3, there would be increased erosion such that much of that caravan park would be lost. Over the same periods of time flooding would increase to the land behind and there would be no space for rolling back of the caravan park. Further north, the potential erosion to adjacent frontages might be in the order of 25m by the end of epoch 2 and over 60m by the end of epoch 3. This could result in loss of the economic viability of the holiday parks.

The erosion of the main Morfa Dyffryn dunes could be at a lower rate than the coast to the south, with the dunes tending roll back from their current relatively stable position. The frontage would however still set back some 30m to 40m

Impact of different Sea Level Rise Scenarios

Increased rates of sea level rise would tend to accelerate erosion, such that for the Sunnysands frontage and to the south erosion over the 100 year period could be around 150m, at Islawffordd some 80m and Morfa Dyffryn some 50m.

3.2 With Present Management – Baseline Scenario 2

Table below sets out the present management policies under SMP1.

SMP 1 No.	Unit	Policy	Subsequent Management Approach
3.2	Rola	HTL	
3.3	Llwyngwril	R	
3.4	Friog Cliffs	HTL	
3.5	Ro Wen	HTL	
4.1	Morfa Mawddach	HTL	
4.2	Penmaenpool	HTL	
4.3	Glandwr	DN	
4.4	Barmouth Harbour	HTL	
5.1	Barmouth	HTL	
5.2	Sunnysands	DN	Further studies have suggested a set back approach to management.
5.3	Bennar	DN	
6.1	Shell Island	DN	

The following information and policy is abstracted from the North West Wales CFMP Draft Plan. The policy units covering this section of the coast are Policy Unit 7, which covers Fairbourne and Barmouth and policy unit 8, which covers Dolgellau.

Preferred policies for Policy Unit 7 – Coastal Lowlands

Policy unit 7 Coastal Lowlands	This unit covers the coastal strip from Cardigan Bay to Barmouth. The main towns are Fairbourne, Tywyn and Barmouth

Physical characteristics:

The policy unit is mostly rural, mostly low grade 4-5 agricultural land.
Urban areas are mainly located along the coast.
Low lying areas on the coastal strip of west Wales.
The catchment includes the lower reaches of the Afon Ysgethin and their tributaries and smaller rivers and streams.
The soils are predominantly brown soils, which are sandy and loamy and well drained.
Contains five Internal Drainage Districts.
Variable geology including Ordovician, Cambrian and Silurian mudstones and shales with St Angus Sand formation strata on the coast.

Flood mechanism:

Tidally influenced fluvial flooding in the at Fairbourne on the Afon Henddol,.
Rapid onset of river flooding ('flashy catchments') in Fairbourne, Llanbedr, Tal-y-Bont.
Sewer flooding in some of the urban areas

Receptor:

People, property and infrastructure in the urban areas along the coast.
Caravan park/camping sites.
Medium to low grade agricultural land.
Important railway lines.
Large sections of locally important A roads which link the coastal area to the rest of Wales.
Landscape designations – Snowdonia National Park.
Environmental Designations - SPAs, SACs, Ramsars, SSSIs and NNRs
Historic Designations – Listed buildings Scheduled Monuments, Historic Landscape Areas and Registered Parks and Gardens.

Climate change is unlikely to have a significant affect on the number of people and properties at risk of flooding in the coastal lowlands. The broadscale model of Fairbourne only shows a small increase in the number of people at risk 100 years in the future. This is likely to be the case across most of the towns along the coast with only small increases in flood risk due to climate change.

More people may be affected by increased surface water and sewer flooding. Wetter winters with more frequent and more severe storm events are expected to increase flow volumes. The flood zone modelling only showed a small increase in flood risk across the coastal lowlands, however further studies on the tidal affects from sea level rise will need to be carried out in more detail to assess the actual risk.

Policy selected	**Policy 3 -** Continue with existing or alternative actions to manage flood risk at the current level.

Flood risk in the coastal lowlands primarily derives from tidally influenced river flooding. Floodwaters are shallow, low velocity and short-lived, limiting the level of disruption caused. Climate change does not significantly increase the flood risk in this policy unit. The number of people currently at risk from the 1% AEP flood event is 590. This increases to 670 people in the future. To put this into perspective, these numbers show 3.7% of the total population in the policy unit is currently at risk and in the future 4% of the total population are estimated to be at risk. As there is no significant increase in flood risk expected as a result of climate change, a policy 3 has been selected. This means we will continue to maintain the channels and local flood defences to ensure the current level of risk is sustained. Stopping or reducing the existing flood risk management actions would allow existing flood defences to fall into a state of disrepair and would put more than 850 people in the policy unit at a greater risk of flooding than at present. The number of properties at risk would also increase. This would not meet the policy unit objectives and therefore policies 1 and 2 are unsuitable. However as there is no significant increase in flood risk due to climate change, a policy 4 and 5 is not required.

Although policy 6 provides opportunities for environmental benefits, on balance there is no evidence to support any social and economic gains from supporting and informing the agri-environmental land management initiatives as a way of reducing surface water run-off in the upper catchments and improving water storage in the lower catchments.

Opportunities:

To provide flood storage and enhance conservation value and biodiversity by restoring rivers to a naturally functioning state through the removal of Environment Agency owned and maintained structures.

Ensure no increase in run-off from the new developments proposed in the Wales Spatial Plan through development control.

Reduce future flood risk by influencing and informing the planning process.

Help meet national biodiversity action plan (BAP) targets through flood risk management activities.

To improve water level management, meeting the needs of flood risk management as well as enhancing wetland habitats through development of Water Level Management Plans (WLMPs).

To reduce flood risk and improve water quality by promoting and encouraging the appropriate use of SuDS in the proposed urban developments in the Wales Spatial Plan.

To improve the sustainability of flood risk management along the coastline and estuaries through influencing the second generation of Shoreline Management Plans.

To reducing surface water run-off and sediment loss in the upper catchments and improving water storage in the lower catchments through supporting and informing existing and developing environmental and land management initiatives, such as Tir Cynnal, Tir Gofal and Catchment Sensitive Farming.

Reduce flood risk throughout the CFMP area through initiatives and actions that will enhance the character of the landscape and increase amenity opportunities for recreation, tourism and leisure activities within the National Park and Areas of Outstanding Natural Beauty.

Reduce run-off from upper catchments through working with the Forestry Commission Wales and their Better Woodlands for Wales project.

Reduce peak discharge rates in rivers through restoration of watercourses to a good geomorphological river status (i.e. naturally functioning watercourse) in accordance with the Water Framework Directive.

Reduce flood risk through improved flood warning and emergency response.

Constraints:

Government and international legislation, environmental management policies, plans and strategies for the catchment should be complied with, such as accommodating new hosing within the catchment as detailed in the Wales Spatial Plan and compliance with the Habitats Regulations.

Some environmentally designated habitats are susceptible to changes in flood frequency, flood water chemistry, groundwater levels and drainage system maintenance.

Visual impact of flood risk management activities within the National Park.

CFMP objectives must compliment those of the Ynys Enlli to Great Ormes Head, Llandudno and the Cardigan Bay Shoreline Management Plans (SMPs).

Presence of protected species with specific water level, water quality and habitat requirements, such as freshwater pearl mussels and water voles.

Large number of river catchments operating individually.

Historic development and some heritage designation present permanent physical obstructions in floodplains.

No degradation of existing fish passage and habitats.

Some exposed and subsurface archaeological sites in the floodplain are susceptible to changes in water level, flood frequency and water chemistry

Strategic influencing

Continue with the review of the management of Internal Drainage Districts;

Encourage the up take of flood resistance and resilience measures by people at risk from all sources of flooding.

Flood risk mapping and modelling

Develop an understanding of flood risk in Fairbourne;

Undertake an appropriate hydrologic and hydraulic modelling study.

Asset management/maintenance

Develop a System Asset Management Plan to review management regimes to maintain current level of flood risk into the future;

Continue maintenance of flood defences in Fairbourne and Barmouth;

Continue maintenance of the main rivers for flood risk benefits;

Continue to monitor and record asset data.

Urban drainage

Provide development control advice;

Promote and support the implementation of Sustainable Drainage Systems (SuDS) in all new developments.

Flood awareness

Provide information about how the communities can help themselves before, during and after a flood.

Flood forecasting and warning

Continue work on the flood warning project.

Flood incident response

Produce a local community flood plan for Fairbourne.

Tidal flooding

Carry out an appropriate study to identify the future flood risk as a result of sea level rise, in Fairbourne;

Encourage the second generation of Shoreline Management Plans to consider the tidal flooding problems in Fairbourne.

Policy unit 8 Dolgellau	This unit covers the town of Dolgellau located within the Afon Wnion Valley, at the top of the Mawddach Estuary.

Physical characteristics:

Fairly densely populated urban centre.

Geology comprises impermeable basalts and Cambrian mudstones and shales.

Podzolic soils are predominant which usually indicate high run-off rates.

The Afon Wnion and Afon Arran flow through Dolgellau before discharging into the Mawddach estuary just downstream of the town.

Estuarine location means susceptibility to fluvial and tidal flooding.

Rapid onset of river flooding owing to geology, soils and location in base of steep sided valley

Flood mechanism:

Fluvial flooding from the Afon Wnion and Afon Arran.

Rapid onset of river flooding ('flashy catchment'). Rainwater in this area runs off the steep catchments and enters the rivers quickly where the channel cannot cope with the amounts of rainwater and cause water to spill over the riverbanks.

Surface water flooding in the urban area. Sewer flooding.

Policy selected	**Policy 4 –** Take further action to sustain the current level of flood risk into the future (responding to the potential increases in risk from urban development, land use change and climate change).

The flood risk in Dolgellau is currently assessed as low to medium and no immediate action is necessary. Therefore a policy 5 is not required. However, climate change has significant impacts on the flood risk in Dolgellau. These changes affect flooding mechanisms in the policy unit. Flood damages increase from £2.2 million now to £5.9 million in the future from a 1% AEP flood event. The number of people at risk increases from approximately 90 to approximately 165.

It is therefore necessary to take future action and mitigate the affects of climate change to reduce future flood risk in the policy unit. For this reason, a policy 4 is selected. This means we intend to improve the channel maintenance and investigate the potential to improve the existing flood defences through the urban area. A policy 4 will achieve the objectives set to ensure the harm to life caused by flooding does not increase due to climate change.

Stopping or reducing the existing flood risk management actions would allow existing flood defences to fall into a state of disrepair and would put people and property in Dolgellau at a greater risk than at present. There are likely to be more than 500 people at risk if the current flood risk management action were discontinued or reduced. This is unacceptable and therefore policies 1 and 2 are unsuitable.

Given the significant increase of risk in the future from climate change it is essential to mitigate the affects of increased inflow to ensure the harm to life, community disruption, number of properties and flood damages do not increase from the current baseline. For this reason policy 3 is unsuitable as it does not mitigate the affects of climate change.

As the policy unit is mostly urban, there are no suitable locations to increase the frequency of flooding, therefore a policy 6 is not considered feasible in this policy unit.

Opportunities:

Ensure no increase in run-off from the new developments proposed in the Wales Spatial Plan through development control.

Reduce future flood risk by influencing and informing the planning process.

To reduce flood risk and improve water quality by promoting and encouraging the appropriate use of SuDS in the proposed urban developments in the Wales Spatial Plan.

Reduce peak discharge rates in rivers through restoration of watercourses to a good geomorphological river status (i.e. naturally functioning watercourse) in accordance with the Water Framework Directive.

Reduce flood risk through improved flood warning and emergency response.

Constraints:

Government and international legislation, environmental management policies, plans and strategies for the catchment should be complied with, such as accommodating new housing within the catchment as detailed in the Wales Spatial plan.

Historic development and some heritage designations present permanent physical obstructions in floodplains.

No degradation of existing sigh passage and habitats.

Some exposed and subsurface archaeological sites in the floodplain are susceptible to changes in water level, flood frequency and water chemistry.

Tourism, leisure and recreation amenities are vital to the economy of the area.

Put in place policies within the Local Development Plans that ensure buildings at risk of flooding are made more resilient.

Flood risk mapping and modelling

Undertake a flood risk mapping study for the fluvial flood risk in Dolgellau;

Undertake an appropriate hydrologic and hydraulic modelling study.

Asset management/maintenance

Develop a System Asset Management Plan;

Continue maintenance of flood defences in Dolgellau;

Continue maintenance of the Afon Wnion and Afon Arran.

Urban drainage

Develop an integrated urban drainage strategy for Dolgellau;

Provide development control advice;

Promote and support the implementation of Sustainable Drainage Systems (SuDS**)** in all new developments.

Flood awareness

Provide information about how the communities can help themselves before, during and after a flood.

The Catchment Flood Management Plan (CFMP) for this region examines the fluvial flood risks and potential influence of tidal waters, but specifically excludes consideration of flooding as a direct result of tidal water levels or wave overtopping. The preferred policy option for the coastal area is Policy 3; *"Continue with existing or alternative flood actions to manage flood risk at the current level".* The policy for Dolgellau is Policy 4: *"Take further action to sustain the current level of flood risk into the future (responding to the potential increases in risk from urban development, land use change and climate change)*".

This tends in terms of management of fluvial flooding to support the general approach of managing coastal risk more generally proposed by SMP1 to the main settlements. With respect specifically to Fairbourne the CFMP policy identifies no increased risk due to climate change and the policy is to maintain current level of fluvial defences. This would in effect provide an on going similar standard of protection. The SMP policy is for Hold the Line. Such a policy would be inappropriate in terms of merely defending against erosion risk as the principal aim of the defence is maintaining appropriate levels of flood defence. As such the With Present Management scenario takes as its baseline the need to improve defences to address sea level rise.

Taking the above approach as defining in general terms the With Present Management scenario, each area of the PDZ is discussed below.

The southern cliffs

In setting a Hold the Line policy for the cliffs through to Rola, SMP1 specifically says that this is in relation to the railway line. It would be feasible to maintain these defences but the length of defence is likely to increase with further erosion. Defence would be specifically to areas of clay cliff. This policy would impact on the designated value of the area but would be considered necessary to maintain the vitally important railway link along the coast. This will involve significant future investment.

The same is the case for defence along the Llwyngwril, Gwastadgoed and Friog Cliffs frontages. Along these frontages there is a longer term risk to property and potentially to the road.

Between these frontages the present policy is for managed realignment. This again is seen as being appropriate with the need to create a buffer zone against use or development. To attempt to hold the line would result in the eventual need to extend defences along most of the frontage as the coast between rolls back. Local defences would create discontinuity in the integrity of the natural flood defence.

Under this scenario, therefore, there would be no increase in sediment supply to Ro Wen.

The estuary entrance together with Ro Wen and Barmouth.
Over this whole length there will be increased pressure on defences and increased flood risk.

