

# Prioritisation of potential areas for polder construction in Wales

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Author Name: Armstrong, S., Blanco, B., Wigley, A, Frost, N.

Author Affiliation: ABPmer

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Author(s): Armstrong, S., Blanco, B., Wigley, A., Frost, N.

Peer Reviewer(s): Nicola Rimington, Iain Fairley, Elizabeth Hopley, Lily Pauls

Approved By: Andrea Winterton

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# Contents

About Natural Resources Wales.....	1
Evidence at Natural Resources Wales.....	1
Recommended citation for this volume:.....	2
Contents .....	3
List of Figures .....	4
List of Tables .....	5
Crynodeb Gweithredol .....	6
Executive summary .....	8
1. Introduction.....	9
2. Methodology .....	11
2.1. Overview .....	11
2.2. Data Collation .....	11
2.3. Methodology development .....	14
2.4. GIS analysis .....	14
2.4.1. Saltmarsh layer refinement.....	15
2.4.2. Criteria used for consideration and heatmapping .....	17
2.4.3. Scoring (and attribution) .....	22
2.5. Prioritisation Process.....	24
2.5.1. Development of recommended shortlist .....	24
2.5.2. Prioritisation workshop .....	25
3. Results.....	26
3.1. Polders opportunity prioritisation data layer.....	26
3.2. Shortlist of possible polders sites .....	26
4. Discussion and next steps.....	31
5. References .....	32

Appendices .....	33
A. Results for all scored saltmarsh sites scored .....	33
B. Attribute definitions.....	37
C. Sensitivity test – alternative scoring for economic value.....	40
D. Sensitivity test – influence of weighting in the scoring .....	42
Data Archive Appendix.....	43

## List of Figures

Figure 1. Histogram of total score for saltmarsh sites. The histogram categories have been coloured according to the shortlist criteria (green for those short-listed as potential sites, amber for those that could be considered and red for rejected sites). .....	24
Figure 2. Potential polders locations categorised according to their combined score (green for those short-listed as potential sites, amber for those that could be considered and red for rejected sites) .....	30
Figure 3. Histogram of total new scores for saltmarsh sites.....	40

# List of Tables

Table 1. Data input catalogue .....	12
Table 2. Opportunities categories and their scores.....	23
Table 3. Constraints categories and their scores.....	23
Table 4 Opportunities scores for shortlist of possible polder sites .....	27
Table 5 Constraints scores for shortlist of possible polder sites .....	28
Table 6 Shortlist of possible polder sites to enhance saltmarshes in Wales .....	29
Table 7. Opportunity and constraints scores, additional information parameters and total scores for the 93 saltmarsh sites .....	34
Table 8 Attribute name and description .....	37
Table 9 Alternative scoring for Flood Risk/ Economic benefit.....	40
Table 10 Shortlist of possible polder sites to enhance saltmarshes in Wales from sensitivity test on an alternative scoring for economic value .....	41
Table 11 Shortlist of possible polder sites to enhance saltmarshes in Wales from sensitivity test on the weighting.....	42

# Crynodeb Gweithredol

Mae Cyfoeth Naturiol Cymru (CNC) yn archwilio lle y gellid defnyddio polderau gwaddodi i helpu i adfer a diogelu morfeydd heli yng Nghymru. Mae morfeydd heli yn cynnig manteision pwysig o ran natur, gwydnwch hinsawdd, a lleihau perygl llifogydd, ond mae llawer o'r morfeydd heli cael eu colli o ganlyniad i erydu, codiad yn lefel y môr a gwasgfa arfordirol.

Comisiynwyd yr astudiaeth hon i ddarparu gorolwg cenedlaethol yn ogystal â chasglu tystiolaeth fanwl -ar gyfer nodi a blaenoriaethu lleoliadau lle gallai cynlluniau polder ar raddfa fwy eang -gael eu creu (sy'n gallu adfer o leiaf 1 hectar o forfa heli) lle bo hynny'n ddichonadwy ac hefyd yn fanteisiol.

Paratowyd map GIS (System Gwybodaeth Ddaearyddol) gofodol oedd yn blaenoriaethu lleoliadau ynghyd â haen ddata oedd yn rhoi sgôr ar gyfer arfordir Cymru gyfan. Gan ddefnyddio setiau data cenedlaethol sydd ar gael eisoes, cafodd ardaloedd morfa heli eu hidlo yn gyntaf i gael gwared ar safleoedd sy'n rhy fach, yn rhy gyfyngedig, neu'n anaddas oherwydd presenoldeb cynefinoedd sensitif (fel morwellt neu riffiau rhynglanwol).

O ganlyniad i'r broses hon, fe nodwyd bod 93 o safleoedd morfa heli ar draws 36 o ardaloedd â photensial damcaniaethol ar gyfer adeiladu polderau. Yna, fe aseswyd pob safle yn erbyn set gyson o ffactorau cyfle (fel maint yr ardal sydd angen ei adfer, buddiannau o ran perygl llifogydd, tueddiadau erydu a gwasgfa arfordirol sy'n cael eu rhagweld) a chyfyngiadau ffisegol (fel egni'r tonnau, amrediad y llanw, ceryntau, graddiant llethr y blaendraeth a pha mor hawdd neu anodd oedd hi o ran y gwaddodion oedd ar gael).

Cyfunwyd y sgoriau hyn i baratoi sgôr gyffredinol ar gyfer pob safle. Ni ddefnyddiwyd unrhyw bwysoli ar y cam hwn er mwyn sicrhau bod y set ddata yn parhau i fod yn hyblyg ar gyfer profi a gwneud penderfyniadau yn y dyfodol. Hefyd casglwyd gwybodaeth ychwanegol, fel a yw'r morfa heli mewn safle gwarchoddedig, beth yw cyflwr y cynefin, polisi'r Cynllun Rheoli Traethlin, agosrwydd at safleoedd tirlenwi ac agosrwydd at welyau cregyn gleision glas yn y set ddata GIS i gefnogi ystyriaeth fanylach o safleoedd posibl, ond ni chafodd yr agweddau hyn eu sgorio.

Y prif allbwn yw cyflwyno set ddata sy'n nodi'r blaenoriaethau cenedlaethol dechreuol, yn hytrach na nodi penderfyniadau pendant o ble y dylid sefydlu polderau. Mae'r dadansoddiad yn amlygu lle mae potensial da ar gyfer sefydlu prosiect polderau llwyddiannus. Ond, bydd angen cynnal astudiaethau safle-benodol lleol yn ogystal ag ystyriaethau o ran rhanddeiliaid ac asesiadau dichonoldeb yn dal yn hanfodol cyn i unrhyw ymyrraeth fynd rhagddo.

Cafodd y 93 o Safleoedd eu gosod mewn tri chategori: Blaenoriaeth uchel (gwyrdd), blaenoriaeth ganolig (ambr) a blaenoriaeth isel (coch).

Arweiniodd hyn at restr fer derfynol o 16 o safleoedd â blaenoriaeth uchel wedi'u dosbarthu ledled Cymru, gan gynnwys lleoliadau yn Aber Afon Dyfrdwy, Aber Afon Dyfi, aberoedd y Tair Afon ac Aber Afon Hafren. Mae'r safleoedd hyn yn cynrychioli'r lleoliadau mwyaf addawol ar gyfer ymchwiliadau pellach.

Mae'r astudiaeth hefyd yn amlygu nifer o gyfyngiadau sy'n gysylltiedig â data ar raddfa genedlaethol, yn enwedig mewn perthynas â symudiad y tonnau, ceryntau a data yn ymwneud â gwaddodion. Am y rheswm hwn, dylid trin y canlyniadau fel cyfrwng sgrinio strategol sydd ddim yn cymryd lle astudiaethau dichonoldeb manwl.