In the case of Fairbourne, there are three principle sources of flooding: that arising from river flows, that arising from surface flooding and ground water and that from tidal flooding and overtopping. In dealing with the first two sources, this relies on the ability to discharge water through tidal gates on the lower period of the tidal cycle. With sea level rise, even though the CFMP states that there is not likely to be a need to raise fluvial defences, there would be a significant increase in reliance on pumping due to ground water levels and tidal locking of the tidal gates.

The front sea defence could be sustained and raised. This as identified in SMP1 might require initially recycling of shingle along the frontage. While the limited supply of sediment from the area to the south exacerbates the problem, the main issue would be the general trend for the shingle ridge to roll back.

With sea level rise there would be a need for greater intervention, either in terms of substantially increasing the level of defence and protecting the toe of the existing defence or in terms of building offshore or shore connected structures to retain sediment. All this would be technically feasible, in that, by creating, in effect, additional width to the defence there is likely to be a build up of sediment from the nearshore area. There would, however, still be a need to raise defences in the future.

The rear defence would also need to be raised and reinforced. This would be an on-going issue as sea level rise continues. Technically and potentially economically, given the number of properties at risk, these works could be justified over the next 100 years. There would however be a substantial increase in reliance on defences.

With sea level rise of 1m and in the event of a major surge event exceeding the level of the defences, the flooding would result in, potentially, over 2m depth of water covering the majority of the village. This approach is not seen as being a sustainable approach to risk management.

Impact of different Sea Level Rise Scenarios

Under a 2m sea level rise scenario defence levels would have to be raised significantly over epoch 2 and again over epoch 3, with the expectation that further works would be needed beyond that.
In the event of a failure of the defence or in the pumping system, the depth of water in the village could potentially be up to 3m on a major surge event.

A similar argument may be made in relation to the area current defended behind the Fegla Islands. Here, however, the consequence of overtopping of defences is far less severe. In terms of economics, there is less justification and the critical issue in terms of management is the significance of the Arthog Bog. In the long term (epoch 3) it would seem unsustainable to defend the bog in an increasingly vulnerable location.

The With Present Management approach would however continue to provide defence to the railway line and against local flood to properties between the islands and behind the railway and at Arthog.

At Barmouth the policy in terms of the harbour and the access road, together with the sea front defences is for Hold the Line. There would be a need to maintain and raise defences around the harbour and to maintain the road and railway defences and probably to further reinforce the defence at Ynys y Brawd. This is seen as being sustainable and sustains the important use of the harbour and access to the town.

In defending Ynys Brawd and the causeway, this would sustain the beach in font of the southern part of the town.

The real issue comes in terms of the northern section of the sea front from Heol-y-Sarn north to where the railway approaches the coast. Here there is basically insufficient width within which to maintain a beach. To the north of this section is Llanaber Point. This is heavily defended to protect the railway line. This is one of the areas along the whole section of coast where there is most pressure on the defence. The point does, however, provide a degree on control to North Barmouth. Current defence practice along both sections is for increased linear defence. Under this scenario, this approach would be taken on over the 100 years. In both areas this would require further work to reinforce the frontage with sea level rise. There would be continuing loss of beach and a need to raise defences along the railway line and along the sea front to protect against flooding.

The need to maintain the railway provides the principle justification for defence at Llanaber. There is little scope for retreating the railway line and to do so would increase exposure of the town northern seafront. Maintaining Llanaber Point is seen as being sustainable so long as there is a need to defend the railway. However, even without this justification, continuing to manage this point also provides benefit to defence to the northern end of Barmouth. The future sustainability of a linear defence along the present line to the north end of Barmouth is, however, questionable.

There would be further loss of beach and increasing vulnerability of defences.

The estuary

Over the southern side of the estuary, SMP1 identifies a policy of Hold the Line. The principal reason for this was in maintaining the old railway line as an important amenity and tourist asset. Considered over a fifty year period, the pathway was not considered to be at significant risk. With sea level rise, however, this structure would become more regularly overtopped. It is not now considered realistic to expect this structure to be raised over its full length over the next 100 years. As such, the With Present Management policy is not seen as being sustainable.

At Penmaenpool, it would be anticipated that defence could be maintained. While these defences do come under pressure from river flow and while there might be a need to adapt use of the area due to increased flood risk, the defence does protect an important tourist feature, with car parks and access to the Toll Bridge as well as listed buildings and with its historic landscape designation.

SMP1 did not consider further upstream. Neither is the area of the confluence between the Mawddach and the Wnion specifically discussed by the CFMP in either policy unit 7 or 8. Under this scenario, it has been taken that a policy of maintaining the defence would apply, with at least the perception that farm land would still be useable in the future. This would imply the need to raise defences in line with sea level rise.

Such an approach would be questionable, however. The extent of defences would require significant investment, with little benefit. The defences do constrain the natural ability for the main channel to adapt and could impact negatively on the nature conservation interests. It is uncertain how holding defences might influence the flood risk to Dolgellau and this might need to be investigated further.

In terms of the Wnion and defence to Dolgellau, this is covered by the CFMP. With sea level rise there would be further incursion of tidal waters up the valley. However, only under a 2m sea level rise scenario would this extend normal tidal limits to affect as far as the sewage works by the A493 road bridge. Under more extreme surge conditions the tidal impact could extend up to the main area of the town. The policy under the CFMP is, therefore considered sound but it would be suggested by the SMP that to extend this policy to the lower reaches of the Wnion may prevent use of valuable flood storage area in the low lying areas around the A493 bridge.

Considering the northern side of the estuary, there are key locations where there is risk primarily to the main road through to Barmouth. SMP1 gives a policy of No Active Intervention but with the need identified to maintain defences locally to the road system.

Opposite Penmaenpool is the defended nose of land, with the Toll Road. Even at present this road could be subject to flooding under normal tide levels. To raise defences in line with sea level rise would require substantial investment. It seems doubtful whether this could be justified in the future. One critical aspect of this, that would need to be examined further, would be the influence this area has on the behaviour of the tidal wave propagating upstream.

It would, however, seem appropriate to continue to mange the flood risk to the main road in the Borthwnog area. Similarly, there is flood risk to the road at Farchynys and at Cutiau. The present policy to manage flood risk in these areas seems appropriate. There is very little scope for setting the road back. Defence in these areas could, however, result in local squeeze of habitat. Such squeeze is exacerbated in many respects by the estuaries trend of accretion. This leads to areas of saltmarsh potentially being submerged by sand build up. In defending the local areas of road, therefore, it would be equally important to follow the With Present Management policy in allowing other areas along the northern side of the estuary to behave naturally, creating the opportunity for natural migration of habitat.

The coast north of Llanaber

The southern part of this frontage from Llanaber would be affected by the management of Llanaber Point. This influence is seen more in holding the alignment at the southern end, rather than significantly limiting sediment supply to the frontage. Under the With Present Management scenario, Llanaber Point would be held.

The SMP1 policy for the whole frontage to the north through to Mochras is for No Active Intervention. This has been modified slightly by subsequent strategies, with respect to the Holiday Parks, to one of Managed Realignment. While this policy has not been fully ratified, this policy is considered as the With Present Management scenario, purely to examine such an approach in comparison to that of No Active Intervention.

Managed Realignment can in reality be applied in different ways. In the case of this frontage various approaches have been suggested: that of setting back defences to a predefined line which would then be defended, through to that of removing defences and using beach recharge to sustain a level of defence.

The concern with the first is that the line assessed as being sustainable is of the order of 50m. This has been identified by the holiday park owners as being unacceptable in that it would mean loss of key assets at present within the buffer zone, and that this in itself would mean that the holiday parks would no longer be viable. In addition, from the assessment of potential on-going erosion rates, to set back to a specific line would in the future give rise to exactly the same situation as at present, with the intent or expectation of defending a line indefinitely along a retreating shoreline. This approach gives little recognition as to the inherent uncertainties associated with sea level rise.

The second approach of using recharge, while very sensible in terms of sustaining the natural function of the beach, would lead to a continuous process of retreat, the rate of which would be uncertain, given again the uncertainties associated with sea level rise. This continuous process of retreat would not enable the holiday parks to plan investment and management with any degree of confidence.

Both approaches do, however, highlight that continued defence along the existing line would be unsustainable in the medium to long term and that planning for change is essential.

The general policy of Managed Realignment is considered appropriate but the manner in which it is undertaken would be critical to sustaining the important role played by the holiday parks in sustaining the significant economic benefits associated with the use of the area.

In term of managing the rest of the frontage a policy of No Active Intervention as set out in SMP1 is appropriate.

4 Summary Comparison and Assessment of Baseline scenarios.

Table 1. Economic Assessment

The following table provides a brief summary of erosion damages determined by the SMP2 MDSF analysis for the whole PDZ. Further details are provided in Appendix H. Where further, more detailed information is provided by studies, this is highlighted. The table aims to provide an initial high level assessment of potential damages occurring under the two baseline scenarios.

ASSESSMENT OF EROSION DAMAGES

Epoch	0 -20 year			20 – 50 years			50 – 100 years			50 – 100 years (2m SLR)		
No Active Intervention	**No. of properties:**		**Value**	**No. of properties:**		**Value**	**No. of properties:**		**Value**	**No. of properties**		**PV Damages**
Location	*Res.*	*Com.*	**x £k**	*Res.*	*Com.*	**x £k**	*Res.*	*Com.*	**x £k**	*Res.*	*Com.*	**(£x1000)**
Gwastadgoed/ Friog Cliffs	0	0	0	0	0	0	4	0	764	4	0	43
Fairbourne	0	0	0	0	0	0	21	1	3,596	34	1	276
Barmouth	0	0	0	0	0	0	33	3	4,133	81	12	233
Llanaber	0	0	0	0	0	0	3	1	603	10	2	57
Sunnysands	0	0	0	0	0	0	2	0	228	2	0	16
											Total for PDZ1	
With Present Management	**No. of properties**		**Value**	**No. of properties**		**Value**	**No. of properties**		**Value**	**No. of properties**		**PV Damages**
Location	*Res.*	*Com.*	**x £k**	*Res.*	*Com.*	**x £k**	*Res.*	*Com.*	**x £k**	*Res.*	*Com.*	**(£x1000)**
Gwastadgoed/ Friog Cliffs	0	0	0	0	0	0	4	0	764	4	0	43
Fairbourne	0	0	0	0	0	0	0	0	0	0	0	0
Barmouth	0	0	0	0	0	0	0	0	0	0	0	0
Llanaber	0	0	0	0	0	0	0	0	0	0	0	0
Sunnysands	0	0	0	0	0	0	2	0	228	2		16
											Total for PDZ1	

Notes: PVD determined for 1m SLR in 100 yrs.

Other information: The assessment does not take account of loss of services which would result in loss of property earlier than shown.

The following flood damages have been determined through use of MDSF. These figures are aimed to indicate the level and impact of flood risk rather than being a detailed economic appraisal. In many areas substantial numbers of properties would be liable to flooding on the more frequent events both under NAI and WPM, a nominal write off value has been allowed in the table for properties at frequent risk; this generally excludes values at risk at present on a 1:1 year event, in 50 years time for the 1:10 year event and in 100 year time the 1:50 year event.

ASSESSMENT OF POTENTIAL FLOOD RISK

	Flood risk tidal 2010			Flood risk tidal 2060			Flood risk tidal 2110			tidal risk 2m SLR		
No Active Intervention	**No. of properties**		**AAD**	**No. of properties**		**AAD**	**No. of properties**		**AAD**	**No. of properties**		**PVD**
Location	<1:10 yr.	>1:10 yr	**x £k**	<1:10 yr.	>1:10 yr	**x £k**	<1:10 yr.	>1:10 yr	**x £k**	<1:10 yr.	>1:10 yr	**(£x1000)**
Llwyngwril	0	0	0	0	0	0	0	0	0	0	1	0
Fairbourne	0	411	411	0	412	2446	412	2	23504	418	4	103,209
Afon Mawddach	0	3	1.44	0	3	8	1	7	102	9	0	410
Porth Aberamffra	0	1	4	0	1	19	0	1	20	0	1	296
Barmouth	1	105	15	2	163	96	4	261	1859	92	294	6916
Llanaber	0	3	3	0	3	19	0	4	29	5	2	317
Other in the PDZ	0	0	0	0	0	0	0	0	0	0	1	0
											Total for PDZ11	111,148

With Present Management	**No. of properties**		**AAD**	**No. of properties**		**AAD**	**No. of properties**		**AAD**	**No. of properties**		**PVD**
Location	<1:10 yr.	>1:10 yr	**x £k**	<1:10 yr.	>1:10 yr	**x £k**	<1:10 yr.	>1:10 yr	**x £k**	<1:10 yr.	>1:10 yr	**(£x1000)**
Llwyngwril	0	0	0	0	0	0	0	0	0	0	0	0.00
Fairbourne	0	411	224	0	412	492	0	414	2767	0	422	16994
Afon Mawddach	0	3	0.70	0	3	2	0	7	16	0	9	78
Porth Aberamffra	0	1	4	0	1	19	0	1	20	0	1	296
Barmouth	0	106	15	0	165	36	0	265	108	0	386	921
Llanaber	0	3	8	0	3	5	0	4	29	0	7	160
Other in the PDZ	0	0	0	0	0	0	0	0	0	0	1	0
											Total for PDZ11	18,449

Table 2. General Assessment of Objectives

The following table provides an overall assessment of how the two baseline scenarios impact upon the overall objectives. Specific objectives are set out in more detail within Appendix E. The table aims to provide an initial high level assessment of the two baseline scenarios, highlighting potential issues of conflict. These issues are discussed in the following section, examining alternative management scenarios from which SMP2 policy is then derived.

STAKEHOLDER OBJECTIVE	NAI			WPM		
	Fails	Neutral	Acceptable	Fails	Neutral	Acceptable
Reduce risk to life						
Protect properties from flood and erosion loss						
Identify communities at risk and allow opportunity for adaptation						
Minimise the need for increasing effort and management of coastal defences						
Avoid reliance on defence particularly where there is a risk of catastrophic failure						
Highlight areas long term sustainability issue and where there may need to be relocation						
Maintain connectivity along the estuaries to main centres in land						
Maintain connectivity between local communities along the coast						
Maintain Barmouth as a critical centre						
Maintain recreational use of beaches and bays						
Maintain access to the coast including car parking and facilities						
Maintain access for boat use and associated water sport activity						
Maintain the opportunity for sustainable adaptation of the main Holiday centres.						
Maintain character and integrity of coastal communities						
Maintain the ability for adaptation and opportunity for economic growth of small communities						
Maintain agricultural value of rural community						
Identify risk and reduce risk of loss of heritage features where possible						
Maintain historic landscape						
Prevent disturbance or deterioration to historic sites and their setting						
Maintain or enhance the condition or integrity of the international (SAC, SPA) designated sites and interest features within the context of a dynamic coastal system.						
Maintain or enhance the condition or integrity of the national (SSSI) designated sites and interest features within the context of a dynamic coastal system.						

STAKEHOLDER OBJECTIVE	NAI			WPM		
	Fails	Neutral	Acceptable	Fails	Neutral	Acceptable
Maintain and enhance educational and scientific understanding of geology and geomorphology						
Avoid damage to and enhance the natural landscape.						
Maintain the human landscape and character of communities						
Maintain the critical road network						
Maintain the critical rail network.						

5 Discussion and Detailed Policy Development

Quite clearly there are critical issues with both baseline scenarios. The conflict between objectives develops mainly over time, with the threat of sea level rise; it is very much in extending the current approach to management into the future where these difficulties arise. The need to reinforce and raise defences creates, in many areas, a much greater reliance on those defences and vulnerability of areas dependent on these defences, this is seen as applying most critically at Fairbourne and at Barmouth.

One major factor steering present management is the need to maintain the railway and road system. In terms of the railway, in particular, this has to be considered over the whole area, and indeed in relation to management in other areas. Quite clearly this raises issues in terms of impacts along the full length of the coast. In relation to this zone, there are three critical areas identified where there are potential links with more local management.

Along the southern cliff line, the need to defend sections of the coast to support the railway would reduce to some degree the supply of sediment to the Ro Wen. There would also be the issue of increasing defence in an environmentally sensitive area. With respect to the first, this reduced sediment supply, while recognised to impact on management of the Fairbourne frontage is not considered to be a significant factor in management decisions in this area. In the case of the latter, the impact at the local level does have to be considered. This is difficult and is assessed in the SEA and HRA. Despite the importance of this issue, it is not one that would change significantly the approach to management elsewhere.

The second location where maintaining the railway is a significant issue is in management at Fairbourne. The railway is behind the village and can therefore be considered to a degree separately from management of risk to the village. This again, therefore, does not substantially influence management at the larger scale, in that the railway is not dictating the approach to management at the shoreline.

The final critical area is at Llanaber. Here the defence of Llanaber Point is considered strategically important in maintaining a sustainable defence along both the Barmouth frontages and to the north. As such, broader management of the shoreline is in line with the specific management of risk to the railway. Even in the absence of the railway, there would, sensibly, still be value in managing the Point as a strategic location along the coast.

There are of course other strategic issues over the whole frontage. These include the impact more generally on the natural environment. Critical areas are seen as being in relation to the southern cliffs as discussed above, within the estuary; this is seen as being quite local although needing to be considered in the context of management elsewhere and along the northern dune frontage; where there is the potential impact of management of the holiday parks. In this latter case, this is seen as being an issue in relation to the whole northern frontage but not substantially linked to areas further south.

There are also issues related to the overall management of the estuary entrance and Barmouth. This whole area has to be considered as a whole, but is not an issue that significantly influences decisions elsewhere.

On this basis it is still appropriate to discuss management within the same sections as used in the discussion of the baseline scenarios.

The southern cliffs

The main issue over the frontage as identified in SMP1 is the risk to the railway. The railway is seen as being a nationally important asset. There would be significant investment needed to be made, particularly in epoch 3. This could result in damage to the nature conservation interests of the area. However, the decision really needs to be made at a national level, taking account of the investment also needed in other areas of the SMP. Should that investment not be considered to be worthwhile at a regional and national level in the future then the default policy would for No Active Intervention. However, to deliver one of the fundamental objectives to maintain the important public transport system, identified as essential in supporting the aims of the Wales Spatial Plan, the intent for areas where the railway is at risk would be to Hold the Line.

More locally, where the railway is not at risk the intent would be to allow the coast to function naturally. Over much of the coast this would be a policy of No Active Intervention. In the area of Gors Wen through to Borth Wen the SMP1 policy of Managed Realignment is considered appropriate. The intent of this would be to manage realignment of the use of the area rather than any specific intervention in terms of defence. This policy approach, therefore, boarders more on a policy of No Active Intervention, but with the intent to facilitate realignment of the caravan parks, providing flood warning and providing advice in terms of managing the consequences of flooding. Under this policy, there would be no support given to private action that might interfere with the coastal processes. This is important in maintaining the integrity of the natural defence provided by the retreating shingle beach.

The estuary entrance together with Ro Wen and Barmouth.

The With Present Management policy for the whole Fairbourne frontage is not considered sustainable in the long term. Under present conditions it is technically and economically possible to maintain the defences and manage flood risk to the area. The critical threshold comes as sea level rises, such that the area would be increasingly dependent on pumping to maintain ground water and surface water flooding to an acceptable level. This is also coupled with the increasing vulnerability of the community to failure of the front line coastal defences.

While it is recognised that the SMP can only make an initial assessment of this risk, it is considered that the issue is not likely to be one of, if the critical threshold is reached, but one of when it would be reached. This critically depends on the rate of sea level rise. In this initial assessment it is considered that the threshold might be of the order of 0.5m sea level rise. Under such conditions, there would be significantly greater pressure on the open coast to retreat, requiring not just the need to raise the concrete wall but also to reinforce the whole front face of the defence such that there would be a step change in the approach to management of this defence. In relation to the rear embankment an increase in defence level of 0.5m might be achieved through construction of a crest wall. Any increase above 0.5m would require significant re-engineering of the defence such that this would require significant investment over the full length of the embankment.

In terms of management of surface and ground water, an increase in sea level of about 0.3m, means that much of the village is below normal high tide levels. The problems identified in the CFMP of wetter winters and sudden fluvial discharge would be significantly exacerbated. General rise in the water table that might be expected with a 0.5m sea level rise would mean that approaches such as sustainable urban drainage or flood resilience measure would become less effective and pumping to maintain acceptable water levels would increase significantly.

Taking this 0.5m threshold level, it is considered that without major investment management of flood risk would not be achievable. Having made this step change in investment, there would be an expectation that further investment would be provided in future years. This would, in effect, be making a commitment to increasing cost of defence and increasing the vulnerability of the community into the future. This is not considered sustainable.

Based on this initial assessment and based on the guidance for sea level rise, the threshold would be reached in 65 years.

Impact of different Sea Level Rise Scenarios

Under a 2m sea level rise scenario the threshold would be reach in about 45 years. Under a lower than anticipated sea level rise the threshold would not be reached potentially for 100 years.

Despite this uncertainty, the SMP has to advise on the basis of current sea level rise guidance. It is also recognised that to manage change will take a significant resource and planning. As such the SMP defines the following policy: epoch 1 – Hold the Line; maintaining and where appropriate taking local measures to improve flood defence and resilience, epoch 2 – Managed realignment; maintaining defences while taking positive action to relocate people from Fairbourne, epoch 3 – No Active Intervention. Clearly planning need to be considered now and this outline timescale for change would need to be developed through more detailed investigation.

The railway runs to the back of the village. While there are issues of long term sustainability, given the policy for Fairbourne, it would be considered possible to maintain this route. Associated with this would be the opportunity to provide defence to areas behind the railway. Much of the land is undeveloped and it is only really locally that there are longer term issues of regular flood risk. As such the consequence of maintaining and, as necessary, raising the railway, becomes less critical in terms of vulnerability. As such the policy for the railway and the land behind would be to Hold the Line. This would not imply that this area is available for any further development.

This policy would be extended to include where the railway links through to the bridge and the old railway would probably need to be improved as a flood defence.

The intent for the land behind the Fegla islands would be for long term managed realignment. This would be in terms of a policy for Hold the Line, during epoch 1 followed by Managed Realignment. There would be scope under this policy for local defence to be considered to properties at Arthog and while it may be possible to maintain defence to properties on the islands, consideration would need to be given as to access.

These again are recognised to be major changes in expectation for continued defence and significant resource would be needed to manage this change.

With the above policy there would be change in the behaviour of the estuary entrance. However, in maintaining the railway and in maintaining the control imposed by the railway causeway beneath the bridge, the main channel would still be fixed in its present position. The Ro Wen spit would tend to roll back and there could be some increased exposure to the harbour area at Barmouth.

At the southern end of Barmouth, the intent would be to maintain the defences and to continue to maintain the influence of Ynys y Brawd. This is considered important in maintaining defence to the southern part of the seafront and in maintaining protection to the harbour with sea level rise.

During consultation there were views expressed that the causeway to the island should be removed to re-establish the old North Channel. In the earlier discussion of coastal processes, it was considered that closure of the channel was, in effect, only bringing forward the time when this channel closed naturally. With sea level rise this channel might have re-opened. However, this would have been associated with the general retreat of the shoreline to the north. The implications of this would have been that sediment would have been carried through the gap between the island and the main land tending increase sediment input to the entrance channel. While locally there might be increased water depth in the channel, the longer term trend would have been for the main area of the harbour to accrete.

Certainly now, to remove the causeway would tend to lower the foreshore in front of the southern area of the sea front and to impose greater pressure for erosion at the apex in the sea front.

The policy for the area of southern Barmouth, Barmouth harbour and the access road to Barmouth is to Hold the Line.

The general policy at Llanaber Point would also be to Hold the Line. However, to the north end of Barmouth the SMP1 policy of Hold the Line is going to become increasingly difficult to sustain. A linear approach to defence of this northern section of the town, together with that for the railway line will require significantly greater effort for defence and result in loss of important amenity value. Consideration should be given to widening the overall defence system in this area. This may require nearshore or shore connected structures to reduce wave energy but is also likely to require some future realignment of the defences, quite probably with the loss of property. This would require a more integrated approach to management, considering how the northern seafront could be developed to better advantage both in term of use and shoreline management. This goes beyond the scope of the SMP. The SMP policy for the northern end of Barmouth would be to Hold the Line during epoch 1, but to change to one of Managed Realignment over epochs 2 and 3.

While the Barmouth frontage through to Llanaber would be defined as three policy units, the policies need to be progressed as one overall area. The manner in which Llanaber Point is managed influences the way in which the north Barmouth frontage and the manner in which the apex between north Barmouth and south Barmouth is approached needs to be integrating management to both north and south. In all probability works will be needed to the north Barmouth frontage towards the end of Epoch 1. Planning for a more adaptive approach to management, therefore, needs to be undertaken during Epoch 1.

The estuary

The SMP1 policy for the southern side of the estuary for Hold the Line is not seen as being realistic possibly even in epoch 2. The path and cycle way along the old embankment would be maintained for as long as possible but during Epoch 2. The embankment would be subject to increased risk of overtopping. While the basic structure would remain and could be maintained, the intent would be that this structure

does not provide a flood defence function. Only at Penmaenpool, would there be an intent to specifically maintain and raise defences to protect the lower part of the village.

It is not considered realistic to commit to the increasing cost of maintaining and raising defences upstream of Penmaenpool. Consideration might be given to local defence of specific property but either the need to substantially increase defences or to reinforce them to withstand increased overtopping is not considered to be sustainable with sea level rise. Typically, depending on the present condition of defences, they would become increasing difficult to maintain during epoch 2. Within the general area further consideration needs to be given to future management of the nose of land running down opposite Penmaenpool. This needs to be considered in term of the potential impact of water levels upstream. Rather than, therefore, having a long term intent of No Active Intervention, the policy for the whole area upstream of Penmaenpool, including the area of the Toll Road would be for possible future management. This would be with the intent of Managed Realignment, not Hold the Line. A policy of Managed Realignment would not preclude continued defence in some areas, particularly with respect to the Toll Road initially. How managed realignment impacts on water levels within the upper estuary needs to be examined in detail and needs to be developed in discussion with land owners.

Downstream of Borthwnog, the intent of management defined in SMP1 is considered appropriate. This would be that defence to the road would be maintained and raised as necessary, but that the overall policy elsewhere on the frontage would be to allow natural development of the estuary. Whether such a policy is defined as No Active Intervention with the caveat that work would still be undertaken to defend the road or one of Managed Realignment is not the essential issue. The intent is to allow natural function of the estuary, while still maintaining access along the road. Even though it is unlikely that there is much opportunity to realign the road, this should still be considered in detail before works are undertaken purely to raise the defence.

The coast north of Llanaber

The underlying intent along this section of coast is to allow its natural development and not to be in a situation where there is commitment to larger and larger defences to protect assets indefinitely. The underlying intent is, therefore, to create space in terms of land use.

However, the various Holiday Parks are recognised to be an important asset to the region and commercial operations which help sustain the small communities in the local area.

It is improbable that public money would be spent in creating or maintaining defences to these parks. However, there are issues in terms of management of the frontage, the potential impact on landscape and on the designated nature conservation areas that do require management. The policy for the frontage is quite clearly Managed Realignment, rather than No Active Intervention. The real issue is the way in which Managed Realignment is undertaken. Associated with this is the uncertainty inherent in predicting sea level rise.

The degree to which existing defences impact on sediment drift at present is uncertain. There is, however, little evidence that there is any significant build up of shingle on the southern side of the defence, as might be anticipated if this were the case. There is also a substantial shingle bank to the north which tends to act to close off the estuary. At present it is concluded that the defences are not significantly impacting, either directly or

indirectly, on the SSSI and SAC area of Morfa Dyffryn to the north or, at present on the development of the SAC directly in front of the various sections of defence. This is likely to change as the natural coastline rolls back. As such it is critical that monitoring is undertaken. It is recognised that the defences do have a significant landscape impact and quite probably affect the amenity use of the beach, which in turn has an impact on the holiday parks.

Even with minimal sea level rise, the continuing erosion of the frontage will start to change this. The existing defences are likely to reduce the area of the beach, potentially increasing scour and erosion. As erosion to the adjacent frontages continues so the defences would form more as headlands and this would ultimately start impacting on potential sediment supply to the shoreline to the north. In addition, maintaining defences would become more difficult and would become increasingly expensive. Typical cost of a rock revetment designed to resist full wave action in deep water is of the order of £10,000/m. This compares to the typical cost of a crest revetment as at present in place of the order of £3000/m.

Under realistic sea level rise scenarios this process would accelerate. This uncertainty is likely to become less as further information on sea rise is developed over epoch 1.

Management needs to achieve a balance, therefore, between:

- sustaining and allowing sustainable operation of the holiday businesses. This requires confidence in planning further investment in infrastructure.
- not exceeding that threshold where defence would start to significantly impact on the beach and the important designated habitats
- and not developing into a situation where there is marked escalation of costs and as a consequence becoming locked into the need for continuing additional cost in the future.

Any realistic buffer zone based on current understanding of the processes developed over the full 100 years would require a distance typically of the order of 100m. This would in the case of Sunnysands take out most of the site and would significantly impact on the viability of Islawffordd. This option, defining a long term buffer zone would not achieve the balance identified above; neither would setting a narrower buffer zone with the expectation that this line could be held indefinitely.

While recharge of the beach may offer significant advantages, this approach to management would require acceptance that the coast would be continuously retreating. This would, although slowing the process, still provide little confidence in use of the forward sections of the sites and would require continuous adjustment to this continuous process of retreat.