Ar y cyfan, mae'r prosiect yn rhoi man cychwyn cadarn a thryloyw y gellir ei ail adrodd ar gyfer cynllunio ar gyfer adfer morfeydd heli sy'n seiliedig ar sefydlu polderau yng Nghymru yn y dyfodol.

# Executive summary

Natural Resources Wales (NRW) is exploring where sedimentation polders could be used to help restore and protect saltmarshes in Wales. Saltmarshes provide important benefits for nature, climate resilience, and flood risk reduction, but many are being lost due to erosion, sea-level rise and coastal squeeze.

This study was commissioned to provide a national, high-level evidence-based means for identifying and prioritising locations where larger-scale polder schemes (capable of restoring at least 1 hectare of saltmarsh) could potentially be feasible and beneficial.

The project developed a GIS based spatial prioritisation map and scoring data layer covering the entire Welsh coastline. Using existing national datasets, saltmarsh areas were first filtered to remove sites that are too small, too constrained, or unsuitable due to the presence of sensitive habitats (such as seagrass or intertidal reefs).

From this process, 93 saltmarsh sites across 36 complexes were identified as having theoretical potential for polder construction. Each site was then assessed against a consistent set of opportunity factors (such as restoration size, flood risk benefit, erosion trends and predicted coastal squeeze) and physical constraints (such as wave energy, tidal range, currents, foreshore slope and sediment availability).

Scores were combined into an overall score for each site. No weighting was applied at this stage so that the dataset remains flexible for future testing and decision-making. Other information such as whether the saltmarsh is in a protected site, habitat condition, Shoreline Management Plan policy, proximity to blue mussel beds, and proximity to landfills, was also collated in the GIS dataset to support more detailed consideration of potential sites, but these aspects were not scored.

The main output is an initial national prioritisation dataset, rather than a definitive determination of where polders should be implemented. The analysis highlights where there is good potential for a successful polder project, but local site-specific studies, stakeholder engagement and feasibility assessments will still be essential before any intervention proceeds.

The 93 Sites were grouped into three categories: High priority (green), Medium priority (amber) and Low priority (red).

This resulted in a final shortlist of 16 high priority sites distributed across Wales, including locations in the Dee Estuary, Dyfi Estuary, Three Rivers estuaries and Severn Estuary. These sites represent the most promising candidates for further investigation.

The study also highlights several limitations linked to national-scale data, particularly around wave conditions, currents and sediment data. For this reason, the results should be treated as a strategic screening tool, not a substitute for detailed feasibility.

Overall, the project provides a robust, transparent and repeatable starting point for planning future polder-based saltmarsh restoration in Wales.

# 1. Introduction

This project has been undertaken to help Natural Resources Wales (NRW) identify and prioritise saltmarsh sites which could benefit from sedimentation polders, by developing a national heatmap for Wales.

Polders, also known as sedimentation fields, have long been employed to encourage mudflat accretion and subsequent saltmarsh development (Dornbusch and Unterholling, 2018). Historically, this technique was used for land reclamation, particularly in the Netherlands and Germany, but its modern application focuses on habitat protection and restoration (Pontee et al., 2021). A photo from the polders in Rumney Great Wharf is shown in Plate 1.

The principle involves installing permeable fences on intertidal flats that trap water during high tides and slow its ebb, allowing suspended sediment to settle and build up the surface. Burgess-Gamble et al. (2018) note that, when applying this technique, important considerations are local causes of erosion and sources of sediment, as 'success will be limited if there is a highly erosive environment with limited sediment feed'. Over time, if successful, this technique can create conditions suitable for saltmarsh vegetation to establish.



Photo Source: NRW

Plate 1 Polders in Rumney Great Wharf near Cardiff

The fences are typically made from brushwood bundles tied between stakes driven into the mudflat. To aid drainage, gaps are incorporated into the seaward-facing fence, and in some cases, artificial channels are added to accelerate sediment accumulation. Construction methods vary; however, the fences tend to be constructed at around 1 m height, with the top of the fences constructed to be at, or near, the Mean High Water (MHW) mark. In Germany and the Netherlands, field dimensions vary from around 100 m

by 200 m to 400 m by 400 m (e.g. von Lieberman et al., 1998; Blumenthal, 1966). However, in the UK, fences have frequently been built closer to the shore. It should be noted that regular maintenance and inspection is required for such brushwood fences, and placement elevations and conditions also need to be carefully considered.