The solution needs to be examined at a local level with the emphasis on monitoring demonstrating that no impact will arise over the lifetime of those defences. The details of such an approach would require careful consideration, discussion and agreement; this involving the land owners, the operating authorities, planning authority and CCW. The landowners would need to look critically at existing assets and consider to what degree each element of their site might be essential to their operation but that how in the future that element of the site might be relocated. The operating authorities and planners, with advice from CCW would need to consider what critical indicators might trigger the need for further adjustment of defences.

In this way the approach to sea level rise and on-going erosion would be responsive, rather than reactive or pre-emptive. It is envisaged that defence of critical park infrastructure would not necessarily extend over the full length of each frontage and that the approach to defence would be looking to allow defences to work more effectively with the natural development of the shoreline.

6 Management Summary.

The coast has been subdivided into five principal management areas, within each area the frontages are further subdivided into policy units. A summary of policies are set out in the tables below. Where sensible the SMP1 unit names have been retained.

MA 21 SOUTHERN CLIFFS: From Tonfanau to Friog Cliffs

Policy Unit		**Policy Plan**			
		2025	**2055**	**2105**	**Comment**
11.1	Rola	HTL	HTL	HTL	This relates specifically to defence of the railway line.
11.2	Llwyngwril	MR	MR	MR	This realignment is in relation to facilitating realignment of land use, with the intent to maintain the natural function of the shoreline.
11.3	Friog Cliffs	HTL	HTL	HTL	This relates to defence of the railway line and road.
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

MA 22 MAWDDACH ENTRANCE - SOUTH: From Friog Cliffs to Arthog

Policy Unit		**Policy Plan**			
		2025	**2055**	**2105**	**Comment**
11.4	Ro Wen coast	HTL	MR	NAI	This would involve relocation of property owners and businesses from Fairbourne
11.5	Ro Wen Spit	MR	MR	NAI	
11.6	Fairbourne Embankment	HTL	MR	NAI	
11.7	Friog	HTL	HTL	HTL	This refers to the railway line behind Fairbourne.
11.8	Morfa Mawddach	HTL	HTL	HTL	This would secure a cut off defence to the back of the area to the rear of Fegla Islands.
11.9	Fegla	HTL	MR	MR	Local consideration would be given to defence of properties on the Fegla Islands and to Arthog
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

MA 23 MAWDDACH ESTAURY: From Arthog to Porth Aberamffra

Policy Unit		**Policy Plan**			
		2025	**2055**	**2105**	**Comment**
11.10	Mawddach south	MR	MR	MR	
11.11	Penmaenpool	HTL	HTL	HTL	
11.12	Upper estuary	MR	MR	MR	This would require further investigation.
11.13	Mawddach north	MR	MR	MR	The intent is solely to manage risk to the

					road.
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

MA 24 BARMOUTH: From Porth Aberamffra to Llanaber Point

Policy Unit		**Policy Plan**			
		2025	**2055**	**2105**	**Comment**
11.14	Barmouth South	HTL	HTL	HTL	
11.15	Barmouth North	HTL	MR	MR	This may include relocation of properties
11.16	Llanaber	HTL	HTL	HTL	This needs to be considered in term of management to the above policy unit.
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

MA 25 DYFFRYN ARDUDWY: From Llanaber Point to Mochras

Policy Unit		**Policy Plan**			
		2025	**2055**	**2105**	**Comment**
11.17	Egryn Marsh	MR	NAI	NAI	
11.18	Sunnysands	MR	MR	MR	The approach would be developed locally based on the demonstration of no impact on designated areas.
11.19	Islawffordd	MR	MR	MR	The approach would be developed locally based on the demonstration of no impact on designated areas.
11.20	Morfa Dyffryn	NAI	NAI	NAI	
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

PDZ11
Management Area Statements

MA 21 Southern Cliffs
Tonfanau to Friog Cliffs

MA 22 Mawddach Entrance - South
Friog Cliffs to Arthog

MA 23 Mawddach Estuary
Arthog to Porth Aberamffra

MA 24 Barmouth
Porth Aberamffra to Llanaber Point

MA 25 Dyffryn Ardudwy
Llanaber Point to Mochras

Location reference:	**Southern Cliffs**
Management Area reference:	**M.A. 21**
Policy Development Zone:	PDZ11

* Note: Predicted shoreline mapping is based on a combination of monitoring data, analysis of historical maps and geomorphological assessment with allowance for sea level rise. Due to inherent uncertainties in predicting future change, these predictions are necessarily indicative. For use beyond the purpose of the shoreline management plan, reference should be made to the baseline data.

The following descriptions are provided to assist interpretation of the map shown overleaf.

100 year shoreline position:
The following maps aim to summarise the anticipated position of the shoreline in 100 years under the two scenarios of "With Present Management" and under the "Draft Preferred Policy" being put forward through the Shoreline Management Plan.

- In some areas the preferred policy does not change from that under the existing management approach. In some areas where there are hard defences this can be accurately identified. In other areas there is greater uncertainty. Even so, where the shoreline is likely to be quite clearly defined by a change such as the crest of a cliff the estimated position is shown as a single line.

- Where there is a difference between With Present Management and the Draft Preferred Policy this distinction is made in showing two different lines:

  With Present Management.
  Draft Preferred Policy.

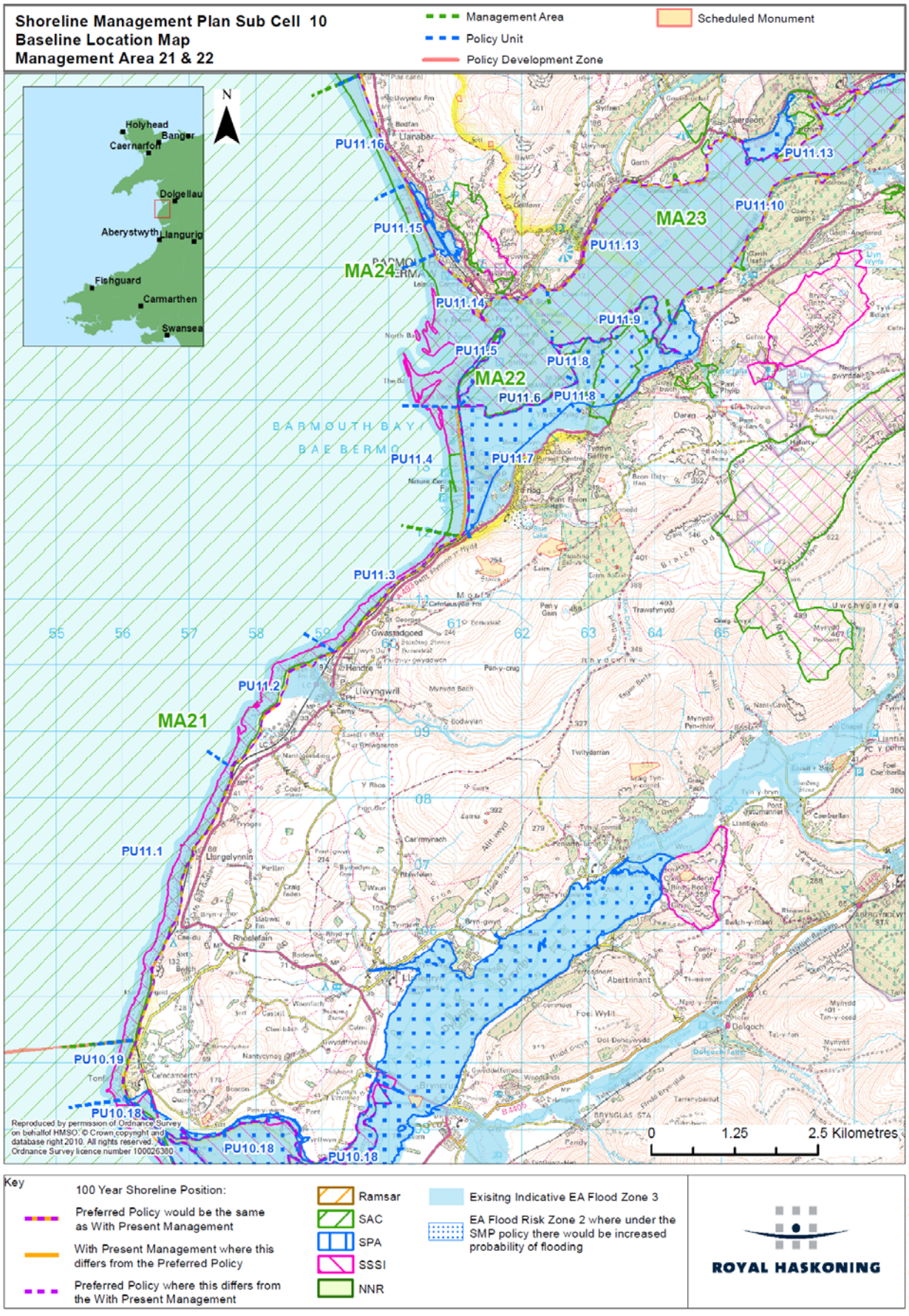
Flood Risk Zones

General Flood Risk Zones. The explanation of these zones is provided on the Environment Agency's web site www.environment-agency.gov.uk. The maps within this Draft SMP document show where SMP policy might influence the management of flood risk.

Indicate areas where the intent of the SMP draft policy is to continue to manage this risk.

Indicate where over the 100 years the policy would allow increased risk of flooding.

The maps should be read in conjunction with the text within the Draft SMP document.


Shoreline Management Plan Sub Cell 10
Baseline Location Map
Management Area 21 & 22
Management Area
Policy Unit
Policy Development Zone
Scheduled Monument
N
Holyhead
Bangor
Caernarfon
Dolgellau
Aberystwyth
Llanguric
Fishguard
Carmarthen
Swansea
MA21
MA22
MA23
MA24
PU11.1
PU11.2
PU11.3
PU11.4
PU11.5
PU11.6
PU11.7
PU11.8
PU11.9
PU11.10
PU11.13
PU11.14
PU11.15
PU11.16
PU10.18
PU10.19
BARMOUTH BAY
BAE BERMO
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0
1.25
2.5 Kilometres
Key
100 Year Shoreline Position:
Preferred Policy would be the same as With Present Management
With Present Management where this differs from the Preferred Policy
Preferred Policy where this differs from the With Present Management
Ramsar
SAC
SPA
SSSI
NNR
Exisitng Indicative EA Flood Zone 3
EA Flood Risk Zone 2 where under the SMP policy there would be increased probability of flooding
ROYAL HASKONING
I:\9T9001\Technical_Data\GIS\Projects\SMP_Report_Figures\Management Areas

SUMMARY OF PREFERRED PLAN RECOMMENDATIONS AND JUSTIFICATION

INTENT OF THE PLAN:

The general aim of the plan is to allow continued natural development and erosion of the shoreline. However, it is recognised that there is a need to maintain the function of the railway and road and therefore suggests a policy of Hold the Line where these assets are at risk. As a consequence of managing the defence to the transport network, defence would also be provided to properties at the northern end of Llwyngwril. Management of these defences would aim to minimise interference with the natural shoreline.

At Borth Wen the coast would be allowed to adapt naturally, developing shingle bank which will provide a degree of flood defence to the areas behind.

KEY ISSUES/RISK AND UNCERTAINTY:

There are uncertainties in terms of timing of possible impacts and the need for future intervention. There is also a need for a detailed planned response to change over the Borth Wen frontage. It will be important to relate this to national monitoring of sea level rise and more general climate change, in addition to continued monitoring of the shoreline.
The need for further intervention to protect the railway line would be subject to the review of investment required along other sections of the coast.

ACTIONS:

ACTION	PARTNERS	
Shoreline monitoring	**GC**	
Adaption planning at Borth Wen	**Landowners**	
Agree form of defence to minimise impact on designated sections of the coast	**Network Rail**	**CCW** **GC**
Assess in detail potential impact on historic environment	**CADW**	

DELIVERY OF THE PLAN

SUMMARY OF SPECIFIC POLICIES

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
11.1	Rola	HTL	HTL	HTL	This relates specifically to defence of the railway line.
11.2	Llwyngwril	MR	MR	MR	This realignment is in relation to facilitating realignment of land use, with the intent to maintain the natural function of the shoreline.
11.3	Friog Cliffs	HTL	HTL	HTL	This relates to defence of the railway line and road.
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

PREFERRED POLICY TO IMPLEMENT PLAN:	
From present day	Maintain existing defences to railway and road and confirm acceptability of future planned defence measures.
Medium term	Maintain existing defences to railway and road and confirm acceptability of future planned defence measures
Long term	Maintain existing defences to railway and road and confirm acceptability of future planned defence measures.

IMPLICATIONS OF THE PLAN

CHANGES FROM PRESENT MANAGEMENT

There is no substantial change in management.

ECONOMIC SUMMARY

Economics (£k PV)	by 2025	by 2055	by 2105	Total £k PV
NAI Damages	0.0	0.0	43.0	43.0
Preferred Plan Damages	0.0	0.0	0.0	0.0
Benefits	0.0	0.0	43.0	43.0
Costs	0.0	0.0	0.0	0.0

No costs have been included for management of railway. Damages do not include for disruption to the transport network.

FLOOD AND EROSION RISK MANAGMENT

POTENTIAL LOSS

There is unlikely to be any loss of property but there would be increased flood risk with sea level rise to the land around Borth Wen.

BENEFITS OF THE PLAN

The plan provides for defence of the transport network and as a consequence also provides continued protection to 4 properties identified at risk from erosion.

SUMMARY OF STRATEGIC ENVIRONMENTAL ASSESSMENT (INCLUDING HRA)

PDZ 11				
SEA Objective	**Impact of Preferred Policy for each Epoch**			
	1	**2**	**3**	**Mitigation**
Policy Units 11.1 to 11.20				
To support natural processes, maintain and enhance the integrity of internationally designated nature conservation sites. Maintain / achieve favourable condition of their interest features (habitats and species).				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance the designated interest of nationally designated nature conservation sites. Maintain/achieve favourable condition.				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance national and local BAP habitats.				Habitat creation
To support natural processes and maintain geological exposures throughout nationally designated geological sites.				Monitoring and appropriate design
To conserve and enhance nationally designated landscapes in relation to risks from coastal flooding and erosion and avoid conflict with AONB and National Park Management Plan Objectives.				Appropriate design
To minimise coastal flood and erosion risk to scheduled and other internationally and nationally important cultural heritage assets, sites and their setting.				Excavation and recording
To minimise the impact of policies on marine operations and activities.				
To minimise coastal flood and erosion risk to critical infrastructure and maintain critical services.				Relocation or realignment
To minimise coastal flood and erosion risk to agricultural land and horticultural activities.				
To minimise coastal flood and erosion risk to people and residential property.				Relocation
To minimise coastal flood and erosion risk to key community, recreational and amenity facilities.				
To minimise coastal flood and erosion risk to industrial, commercial, economic and tourism assets and activities.				

There is little opportunity for habitat creation within this area although some opportunity may arise from MR at Borth Wen.

This table provides a summary of the SEA (appendix E) and reference should be made to the Appendix for full details of the assessment.

These next two sections provide a headline summary of the findings of the HRA (Appendix G) and the WFA (Appendix H). Reference should be made as appropriate to these Appendices for full details.

HRA SUMMARY

Anticipated Habitat Loss in PDZ 11 as a result of SMP Policy

Designated Site	PU	Habitat Type	Extent of Loss of Habitat (ha)			
			Epoch 1	Epoch 2	Epoch 3	Total
Llŷn Peninsula and the Sarnau SAC	11.1	Intertidal sandflat	0.00	6.82	1.46	8.28
	11.3	Intertidal sandflat	0.00	0.90	0.11	1.01

Pen Llyn a`r Sarnau/ **Llŷn Peninsula** and the Sarnau SAC: It is concluded that there would be an adverse effect on the integrity of the intertidal habitat (sandflat) within the boundary of the SAC as a result of the SMP2 policies. There will however, be no adverse effect on the integrity of the other SAC features.
Morfa Harlech a Morfa Dyffryn SAC: **no adverse effect on the integrity of the SAC**.

Coedydd Derw a Safleoedd Ystlumod Meirion/ Meirionnydd Oakwoods and Bat Sites SAC: no adverse effect on the integrity of the SAC.

Preventative/mitigation measures: Potentially move defences landward were feasible to allow saltmarshes to roll back in time with sea level rise; and investigate possibilities of realigning small areas of the banks to mitigate for coastal squeeze of saltmarshes within the estuary for all epochs in PU 11.11.

The MR policy within PU 11.13 would need to ensure that there is no loss of woodland/heathland, and that it results in sensitive and natural flooding to any habitat rather than structures.

Risks/Assumptions: The habitat loss is considered precautionary, and where any works are to be undertaken detailed study would provide an accurate identification of whether habitat would be lost and the extent. Potentially, given the worst case assumptions, further detail of the likely actions and site specific study may conclude no habitat loss, given the worst case scenario used in this assessment. The areas of potential habitat loss are large, and this is exacerbated by the fact that such low lying areas would show a large scale change, but this does not take into account accretion of sediments within the estuary. Consequently, the assumptions used to determine loss are expected to have resulted in much greater extents of habitat loss than would occur.

SUMMARY CONCLUSION FROM THE WATER FRAMEWORK ASSESSMENT							
Water body (and relevant PDZ)	**Environmental Objectives met?**				**WFD Summary Statement required?**	**Achievement of Any South East RBMP Mitigation Measures?**	**Details on how the specific South East RBMP Mitigation Measures have been attained** (dark green = achieved; light green = partly achieved & red = not achieved)
	WFD 1	**WFD2**	**WFD3**	**WFD4**			
Cardigan Bay North (Coastal) (PDZs 9, 10, 11, part 12, part 13 and 14.) (MAN 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, part 26, 33, 34, 35, 36 and 37)	N/A	**x** (PDZ 10, 11)	**x** (PDZ 10, 11)	✓	**Yes** – Environmental Objectives WFD 2 and 3 may not be met because of the SMPs policy in PDZ 10 (MAN 20), PDZ 11 (MAN 21).	There were no relevant measures to the SMP2 for this water body, though there are for the affected FWBs.	Mitigation measures for the FWB (GB110064048310), of which none have been implemented within the SMP2: • Increase in-channel morphological diversity; • Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works; • Operational and structural changes to locks, sluices, weirs, beach control, etc; • Selective Vegetation Control Regime; • Appropriate Vegetation Control Technique; • Appropriate timing (Vegetation control); • Appropriate Techniques (Invasive Species); and • Retain marginal aquatic and riparian habitats (channel alteration).

Location reference:	**Mawddach Entrance - South**
Management Area reference:	**M.A. 22**
Policy Development Zone:	PDZ11

* Note: Predicted shoreline mapping is based on a combination of monitoring data, analysis of historical maps and geomorphological assessment with allowance for sea level rise. Due to inherent uncertainties in predicting future change, these predictions are necessarily indicative. For use beyond the purpose of the shoreline management plan, reference should be made to the baseline data.

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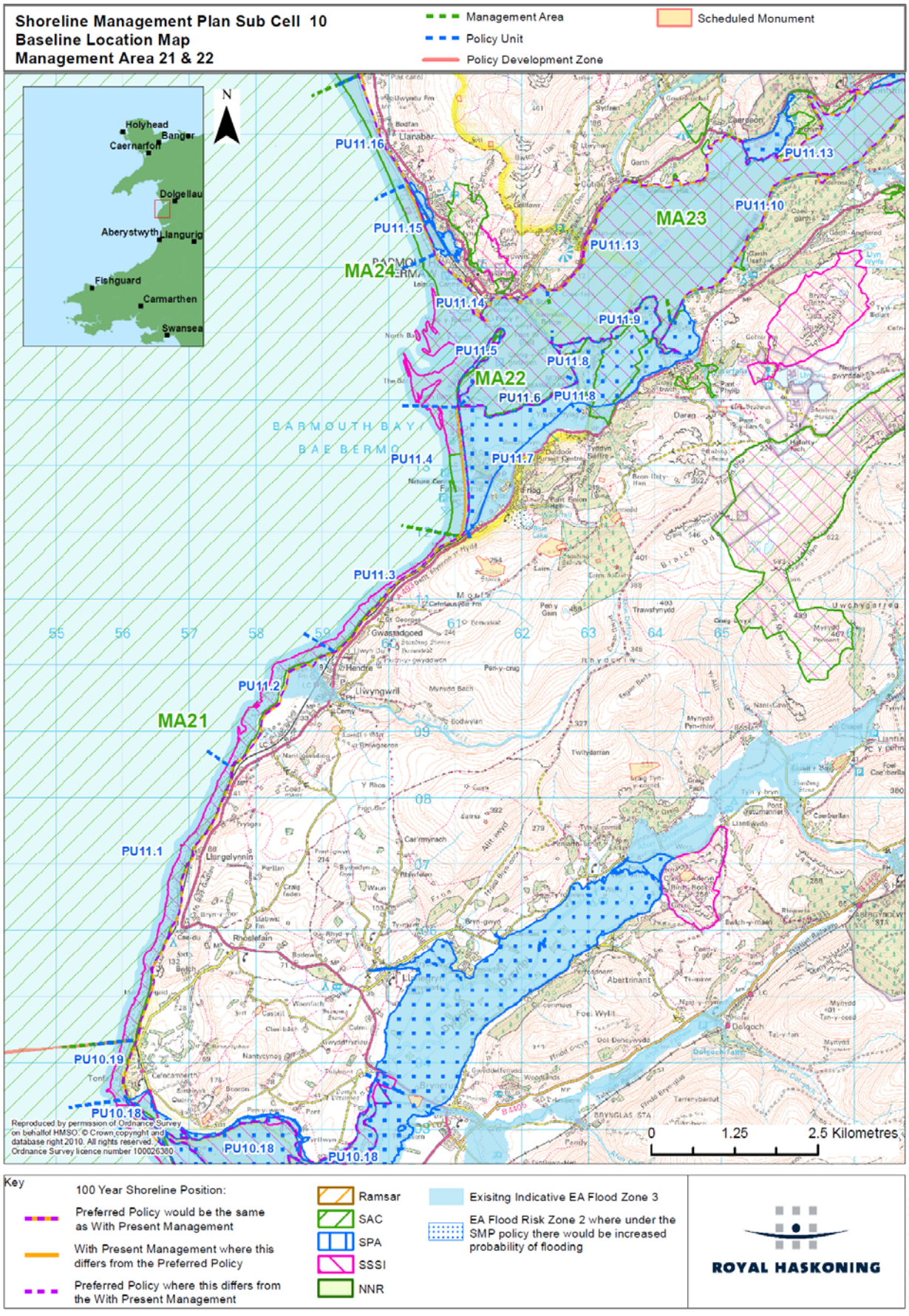
General Flood Risk Zones. The explanation of these zones is provided on the Environment Agency's web site www.environment-agency.gov.uk. The maps within this Draft SMP document show where SMP policy might influence the management of flood risk.

Indicate areas where the intent of the SMP draft policy is to continue to manage this risk.

Indicate where over the 100 years the policy would allow increased risk of flooding.

The maps should be read in conjunction with the text within the Draft SMP document.


Shoreline Management Plan Sub Cell 10
Baseline Location Map
Management Area 21 & 22
Management Area
Policy Unit
Policy Development Zone
Scheduled Monument
N
Holyhead
Bangor
Caernarfon
Dolgellau
Aberystwyth
Llanguric
Fishguard
Carmarthen
Swansea
MA21
MA22
MA23
MA24
PU11.1
PU11.2
PU11.3
PU11.4
PU11.5
PU11.6
PU11.7
PU11.8
PU11.9
PU11.10
PU11.13
PU11.14
PU11.15
PU11.16
PU10.18
PU10.19
BARMOUTH BAY
BAE BERMO
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0
1.25
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Exisitng Indicative EA Flood Zone 3
EA Flood Risk Zone 2 where under the SMP policy there would be increased probability of flooding
ROYAL HASKONING
I:\9T9001\Technical_Data\GIS\Projects\SMP_Report_Figures\Management Areas

SUMMARY OF PREFERRED PLAN RECOMMENDATIONS AND JUSTIFICATION

INTENT OF THE PLAN:

There are significant concerns over the medium to long term sustainability of defence at Fairbourne. There is a need to maintain existing defences and reduce flood risk to the area in the short term. However, any major increase in protection, particularly with respect to deal with groundwater, pluvial and fluvial water as sea level rises, starts to create an unsustainable approach to management. This could lead to significant residual risk and the possibility of a catastrophic failure should the standard of defence be exceeded. For these reasons the intent of the plan is to move away from defence over epochs 2 and 3, with the consequential need for relocation. There is little, or no opportunity for adaptation, in terms of defence or property. Defence would continue to the railway line along the rear of the village and this would provide opportunity for defence to properties behind.

Similar arguments exist for the defence behind the Fegla frontage and the intent of the plan here is to allow increased flooding. This could be managed over epochs 1 and 2, providing an opportunity for adaptation of the community, land use and the nature conservation interests. The intent would be to examine the opportunity for local defence to the community of Arthog.

KEY ISSUES/RISK AND UNCERTAINTY:

There are uncertainties in terms of timing of the proposed changes and impacts. There is also a need for a detailed planned response to change. It will be important to relate this to national monitoring of sea level rise and more general climate change and to monitoring at the shoreline.

At present there are no specific funding measures for relocation of large communities beyond the responsibilities for re-housing. This is an issue that would need to be considered further at a national level.

ACTIONS:

ACTION	PARTNERS	
Shoreline monitoring	**GC/EA**	
Short term strategy for defence	**EA**	
Relocation and adaption planning ▪ Fairbourne ▪ Arthog and Fegla	**GC** **Communities** **CCW** **WAG** **Snowdonia National Park**	**Highways** **EA** **Network Rail**
Assess in detail potential impact on historic environment	**CADW**	
Assess opportunities for habitat creation and adaptation.	**GC** **EA**	**CCW**

DELIVERY OF THE PLAN

SUMMARY OF SPECIFIC POLICIES

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
11.4	Ro Wen coast	HTL	MR	NAI	This would involve relocation of property owners and businesses from Fairbourne
11.5	Ro Wen Spit	MR	MR	NAI	
11.6	Fairbourne Embankment	HTL	MR	NAI	
11.7	Friog	HTL	HTL	HTL	This refers to the railway line behind Fairbourne.
11.8	Morfa Mawddach	HTL	HTL	HTL	This would secure a cut off defence to the back of the area to the rear of Fegla Islands, maintaining transport routes.
11.9	Fegla	HTL	MR	MR	Local consideration would be given to defence of properties on the Fegla Islands and to Arthog, with the gradual re-integration of the bog into the estuary.
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

PREFERRED POLICY TO IMPLEMENT PLAN:	
From present day	Maintain existing defences. Develop adaptation and relocation planning
Medium term	Realignment of defence, implement plans for adaption and relocation.
Long term	Maintain set back defences.

IMPLICATIONS OF THE PLAN

CHANGES FROM PRESENT MANAGEMENT

Significant change in medium to long term approach to defence at Fairbourne.

ECONOMIC SUMMARY

Economics (£k PV)	by 2025	by 2055	by 2105	Total £k PV
NAI Damages	28,746.0	26,481.3	81,844.9	137,072.2
Preferred Plan Damages	2,811.4	9,625.5	78,595.9	91,032.8
Benefits	25,934.7	16,855.8	3,248.9	46,039.4
Costs	2,445.1	136.9	1,846.7	4,428.8

FLOOD AND EROSION RISK MANAGMENT

POTENTIAL LOSS

There would be a loss potentially of some 350 to 400 properties.

BENEFITS OF THE PLAN

The plan provides a longer term sustainable approach to defence. Defences would be maintained in the short term reducing flood risk. In the medium to long term communities would be relocated reducing risk of catastrophic flood risk in the long term.

SUMMARY OF STRATEGIC ENVIRONMENTAL ASSESSMENT (INCLUDING HRA)

PDZ 11				
SEA Objective	**Impact of Preferred Policy for each Epoch**			
	1	**2**	**3**	**Mitigation**
Policy Units 11.1 to 11.20				
To support natural processes, maintain and enhance the integrity of internationally designated nature conservation sites. Maintain / achieve favourable condition of their interest features (habitats and species).				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance the designated interest of nationally designated nature conservation sites. Maintain/achieve favourable condition.				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance national and local BAP habitats.				Habitat creation
To support natural processes and maintain geological exposures throughout nationally designated geological sites.				Monitoring and appropriate design
To conserve and enhance nationally designated landscapes in relation to risks from coastal flooding and erosion and avoid conflict with AONB and National Park Management Plan Objectives.				Appropriate design
To minimise coastal flood and erosion risk to scheduled and other internationally and nationally important cultural heritage assets, sites and their setting.				Excavation and recording
To minimise the impact of policies on marine operations and activities.				
To minimise coastal flood and erosion risk to critical infrastructure and maintain critical services.				Relocation or realignment
To minimise coastal flood and erosion risk to agricultural land and horticultural activities.				
To minimise coastal flood and erosion risk to people and residential property.				Relocation
To minimise coastal flood and erosion risk to key community, recreational and amenity facilities.				
To minimise coastal flood and erosion risk to industrial, commercial, economic and tourism assets and activities.				

Major risk to people would be mitigated by relocation, although impact still significant. Opportunities for habitat creation to be considered.