Rumney Great Wharf near Cardiff is one such location in Wales which has experienced long-term erosion, threatening its saltmarsh habitat. Previous brushwood polders had relatively limited success and were not maintained long-term. A 2021 feasibility study (Armstrong et al., 2021a) warned that saltmarsh could disappear by 2070 without intervention, recommending reinstating and extending polders. Subsequently a new polder field was built in 2024, with plans for ongoing maintenance and monitoring. This work was led by NRW under Nature Networks - a Welsh Government Programme to address the nature emergency in Wales. It aims to restore saltmarsh and mudflats for nature conservation and flood risk reduction, while studying polder performance in high-energy environments (Fairley et al., 2025).

NRW is now looking to the future of polder construction in Wales, and this study is aimed at aiding NRW in understanding what further locations may be appropriate for establishing polders to restore saltmarsh. The potential biodiversity enhancements to existing saltmarshes facing erosion and coastal squeeze, as well as flood risk benefits to a local area through the implementation of a nature-based solution (avoiding/delaying need for hard defences), need to be considered.

The focus of this project was to determine and rank areas suitable for polders capable of restoring a minimum of 1 hectare (ha) of saltmarsh. Although it is anticipated that the design will largely reflect the rectangular sedimentation field design used at Rumney Great Wharf, NRW are open to alternative construction designs, as long as the scope focuses on larger restoration interventions.

## 2. Methodology

### 2.1. Overview

To assess the potential sites for polder placement around Wales to enhance saltmarsh resilience, five project phases were undertaken:

- Data collation;
- Methodology development;
- Geographical Information System (GIS) analysis, including:
  - Baselayer refinement:
    - Exclusion of unsuitable saltmarsh complexes/areas;
    - Definition of saltmarsh frontages (and exclusion of very short frontages);
    - Definition of saltmarsh sites;
  - Heatmapping of sites (including scoring and attribution);
- Development of recommended shortlist; and
- Prioritisation workshop.

These are described below.

### 2.2. Data Collation

Input data utilised for this project were collated using publicly available data portals, licensed data provided by NRW, and the outputs from the Coastal Squeeze project (Oaten et al., 2024).

Due to the national-level scale of the assessment, existing spatial data layers were used for the methodology; therefore, no manual digitisation or data layer creation was undertaken (with one exception, turbidity; see Section 2.4.2 for more detail). All data were stored in an ArcGIS Pro geodatabase, and key information saved in an associated data catalogue. The table below (Table 1) provides the full list of input datasets considered, with associated descriptions to aid interpretation of the project methodology. The (minimal) modifications to some of these layers are also specified in square brackets, where applicable.

Table 1. Data input catalogue

Name	Source	Definition
Saltmarsh	<a href="#">Environment (Wales) Act Section 7 and OSPAR: Marine Habitats - Section 7 OSPAR Saltmarsh Polygon   DataMapWales</a>	2022 Section 7/OSPAR saltmarsh complex location and names
Foreshore	Coastal Squeeze	Approximate low water line
Seagrass	<a href="#">Environment (Wales) Act Section 7 and OSPAR: Marine Habitats   DataMapWales</a>	Extent of seagrass in Wales
Habitat (Intertidal Reef)	<a href="#">Environment (Wales) Act Section 7 and OSPAR: Marine Habitats   DataMapWales</a>	Extent of intertidal reef in Wales
Blue Mussels	<a href="#">Environment (Wales) Act Section 7 and OSPAR: Marine Habitats   DataMapWales</a>	Extent of blue mussels in Wales
Predicted coastal squeeze	Coastal Squeeze	Predicted coastal squeeze (total) in 2155 for saltmarshes
Shoreline (HW)	Ordnance Survey	High water line along the coast
Railways	Ordnance Survey	High-level dataset of the rail network
OS Open Roads	Ordnance Survey	High-level dataset of the road network
Flood Risk Benefit	Robbins et al., 2025	Flood risk benefit of coastal habitats from Robbins et al., 2025, by coastal unit (coastal unit from Coastal Squeeze)