This table provides a summary of the SEA (appendix E) and reference should be made to the Appendix for full details of the assessment.

These next two sections provide a headline summary of the findings of the HRA (Appendix G) and the WFA (Appendix H). Reference should be made as appropriate to these Appendices for full details.

HRA SUMMARY

Anticipated Habitat Loss in PDZ 11 as a result of SMP Policy

Designated Site	PU	Habitat Type	Extent of Loss of Habitat (ha)			
			Epoch 1	Epoch 2	Epoch 3	Total
Llŷn Peninsula and the Sarnau SAC	11.4	Intertidal sandflat	0.00			0.00
	11.6	Intertidal sandflat	0.00			0.00
	11.7	Intertidal sandflat	0.00	2.42	2.51	4.92
	11.8	Intertidal sandflat	0.00	2.15	2.98	5.13
	11.9	Intertidal sandflat	0.00			0.00

Pen Llyn a`r Sarnau/ **Llŷn Peninsula** *and the Sarnau SAC:* It is concluded that there would be an **adverse effect on the integrity** of the intertidal habitat (sandflat) within the boundary of the SAC as a result of the SMP2 policies. There will however, be **no adverse effect on the integrity** of the other SAC features.

Morfa Harlech a Morfa Dyffryn SAC: **no adverse effect on the integrity of the SAC**.
Coedydd Derw a Safleoedd Ystlumod Meirion/ Meirionnydd Oakwoods and Bat Sites SAC: **no adverse effect on the integrity of the SAC**.

Preventative/mitigation measures: Potentially move defences landward were feasible to allow saltmarshes to roll back in time with sea level rise; and investigate possibilities of realigning small areas of the banks to mitigate for coastal squeeze of saltmarshes within the estuary for all epochs in PU 11.11.

Risks/Assumptions: The habitat loss is considered precautionary, and where any works are to be undertaken detailed study would provide an accurate identification of whether habitat would be lost and the extent. Potentially, given the worst case assumptions, further detail of the likely actions and site specific study may conclude no habitat loss, given the worst case scenario used in this assessment. The areas of potential habitat loss are large, and this is exacerbated by the fact that such low lying areas would show a large scale change, but this does not take into account accretion of sediments within the estuary. Consequently, the assumptions used to determine loss are expected to have resulted in much greater extents of habitat loss than would occur.

SUMMARY CONCLUSION FROM THE WATER FRAMEWORK ASSESSMENT							
Water body (and relevant PDZ)	**Environmental Objectives met?**				**WFD Summary Statement required?**	**Achievement of Any South East RBMP Mitigation Measures?**	**Details on how the specific South East RBMP Mitigation Measures have been attained** (dark green = achieved; light green = partly achieved & red = not achieved)
	WFD 1	**WFD2**	**WFD3**	**WFD4**			
Cardigan Bay North (Coastal) (PDZs 9, 10, 11, part 12, part 13 and 14.) (MAN 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, part 26, 33, 34, 35, 36 and 37)	N/A	**x** (PDZ 10, 11)	**x** (PDZ 10, 11)	✓	**Yes** – Environmental Objectives WFD 2 and 3 may not be met because of the SMPs policy in PDZ 10 (MAN 20), PDZ 11 (MAN 21).	There were no relevant measures to the SMP2 for this water body, though there are for the affected FWBs.	Mitigation measures for the FWB (GB110064048310), of which none have been implemented within the SMP2: • Increase in-channel morphological diversity; • Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works; • Operational and structural changes to locks, sluices, weirs, beach control, etc; • Selective Vegetation Control Regime; • Appropriate Vegetation Control Technique; • Appropriate timing (Vegetation control); • Appropriate Techniques (Invasive Species); and • Retain marginal aquatic and riparian habitats (channel alteration).
Mawddach (Transitional) (PDZ part 11) (MAN part 22, 23 and 24)	N/A	✓	✓	✓	**No** - not necessary as delivery of the WFD Environmental Objectives will not be prevented by the SMP policies and in some cases will ensure they are of benefit.	There were no relevant measures to the SMP2 for this water body.	N/A

Location reference:	**Mawddach Estuary**
Management Area reference:	**M.A. 23**
Policy Development Zone:	PDZ11

* Note: Predicted shoreline mapping is based on a combination of monitoring data, analysis of historical maps and geomorphological assessment with allowance for sea level rise. Due to inherent uncertainties in predicting future change, these predictions are necessarily indicative. For use beyond the purpose of the shoreline management plan, reference should be made to the baseline data.

The following descriptions are provided to assist interpretation of the map shown overleaf.

100 year shoreline position:
The following maps aim to summarise the anticipated position of the shoreline in 100 years under the two scenarios of "With Present Management" and under the "Draft Preferred Policy" being put forward through the Shoreline Management Plan.

- In some areas the preferred policy does not change from that under the existing management approach. In some areas where there are hard defences this can be accurately identified. In other areas there is greater uncertainty. Even so, where the shoreline is likely to be quite clearly defined by a change such as the crest of a cliff the estimated position is shown as a single line.

- Where there is a difference between With Present Management and the Draft Preferred Policy this distinction is made in showing two different lines:

  With Present Management.
  Draft Preferred Policy.

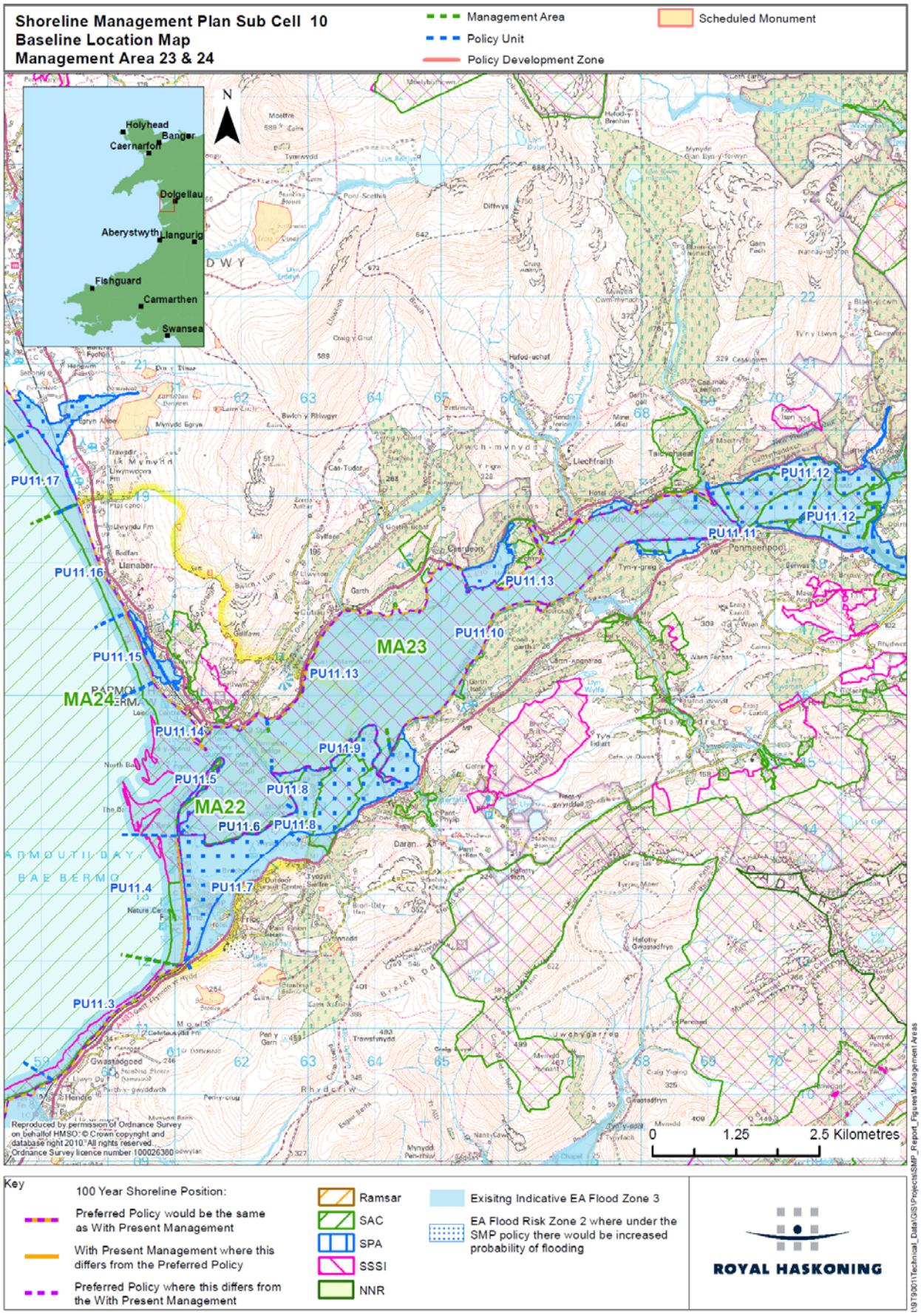
Flood Risk Zones

General Flood Risk Zones. The explanation of these zones is provided on the Environment Agency's web site www.environment-agency.gov.uk. The maps within this Draft SMP document show where SMP policy might influence the management of flood risk.

Indicate areas where the intent of the SMP draft policy is to continue to manage this risk.

Indicate where over the 100 years the policy would allow increased risk of flooding.

The maps should be read in conjunction with the text within the Draft SMP document.


Shoreline Management Plan Sub Cell 10
Baseline Location Map
Management Area 23 & 24
Management Area
Policy Unit
Policy Development Zone
Scheduled Monument
Holyhead
Bangor
Caernarfon
Dolgellau
Aberystwyth
Llangurig
Fishguard
Carmarthen
Swansea
N
MA23
MA24
MA22
PU11.17
PU11.16
PU11.15
PU11.14
PU11.5
PU11.6
PU11.4
PU11.3
PU11.7
PU11.8
PU11.9
PU11.10
PU11.11
PU11.12
PU11.13
0
1.25
2.5 Kilometres
Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2010. All rights reserved. Ordnance Survey licence number 100026380
Key
100 Year Shoreline Position:
Preferred Policy would be the same as With Present Management
With Present Management where this differs from the Preferred Policy
Preferred Policy where this differs from the With Present Management
Ramsar
SAC
SPA
SSSI
NNR
Exisitng Indicative EA Flood Zone 3
EA Flood Risk Zone 2 where under the SMP policy there would be increased probability of flooding
ROYAL HASKONING
I:\9T9001\Technical_Data\GIS\Projects\SMP_Report_Figures\Management Areas

SUMMARY OF PREFERRED PLAN RECOMMENDATIONS AND JUSTIFICATION

INTENT OF THE PLAN:

The management intent is for adaptation within the estuary to support both the nature conservation values and the sustainable defence. Key areas are at Penmaenpool, where the intent would be to continue to defend the frontage, and within the upper estuary, where the plan identifies the longer term issues of sustainably with respect to the agricultural land.

There is uncertainty as to the impact of future management of both the Toll Road and the defence to this area opposite Penmaenpool in the way in which the upper estuary might then be managed. In particular, it is uncertain whether holding the line here would increase or decrease water levels in the upper estuary. This needs to be investigated further before detailed planning for upstream management could be confirmed.

Even so it seems unlikely that with sea level rise defences over the whole upper estuary area could be sustained. To do so would create a situation where future investment was being made on the basis of increasing reliance on defences. For this reason and to support habitat creation opportunities the approach to management would be for realignment. This would need to be developed in consultation with landowners. In relation specifically to the management of the Toll Road, the intent would be to maintain defences with the intent to allow time for further investigation into estuary behaviour and with the intent of allowing development of a coherent management plan throughout the area. This would include consideration of adaptation in land use. The initial policy would not preclude local maintenance of local defences upstream of Penmaenpool but would not include enhancement of defences. However, any such realignment needs to have regard to the uncertainties associated with management of the Toll Road and should not encourage a piecemeal approach to defence management within this potentially sensitive area.

KEY ISSUES/RISK AND UNCERTAINTY:

There are uncertainties in terms of timing of the proposed changes and with respect to the upper estuary processes. However, there is also a need for a detailed planned response to change. It will be important to relate this to national monitoring of sea level rise and more general climate change.

There is unlikely to be funding based solely on FCERM for this area and alternative funding sources need to be investigated.

ACTIONS:

ACTION	PARTNERS	
Study of response and significance of the Toll Road, with respect to estuary dynamics.	**GC**	**CCW**
Adaption planning for upper estuary	**GC** **Landowners** **CCW** **Snowdonia National Park**	**Highways** **EA**
Examine opportunities fro habitat creation	**EA** **GC**	**CCW**
Plan relocation of estuary cycle path	**GC**	

DELIVERY OF THE PLAN

SUMMARY OF SPECIFIC POLICIES

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
11.10	Mawddach south	MR	MR	MR	
11.11	Penmaenpool	HTL	HTL	HTL	
11.12	Upper estuary	MR	MR	MR	This would require further investigation and would not preclude local management of defences
11.13	Mawddach north	MR	MR	MR	The intent is solely to manage risk to the road.
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

PREFERRED POLICY TO IMPLEMENT PLAN:	
From present day	Maintain existing defences at Penmaenpool. Continue to maintain road defences
Medium term	Maintain existing defences at Penmaenpool. Continue to maintain road defences
Long term	Maintain existing defences at Penmaenpool. Continue to maintain road defences

IMPLICATIONS OF THE PLAN

CHANGES FROM PRESENT MANAGEMENT

At

ECONOMIC SUMMARY

Economics (£k PV)	by 2025	by 2055	by 2105	Total £k PV
NAI Damages	5.5	5.9	29.7	41.2
Preferred Plan Damages	2.8	2.9	15.0	20.6
Benefits	2.8	3.0	14.8	20.5
Costs	0.0	930.8	49.6	980.4

Damages do not fully reflect potential disruption to road network.

FLOOD AND EROSION RISK MANAGMENT

POTENTIAL LOSS

There is likely to be increased flooding to agricultural land.

BENEFITS OF THE PLAN

The plan provides a longer term sustainable approach to defence, with the aim to reduce flood risk to some 8 properties.

SUMMARY OF STRATEGIC ENVIRONMENTAL ASSESSMENT (INCLUDING HRA)

PDZ 11				
SEA Objective	**Impact of Preferred Policy for each Epoch**			
	1	**2**	**3**	**Mitigation**
Policy Units 11.1 to 11.20				
To support natural processes, maintain and enhance the integrity of internationally designated nature conservation sites. Maintain / achieve favourable condition of their interest features (habitats and species).				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance the designated interest of nationally designated nature conservation sites. Maintain/achieve favourable condition.				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance national and local BAP habitats.				Habitat creation
To support natural processes and maintain geological exposures throughout nationally designated geological sites.				Monitoring and appropriate design
To conserve and enhance nationally designated landscapes in relation to risks from coastal flooding and erosion and avoid conflict with AONB and National Park Management Plan Objectives.				Appropriate design
To minimise coastal flood and erosion risk to scheduled and other internationally and nationally important cultural heritage assets, sites and their setting.				Excavation and recording
To minimise the impact of policies on marine operations and activities.				
To minimise coastal flood and erosion risk to critical infrastructure and maintain critical services.				Relocation or realignment
To minimise coastal flood and erosion risk to agricultural land and horticultural activities.				
To minimise coastal flood and erosion risk to people and residential property.				Relocation
To minimise coastal flood and erosion risk to key community, recreational and amenity facilities.				
To minimise coastal flood and erosion risk to industrial, commercial, economic and tourism assets and activities.				

Opportunity for habitat creation would need to be examined..

This table provides a summary of the SEA (appendix E) and reference should be made to the Appendix for full details of the assessment.

These next two sections provide a headline summary of the findings of the HRA (Appendix G) and the WFA (Appendix H). Reference should be made as appropriate to these Appendices for full details.

HRA SUMMARY

Anticipated Habitat Loss in PDZ 11 as a result of SMP Policy

Designated Site	PU	Habitat Type	Extent of Loss of Habitat (ha)			
			Epoch 1	Epoch 2	Epoch 3	Total
Llŷn Peninsula and the Sarnau SAC	11.11	Intertidal sandflat	0.00	0.00	0.02	0.02
	11.12	Intertidal sandflat	0.00			0.00

Pen Llyn a`r Sarnau/ **Llŷn Peninsula** *and the Sarnau SAC:* It is concluded that there would be an **adverse effect on the integrity** of the intertidal habitat (sandflat) within the boundary of the SAC as a result of the SMP2 policies. There will however, be **no adverse effect on the integrity** of the other SAC features.

Morfa Harlech a Morfa Dyffryn SAC: **no adverse effect on the integrity of the SAC**.

Coedydd Derw a Safleoedd Ystlumod Meirion/ Meirionnydd Oakwoods and Bat Sites SAC: **no adverse effect on the integrity of the SAC**.

Preventative/mitigation measures: Potentially move defences landward were feasible to allow saltmarshes to roll back in time with sea level rise; and investigate possibilities of realigning small areas of the banks to mitigate for coastal squeeze of saltmarshes within the estuary for all epochs in PU 11.11.

The MR policy within PU 11.13 would need to ensure that there is no loss of woodland/heathland, and that it results in sensitive and natural flooding to any habitat rather than structures.

Risks/Assumptions: The habitat loss is considered precautionary, and where any works are to be undertaken detailed study would provide an accurate identification of whether habitat would be lost and the extent. Potentially, given the worst case assumptions, further detail of the likely actions and site specific study may conclude no habitat loss, given the worst case scenario used in this assessment. The areas of potential habitat loss are large, and this is exacerbated by the fact that such low lying areas would show a large scale change, but this does not take into account accretion of sediments within the estuary. Consequently, the assumptions used to determine loss are expected to have resulted in much greater extents of habitat loss than would occur.

SUMMARY CONCLUSION FROM THE WATER FRAMEWORK ASSESSMENT							
Water body (and relevant PDZ)	**Environmental Objectives met?**				**WFD Summary Statement required?**	**Achievement of Any South East RBMP Mitigation Measures?**	**Details on how the specific South East RBMP Mitigation Measures have been attained** (dark green = achieved; light green = partly achieved & red = not achieved)
	WFD 1	**WFD2**	**WFD3**	**WFD4**			
Cardigan Bay North (Coastal) (PDZs 9, 10, 11, part 12, part 13 and 14.) (MAN 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, part 26, 33, 34, 35, 36 and 37)	N/A	**x** (PDZ 10, 11)	**x** (PDZ 10, 11)	✓	**Yes** – Environmental Objectives WFD 2 and 3 may not be met because of the SMPs policy in PDZ 10 (MAN 20), PDZ 11 (MAN 21).	There were no relevant measures to the SMP2 for this water body, though there are for the affected FWBs.	Mitigation measures for the FWB (GB110064048310), of which none have been implemented within the SMP2: • Increase in-channel morphological diversity; • Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works; • Operational and structural changes to locks, sluices, weirs, beach control, etc; • Selective Vegetation Control Regime; • Appropriate Vegetation Control Technique; • Appropriate timing (Vegetation control); • Appropriate Techniques (Invasive Species); and • Retain marginal aquatic and riparian habitats (channel alteration).
Mawddach (Transitional) (PDZ part 11) (MAN part 22, 23 and 24)	N/A	✓	✓	✓	**No** - not necessary as delivery of the WFD Environmental Objectives will not be prevented by the SMP policies and in some cases will ensure they are of benefit.	There were no relevant measures to the SMP2 for this water body.	N/A

Location reference:	**Barmouth**
Management Area reference:	**M.A. 24**
Policy Development Zone:	PDZ11

* Note: Predicted shoreline mapping is based on a combination of monitoring data, analysis of historical maps and geomorphological assessment with allowance for sea level rise. Due to inherent uncertainties in predicting future change, these predictions are necessarily indicative. For use beyond the purpose of the shoreline management plan, reference should be made to the baseline data.

The following descriptions are provided to assist interpretation of the map shown overleaf.

100 year shoreline position:
The following maps aim to summarise the anticipated position of the shoreline in 100 years under the two scenarios of "With Present Management" and under the "Draft Preferred Policy" being put forward through the Shoreline Management Plan.

- In some areas the preferred policy does not change from that under the existing management approach. In some areas where there are hard defences this can be accurately identified. In other areas there is greater uncertainty. Even so, where the shoreline is likely to be quite clearly defined by a change such as the crest of a cliff the estimated position is shown as a single line.

- Where there is a difference between With Present Management and the Draft Preferred Policy this distinction is made in showing two different lines:

  With Present Management.
  Draft Preferred Policy.

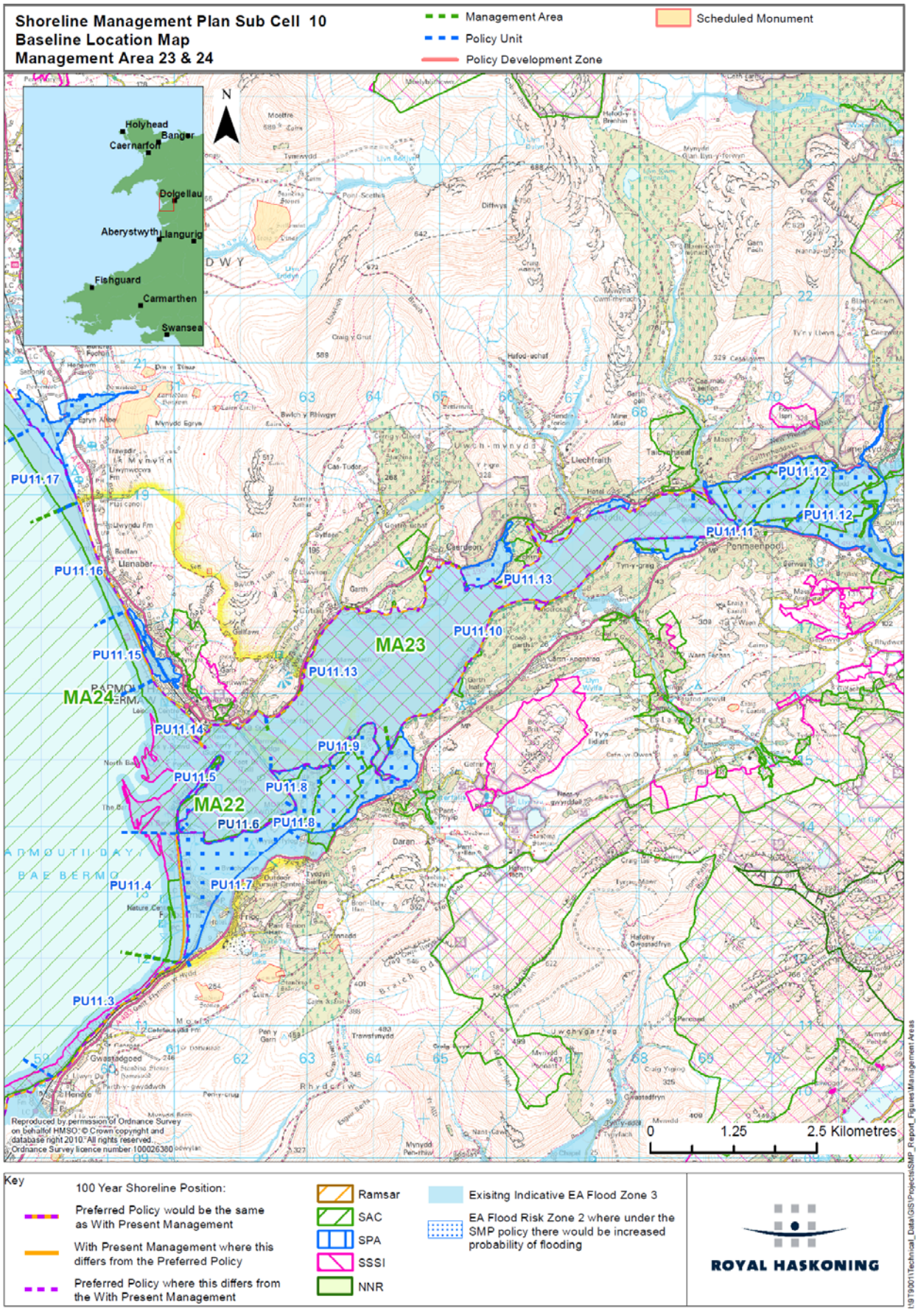
Flood Risk Zones

General Flood Risk Zones. The explanation of these zones is provided on the Environment Agency's web site www.environment-agency.gov.uk. The maps within this Draft SMP document show where SMP policy might influence the management of flood risk.

Indicate areas where the intent of the SMP draft policy is to continue to manage this risk.

Indicate where over the 100 years the policy would allow increased risk of flooding.

The maps should be read in conjunction with the text within the Draft SMP document.


Shoreline Management Plan Sub Cell 10
Baseline Location Map
Management Area 23 & 24
Management Area
Policy Unit
Policy Development Zone
Scheduled Monument
Holyhead
Bangor
Caernarfon
Dolgellau
Aberystwyth
Llangurig
Fishguard
Carmarthen
Swansea
N
MA23
MA24
MA22
PU11.17
PU11.16
PU11.15
PU11.14
PU11.5
PU11.4
PU11.3
PU11.6
PU11.7
PU11.8
PU11.9
PU11.10
PU11.11
PU11.12
PU11.13
0
1.25
2.5 Kilometres
Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2010. All rights reserved. Ordnance Survey licence number 100026380
Key
100 Year Shoreline Position:
Preferred Policy would be the same as With Present Management
With Present Management where this differs from the Preferred Policy
Preferred Policy where this differs from the With Present Management
Ramsar
SAC
SPA
SSSI
NNR
Exisitng Indicative EA Flood Zone 3
EA Flood Risk Zone 2 where under the SMP policy there would be increased probability of flooding
ROYAL HASKONING
I:\9T9001\Technical_Data\GIS\Projects\SMP_Report_Figures\Management Areas

SUMMARY OF PREFERRED PLAN RECOMMENDATIONS AND JUSTIFICATION

INTENT OF THE PLAN:

The intent of the plan is to maintain the core areas of Barmouth and the railway line past Llanaber. Within this, both operation of the harbour and town/seafront enhancements would be supported. At present there is significant pressure on the shoreline defence along the north Barmouth frontage and, with sea level rise, the present alignment of defence would be difficult to sustain. As such, the approach recommended by the SMP, is to look for realignment in this area so as to benefit from the headlands of south Barmouth and Llanaber. This may incur the loss of properties to allow width for a sustainable flood and coast protection defence.

It is noted that several properties on the seafront have cellars, including the theatre. With sea level rise ground water is likely to rise and this may be an issue.

The harbour is recognised to be an important element of the town. There is seen as being no benefit in attempting to re-create the north channel through the harbour. This would have a significant impact on the beach to the main sea front and would not address the issues of siltation within the harbour. Future use of the harbour does need to be planned in relation to maintaining flood defence to the wider area. There may be potential for beneficial use of dredgings from within the harbour area to support beaches along North Barmouth following realignment.

KEY ISSUES/RISK AND UNCERTAINTY:

There are uncertainties in terms of timing of the proposed changes. There is also a need for a detailed planned response to change. It will be important to relate this to national monitoring of sea level rise and more general climate change.

There is significant benefit in continuing to manage the frontage. Even so, to develop a strategy for enhancement of the sea front and harbour there may need to be alternative funding developed through more integrated planning.

ACTIONS:

ACTION	PARTNERS	
Shoreline monitoring	**GC**	
Adaption planning along North Barmouth within development of a coastal plan for the frontage.	**GC** **Communities** **Harbour users**	**Network Rail**
Assess in detail potential impact on historic environment	**CADW**	
Plan relocation of coastal path	**PNP**	

DELIVERY OF THE PLAN

SUMMARY OF SPECIFIC POLICIES

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
11.14	Barmouth South	HTL	HTL	HTL	
11.15	Barmouth North	HTL	MR	MR	This may include relocation of properties
11.16	Llanaber	HTL	HTL	HTL	This needs to be considered in term of management to the above policy unit.
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

PREFERRED POLICY TO IMPLEMENT PLAN:	
From present day	Maintain existing defences.
Medium term	Develop strategy to look at opportunities for MR at north Barmouth.
Long term	Maintain defences.

IMPLICATIONS OF THE PLAN

CHANGES FROM PRESENT MANAGEMENT

The only significant change is in approach to defence along the North Barmouth frontage, where there would be a policy for MR. The broader intent is in line with current management.

ECONOMIC SUMMARY

Economics (£k PV)	by 2025	by 2055	by 2105	Total £k PV
NAI Damages	235.5	744.7	6,529.9	7,510.1
Preferred Plan Damages	235.5	714.2	450.7	1,400.4
Benefits	0.0	30.5	6,079.2	6,109.7
Costs	0.0	1,469.9	381.7	1,851.6

FLOOD AND EROSION RISK MANAGMENT

POTENTIAL LOSS

There could be loss of property along the North Barmouth sea front as part fo and subject to the development of a strategic plan for defence.

BENEFITS OF THE PLAN

The plan provides a longer term sustainable approach to defence, maintaining defence to the core community areas. The plan would continue to provide protection against erosion to somewhere between 30 to 40 properties, including the harbour. The plan reduces flood risk to some 270 properties within the town.