Name	Source	Definition
Tidal Layer	Coastal Squeeze	Defines the present-day mean low water springs (MLWS), mean high water neaps (MHWN), and the highest astronomical tide (HAT) around the entire Welsh coastline
Marine Protected Areas (MPAs), Sites of Special Scientific Interest (SSSI), and Marine Conservation Zones (MCZ)	<a href="#">Marine Protected Areas in Welsh Waters   DataMapWales</a>	Spatial data representing designated sites in Wales
SAC condition assessment	2018 - <a href="#">Natural Resources Wales / Indicative feature condition assessments for European marine sites (EMS)</a> 2025 - <a href="#">Natural Resources Wales / Condition assessments for Welsh European marine sites (EMS)</a>	Assessment of each SAC's condition [updated according to the Indicative feature condition assessments for European Marine Sites (EMS)]
Mean wave height	Armstrong et al., 2021b	Mean wave height (m), extracted from ABPmer SEASTATES hindcast model, which covers the period 01/01/1979 to 31/12/2009
Spring tide peak surface currents	Armstrong et al., 2021b	Mean Spring peak surface current speed (m/s), extracted from ABPmer SEASTATES hindcast model, which covers the period 01/01/1979 to 31/12/2009
Waterbodies	<a href="#">Water Framework Directive (WFD) Groundwater bodies Cycle 2   DataMapWales</a>	Transitional water bodies boundaries from the Water Framework Directive (WFD) Groundwater bodies Cycle 2 (2014-2019) (used to add turbidity values).

Name	Source	Definition
Sediment/ Turbidity	Provided by NRW	Point data of available samples where suspended solids have been analysed in estuaries (2010-2025).
Suspended Particular matter	Cefas, 2016	Suspended Particulate Matter (mg/l) monthly averages (1998-2015)
Saltmarsh Change	Provided by NRW	Area (ha) of saltmarsh change (gain, no change, loss), per saltmarsh site
Shoreline Management Plan (SMP) policy	<a href="#">Shoreline Management Plan Policies   DataMapWales</a>	Set of preferred policies identified which are assigned to 'policy units' for each SMP epoch. Policies: Hold the Line (HTL), Advance the Line (ATL), Managed Realignment (MR), No Active Intervention (NAI). Epochs: short term (Epoch 1 0-20 years), medium term (Epoch 2 20-50 years) and long term (Epoch 3 50-100 years)
Landfill sites	Robbins et al, 2023	Location of landfill sites close to the polders' sites

The use of these data layers for the analysis is described in the methodology below. As this was a national level assessment, a number of assumptions and limitations are associated with the approach used. These are mentioned throughout the methods section but are discussed in more detail in the 'Discussion and next steps' section (Section 4) of the report.

## 2.3. Methodology development

The method was developed iteratively, based on consideration of the available data and agreement on the key criteria to be considered.

## 2.4. GIS analysis

For this study, the existing (2022 Section 7/OSPAR) saltmarsh layer formed the initial basis of the analysis. In the first instance, this layer was edited so that it only captured frontages suitable for polder installation. Potential sites were also defined at this stage, as described in further detail in Section 2.4.1. Once the layer was reduced to only include saltmarsh complexes where relatively substantial polder installation could be feasible, a

heatmapping exercise was then undertaken by overlaying it with other datasets. The heatmap and site scoring is described in Sections 2.4.2 and 2.4.3 respectively.

The analysis described in this document was carried out with a concurrent audit trail, where the changes made were documented in a way that they could be replicated or stepped back. This was documented in a GIS processing log.

## 2.4.1. Saltmarsh layer refinement

The initial phase for refining the 2022 saltmarsh layer for the purpose of this polder site prioritisation project included several steps in a GIS environment, each of which is explained in more detail below.