SUMMARY OF STRATEGIC ENVIRONMENTAL ASSESSMENT (INCLUDING HRA)

PDZ 11				
SEA Objective	**Impact of Preferred Policy for each Epoch**			
	1	**2**	**3**	**Mitigation**
Policy Units 11.1 to 11.20				
To support natural processes, maintain and enhance the integrity of internationally designated nature conservation sites. Maintain / achieve favourable condition of their interest features (habitats and species).				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance the designated interest of nationally designated nature conservation sites. Maintain/achieve favourable condition.				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance national and local BAP habitats.				Habitat creation
To support natural processes and maintain geological exposures throughout nationally designated geological sites.				Monitoring and appropriate design
To conserve and enhance nationally designated landscapes in relation to risks from coastal flooding and erosion and avoid conflict with AONB and National Park Management Plan Objectives.				Appropriate design
To minimise coastal flood and erosion risk to scheduled and other internationally and nationally important cultural heritage assets, sites and their setting.				Excavation and recording
To minimise the impact of policies on marine operations and activities.				
To minimise coastal flood and erosion risk to critical infrastructure and maintain critical services.				Relocation or realignment
To minimise coastal flood and erosion risk to agricultural land and horticultural activities.				
To minimise coastal flood and erosion risk to people and residential property.				Relocation
To minimise coastal flood and erosion risk to key community, recreational and amenity facilities.				
To minimise coastal flood and erosion risk to industrial, commercial, economic and tourism assets and activities.				

Mitigation associated with the impacted features of the historic environment may include excavation and recording and monitoring of erosion rates.

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These next two sections provide a headline summary of the findings of the HRA (Appendix G) and the WFA (Appendix H). Reference should be made as appropriate to these Appendices for full details.

HRA SUMMARY

Anticipated Habitat Loss in PDZ 11 as a result of SMP Policy not identified as being critical within this area.

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SUMMARY CONCLUSION FROM THE WATER FRAMEWORK ASSESSMENT

Water body (and relevant PDZ)	**Environmental Objectives met?**				**WFD Summary Statement required?**	**Achievement of Any South East RBMP Mitigation Measures?**	**Details on how the specific South East RBMP Mitigation Measures have been attained** (dark green = achieved; light green = partly achieved & red = not achieved)
	WFD 1	**WFD2**	**WFD3**	**WFD4**			
Cardigan Bay North (Coastal) (PDZs 9, 10, 11, part 12, part 13 and 14.) (MAN 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, part 26, 33, 34, 35, 36 and 37)	N/A	**x** (PDZ 10, 11)	**x** (PDZ 10, 11)	✓	**Yes** – Environmental Objectives WFD 2 and 3 may not be met because of the SMPs policy in PDZ 10 (MAN 20), PDZ 11 (MAN 21).	There were no relevant measures to the SMP2 for this water body, though there are for the affected FWBs.	Mitigation measures for the FWB (GB110064048310), of which none have been implemented within the SMP2: • Increase in-channel morphological diversity; • Structures or other mechanisms in place and managed to enable fish to access waters upstream and downstream of the impounding works; • Operational and structural changes to locks, sluices, weirs, beach control, etc; • Selective Vegetation Control Regime; • Appropriate Vegetation Control Technique; • Appropriate timing (Vegetation control); • Appropriate Techniques (Invasive Species); and • Retain marginal aquatic and riparian habitats (channel alteration).
Mawddach (Transitional) (PDZ part 11) (MAN part 22, 23 and 24)	N/A	✓	✓	✓	**No** - not necessary as delivery of the WFD Environmental Objectives will not be prevented by the SMP policies and in some cases will ensure they are of benefit.	There were no relevant measures to the SMP2 for this water body.	N/A

Location reference:	**Dyffryn Ardudwy**
Management Area reference:	**M.A. 25**
Policy Development Zone:	PDZ11

* Note: Predicted shoreline mapping is based on a combination of monitoring data, analysis of historical maps and geomorphological assessment with allowance for sea level rise. Due to inherent uncertainties in predicting future change, these predictions are necessarily indicative. For use beyond the purpose of the shoreline management plan, reference should be made to the baseline data.

The following descriptions are provided to assist interpretation of the map shown overleaf.

100 year shoreline position:
The following maps aim to summarise the anticipated position of the shoreline in 100 years under the two scenarios of "With Present Management" and under the "Draft Preferred Policy" being put forward through the Shoreline Management Plan.

- In some areas the preferred policy does not change from that under the existing management approach. In some areas where there are hard defences this can be accurately identified. In other areas there is greater uncertainty. Even so, where the shoreline is likely to be quite clearly defined by a change such as the crest of a cliff the estimated position is shown as a single line.

- Where there is a difference between With Present Management and the Draft Preferred Policy this distinction is made in showing two different lines:

  With Present Management.
  Draft Preferred Policy.

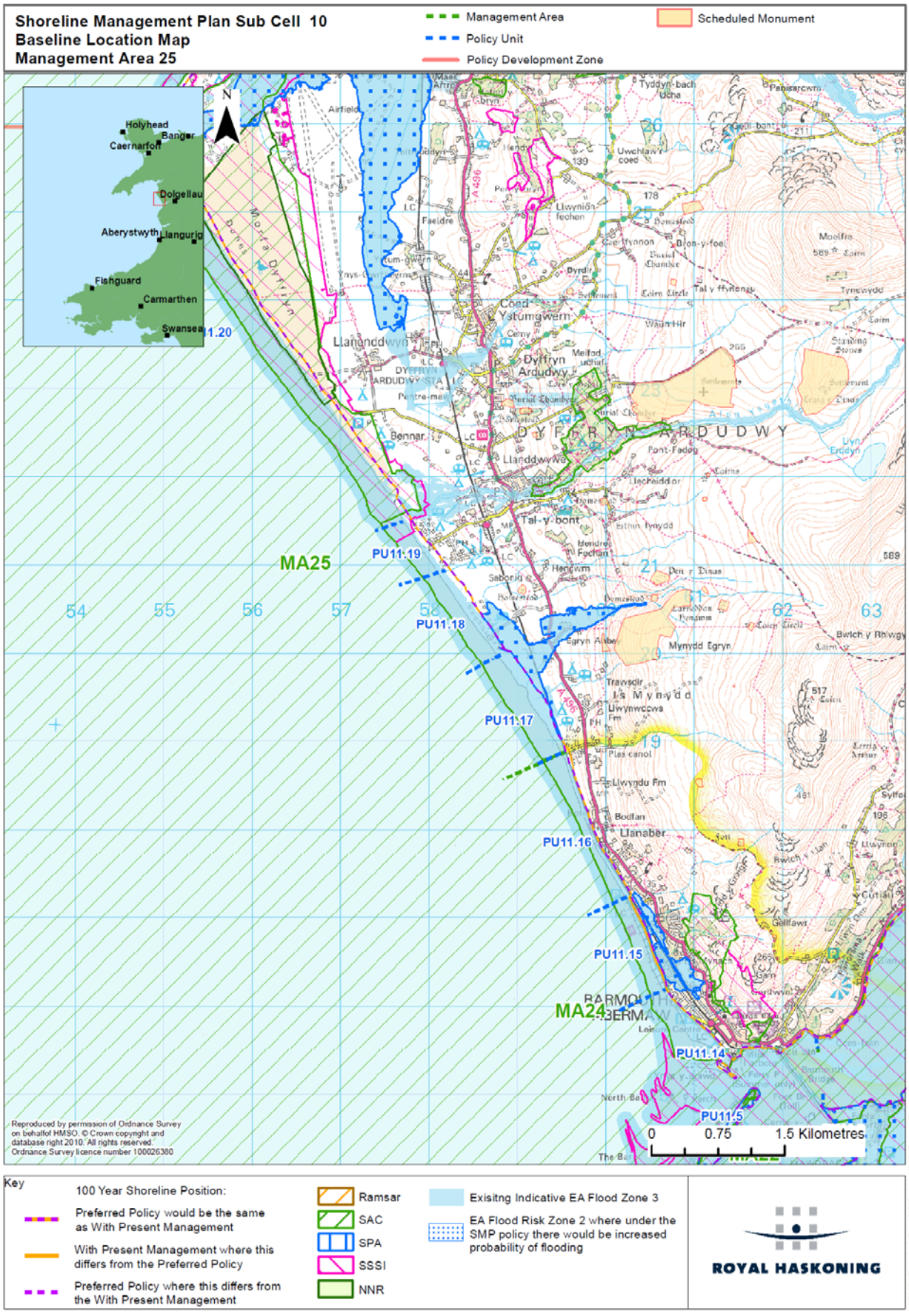
Flood Risk Zones

General Flood Risk Zones. The explanation of these zones is provided on the Environment Agency's web site www.environment-agency.gov.uk. The maps within this Draft SMP document show where SMP policy might influence the management of flood risk.

Indicate areas where the intent of the SMP draft policy is to continue to manage this risk.

Indicate where over the 100 years the policy would allow increased risk of flooding.

The maps should be read in conjunction with the text within the Draft SMP document.


Shoreline Management Plan Sub Cell 10
Baseline Location Map
Management Area 25
Management Area
Policy Unit
Policy Development Zone
Scheduled Monument
Holyhead
Bangor
Caernarfon
Dolgellau
Aberystwyth
Llangurig
Fishguard
Carmarthen
Swansea
N
MA25
PU11.19
PU11.18
PU11.17
PU11.16
PU11.15
MA24
PU11.14
PU11.5
Llanddwywe
Dyffryn Ardudwy
Tal-y-bont
Llanaber
Barmouth
0
0.75
1.5 Kilometres
Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2010. All rights reserved. Ordnance Survey licence number 100026380
Key
100 Year Shoreline Position:
Preferred Policy would be the same as With Present Management
With Present Management where this differs from the Preferred Policy
Preferred Policy where this differs from the With Present Management
Ramsar
SAC
SPA
SSSI
NNR
Exisitng Indicative EA Flood Zone 3
EA Flood Risk Zone 2 where under the SMP policy there would be increased probability of flooding
ROYAL HASKONING
I:\9T9001\Technical_Data\GIS\Projects\SMP_Report_Figures\Management Areas

SUMMARY OF PREFERRED PLAN RECOMMENDATIONS AND JUSTIFICATION

INTENT OF THE PLAN:

The aim of the plan is to allow natural development of the shoreline over the longer term, looking to adapt management to minimise reliance on and impact of defence. Within this, the aim would be to provide greater confidence for the various Holiday Parks along the frontage as they function as businesses, supporting the local economy, while still adapting to erosional processes and increasing pressure as sea levels rise. An essential criteria governing the impact of existing and future defences would be the need to sustain sediment transport along the frontage and to avoid damage to the internationally important Dyffryn Dune system. Furthermore it would be intended that defences were maintained and developed in such a manner as to support the important landscape values.

Over the southern length of the area, the approach would be for the Environment Agency to cease undertaking management of the shingle ridge, encouraging natural development of the shoreline. There would need to be detailed examination of possible local flood impacts.

Over the central area the intent would be not to preclude management of private defence but to establish an agreed practice whereby defences were moved landward as indicated by impact monitoring on shoreline behaviour. Monitoring would be seen as being part of the agreement but this would sensibly be integrated with more general monitoring undertaken by the Local Authority.

Over the northern half of the frontage, the intent would be to encourage the natural dynamic behaviour of the dune system, allowing this system to roll back, potentially occupying land behind. This would need to be considered in relation to local airfield development plans.

KEY ISSUES/RISK AND UNCERTAINTY:

There are accepted uncertainties in terms of timing of the response at the shoreline. There is would need to be an agreed plan for managed realignment based on agreed impact indictors. It will be important to relate this to national monitoring of sea level rise and more general climate change.

Any future work along the frontage would be privately funded.

ACTIONS:

ACTION	PARTNERS	
Shoreline monitoring	**GC**	**Landowners**
Establish an adaption plan agreement	**GC** **CCW** **EA**	**Landowners** **SNPA**
Assess in detail potential impact on historic environment	**CADW**	
Examine opportunities for habitat creation	**EA** **GC**	**CCW**

DELIVERY OF THE PLAN

SUMMARY OF SPECIFIC POLICIES

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
11.17	Egryn Marsh	MR	NAI	NAI	
11.18	Sunnysands	MR	MR	MR	The approach would be developed locally based on the demonstration of no impact on designated areas.
11.19	Islawffordd	MR	MR	MR	The approach would be developed locally based on the demonstration of no impact on designated areas..
11.20	Morfa Dyffryn	NAI	NAI	NAI	

Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention
MR – Managed Realignment

PREFERRED POLICY TO IMPLEMENT PLAN:	
From present day	Maintain EA management of natural defence. Develop an MR agreement with landowners.
Medium term	Implement agreement for MR
Long term	Review and implement agreement for MR.

IMPLICATIONS OF THE PLAN

CHANGES FROM PRESENT MANAGEMENT

No substantial change in approach, but developing plan for MR with landowners.

ECONOMIC SUMMARY

Economics (£k PV)	by 2025	by 2055	by 2105	Total £k PV
NAI Damages	100.2	150.7	167.4	418.3
Preferred Plan Damages	37.6	122.9	167.4	327.8
Benefits	62.6	27.9	0.0	90.5
Costs	6.3	1.0	0.0	7.3

FLOOD AND EROSION RISK MANAGMENT

POTENTIAL LOSS

There would be increasing flood risk with sea level rise and loss of potentially 2 properties in epoch 3.

BENEFITS OF THE PLAN

The plan aims to provide better framework for management of the above losses.

SUMMARY OF STRATEGIC ENVIRONMENTAL ASSESSMENT (INCLUDING HRA)

PDZ 11				
SEA Objective	**Impact of Preferred Policy for each Epoch**			
	1	**2**	**3**	**Mitigation**
Policy Units 11.1 to 11.20				
To support natural processes, maintain and enhance the integrity of internationally designated nature conservation sites. Maintain / achieve favourable condition of their interest features (habitats and species).				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance the designated interest of nationally designated nature conservation sites. Maintain/achieve favourable condition.				Habitat creation
To avoid adverse impacts on, conserve and where practical enhance national and local BAP habitats.				Habitat creation
To support natural processes and maintain geological exposures throughout nationally designated geological sites.				Monitoring and appropriate design
To conserve and enhance nationally designated landscapes in relation to risks from coastal flooding and erosion and avoid conflict with AONB and National Park Management Plan Objectives.				Appropriate design
To minimise coastal flood and erosion risk to scheduled and other internationally and nationally important cultural heritage assets, sites and their setting.				Excavation and recording
To minimise the impact of policies on marine operations and activities.				
To minimise coastal flood and erosion risk to critical infrastructure and maintain critical services.				Relocation or realignment
To minimise coastal flood and erosion risk to agricultural land and horticultural activities.				
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To minimise coastal flood and erosion risk to key community, recreational and amenity facilities.				
To minimise coastal flood and erosion risk to industrial, commercial, economic and tourism assets and activities.				

Examine opportunity for habitat creation.

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