- Excluding areas with insufficient foreshore width;
- Defining the saltmarsh frontage (and excluding areas with insufficient width);
- Excluding areas fronted by habitats unsuitable for polder placement;
- Splitting saltmarsh sites if needed, e.g. across an estuary;
- Checking areas with insufficient frontage length;
- Include areas which might have historically been saltmarshes; and
- Definition of saltmarsh sites.

### Exclude areas with insufficient frontage width

This analysis was based on the foreshore dataset from the national coastal squeeze assessment, which provided the best available resolution of subtidal channels and foreshore areas at the national scale. Please note that, according to Oaten et al. (2024), the Foreshore Area encompasses the area seaward of an Assessment Unit, extending from present-day (2025) MLWS, to HAT +1 m in 2155 (using UKCP18, RCP 8.5 95th percentile SLR allowance). Within estuaries, the seaward limit of the Foreshore Area is taken to be the centre line of the main channel running through the estuary.

Those saltmarshes with **less than 100 m of fronting foreshore** (i.e. perpendicular to the shoreline) were excluded from the analysis to ensure that there is sufficient foreshore width to enable the underlying project requirements to be met (i.e. on the basis of fences typically being installed at a minimum distance of around 50 to 100 m from the saltmarsh edge).

This exercise led to the exclusion of most saltmarsh complexes along constrained upper estuaries, and narrow tidal rivers and estuaries. Please note that it may still be valuable to place fences along narrower frontages for erosion protection purposes.

### Define the saltmarsh frontage (and exclude very short frontages where < 1 ha would be achieved)

A **saltmarsh frontage line** was then **derived**. This was needed to identify and exclude those areas where the minimum restoration area of 1 ha, as specified by NRW, cannot be achieved. When deriving the saltmarsh frontage line, undulations were smoothed out, and frontages with sides adjoining dunes excluded (utilising the *coastal squeeze dune habitat group layer* for the latter task). A subset of manual checks of the automated process was carried out.

A minimum length of 150 m saltmarsh frontage was assumed to be required to make polders economically viable. Any (parts of) **saltmarsh complexes with very short frontage widths** were therefore **excluded** (i.e. those less than 150 m).

## Exclude areas fronted by habitats unsuitable for polder placement

The frontages where particularly sensitive habitats are mapped within 50 m of the saltmarsh edge were also excluded. This was restricted to **intertidal reefs and seagrass**, on the basis that it would be undesirable to place polder fields over such habitats (and in the case of intertidal reefs, also impracticable). Intertidal mussel beds were also considered for exclusion; however, these tend to be less extensive and typically occur further down the shore. Their presence should be considered when prioritising sites, rather than as an exclusion factor, and information has therefore been included in the heatmap layer (see Section 2.4.2).

The coastal squeeze intertidal reef habitat group and the Section 7 / OSPAR seagrass layers were utilised for this exclusion task.

A data layer depicting the saltmarsh complexes which have been excluded from the original 2022 Welsh saltmarsh layer has been created, with the reason for the exclusion clearly documented to provide an audit trail and facilitate area calculation.

## Splitting saltmarsh sites

The **saltmarsh complex names as applied in the 2022 Section 7/OSPAR saltmarsh layer** were used, and a main numerical ID assigned to ensure the saltmarsh sites had a unique identifier.

With many of the complexes, it was necessary to split them into sub-units, for example along different margins of an estuary, or if a site was split across a long distance (more than 1 km apart) by preceding steps. If it was determined that certain complexes required subdivision, they were renamed in a standardised format (saltmarsh complex name followed by an underscore and a number). This approach facilitates differentiation among the sites while maintaining recognition of their affiliation.

## Checking areas with insufficient frontage length

After excluding the areas fronted by habitats unsuitable for polder placement, the site hectareage and frontage length were recalculated (and split again if needed). Sites where less than 1 ha of saltmarsh restoration would result were then removed (again using the 150 m saltmarsh frontage length as a proxy).

## Buffer saltmarsh frontage by 500 m (to include nearby areas which may have historically been saltmarsh)

The remaining saltmarsh frontage was **buffered by 500 m**, and extended along the foreshore where possible. This was to reduce the risk of areas which may have historically been saltmarsh being excluded from the analysis. In doing so, areas that had been excluded previously as deemed unsuitable were not buffered, so that a total of 15 frontages were extended to include historical saltmarshes.

## Final definition of saltmarsh sites

After the refinement to the saltmarsh layer, a total of 93 saltmarsh sites in 36 saltmarsh complexes were identified as sites with theoretical potential for polder placement. The heatmapping exercise was subsequently applied to those areas.

### 2.4.2. Criteria used for consideration and heatmapping

Once the potentially suitable saltmarsh sites had been identified, a heat mapping exercise was undertaken. The criteria for consideration, most of which were included in the mapping and scoring, included the following:

- Scored criteria which indicate opportunity/benefits (restoration scale, flood risk value/economic benefit, recent saltmarsh change, predicted coastal squeeze loss, foreshore width);
- Scored criteria for physical environment or constraints (tidal range, foreshore slope, wave height, tidal currents, sediment supply); and
- Non-scored supporting information (protected status and designation, saltmarsh condition, proximity to blue mussel beds, SMP policy, historical saltmarsh, proximity to landfill sites).

The rationale for, and feasibility of, the inclusion of these parameters is provided below; and the scoring system is outlined in Section 2.4.3.

In addition to the aspects bulleted above, two other parameters were also considered but subsequently not included. The reasons for their exclusion are summarised below:

- Coastal erosion risk – due to the available national NCERM data layer generally not overlapping with saltmarsh frontages. However, please note that recent saltmarsh change has been considered; and
- Historic saltmarsh presence (pre-2000) – due to there not being a suitable existing national data layer prior to 2000.

## Principles and purpose for criteria included

The following subsections outline the rationale for the inclusion of the various parameters, and the analysis and scoring undertaken, as well as notable limitations, where applicable.

### Scored criteria which indicate Opportunity/benefits

#### Restoration extent

- **Key principle:** Prioritise larger restoration extents.
- **Purpose:** Maximises the efficiency of polder interventions.
- **Analysis and scoring:** The area of the possible restoration extent was calculated per saltmarsh site (by applying a calculation of 1 hectare per 100 meters of frontage length). The resulting values were found to vary from 1.5 to 82 Ha, with most of the values being less than 10 Ha, so the final scoring for this category (see Table 2) was selected to reflect this spread of values. It is important to note that none of the sites scored 0, as any potential sites less than 1.5 Ha had already been removed during the saltmarsh layer refinement step.
- **Limitations:** Larger complexes will tend to receive a higher score, and thus results will be skewed in their favour. This is something to be aware of, particularly when investigating several sites in the same system.

## Flood risk value / economic benefit

- **Key principle:** Prioritise saltmarshes fronting areas with high flood risk and/or significant economic assets.
- **Purpose:** Focusses effort on sites with greatest societal benefit of polder interventions.
- **Analysis and scoring:** the flood risk benefits of Welsh saltmarshes were calculated for a previous project (Robbins et al. 2025); noting that this only applied to areas where there is floodplain backing a saltmarsh complex. A 5-point scoring system (Very Low, Low, Medium, High and Very High) was adopted for this current study (see Table 2 for thresholds).

For saltmarsh complexes which do not front a floodplain, infrastructure value was also considered. Those bordering key infrastructure like major roads or active railways were to receive higher scores. However, none of the ten sites this applied to bordered any major roads or railway lines.

An alternative score was also developed, where the flood risk value per coastal unit was divided by the accommodation space area, to give an alternative representation without biasing towards large Coastal Units; this is presented in Appendix C.

## Recent saltmarsh change

- **Rule:** Score saltmarsh complexes according to whether or not they have recently been experiencing net losses or gains. Complexes with higher percentages of erosion scored higher than those with less change or even gains.
- **Purpose:** Prioritises complexes where there is likely to be a greater need for polders; focusses effort.
- **Analysis and scoring:** NRW provided ABPmer with a data layer showing saltmarsh changes since 2000 as gain, loss or no change. The scoring thresholds were chosen to distinguish between major and minor losses or gains (see Table 2).
- **Limitations:** The scoring was done against trends observed for the whole of the saltmarsh complex and not individual sites.

## Predicted coastal squeeze loss

- **Rule:** Score sites according to predicted coastal squeeze losses. Complexes with higher anticipated losses scored higher than those with lower predicted loss scores.
- **Purpose:** Helps prioritise sites where coastal squeeze is predicted to be highest.
- **Analysis and scoring:** The analysis was performed based on results from the Coastal Squeeze project (Oaten et al., 2024), as mapped onto the assessment unit (AU) lines. The coastal squeeze scenario considered was the 'National level, Defences maintained, worst case scenario of sea level rise (95th <sup>ile</sup>), 2155', for coastal squeeze and natural squeeze together. Losses were attributed to the values calculated to the neighbouring AU. When there was more than one AU at the saltmarsh site, a proportionate cumulative value was derived. The sites were scored according to the percentage of predicted coastal squeeze losses within the saltmarsh site. For those rare cases where a gain was predicted, a 0% loss was recorded. The remaining four scores were set at 25% loss intervals (Table 2).
- **Limitations:** The proximity and frontage calculations are approximate.

## Foreshore width

- **Key principle:** Score sites with wider (/deeper) foreshore higher than those with narrow frontages.
- **Purpose:** Wider frontages will likely be less steep than narrower ones and also allow for wider, more extensive, fields to be installed.
- **Analysis and scoring:** An average foreshore width was calculated by taking width readings at 50 m intervals and averaging values (whilst removing outliers).
- **Limitations:** It is noted that this is an approximate method to calculating the foreshore width, and that some spurious values may be produced in some instances. However, it was considered the best available method to automate the calculation within this national scale study. Moreover, the method is based on the foreshore dataset from the coastal squeeze project (as the approximate low water line). It is acknowledged that subtidal channels can be highly dynamic, and that minor channels would not necessarily have been mapped in the frontage dataset.

## Scored criteria for physical environment or constraints

### Tidal range

- **Key principle:** Categorise sites by tidal range, as polders are likely to be more successful in locations with lower tidal ranges. As the permeable fences trap water during high tides in locations with greater tidal ranges, the amount of time that these locations are under water is less. Fences are about 1 m high with the top of the fence being around MHW, so in locations with greater tidal ranges it is more difficult to achieve.
- **Purpose:** Ensures physical feasibility of polder construction.
- **Analysis and scoring:** The spring tidal range was calculated as Mean High Water Spring levels (MHWS) minus Mean Low Water Spring levels (MLWS). The values for these two tidal levels were taken from the National Coastal Squeeze assessment deliverables, which contains values for different tidal levels. The geographically closest tidal range value to the saltmarsh site was used to derive each value. The scoring thresholds were chosen based on tidal range classification categories.

### Foreshore slope

- **Key principle:** Score sites with steeper foreshore slope lower than those with gentler slopes.
- **Purpose:** Sites with gentler slopes will likely have more suitable elevations and also relatively lower energy due to waves and tidal currents.
- **Analysis and scoring:** Calculated using tidal range and foreshore width values. The scoring thresholds were chosen based on expert judgement, based on typical slopes for gravel beaches (about 1:10), sandy beaches (around 1:20) and muddy slopes (shallower than 1:20).
- **Limitations:** as the value is based on two other factors which are being scored, this introduces double counting into the methodology.

### Wave height

- **Key principle:** Assign scores based on mean wave height. Sites with less energetic conditions may be preferred; extreme conditions could reduce feasibility/likelihood of success.
- **Purpose:** Assesses risk to polder infrastructure and likelihood of successful sedimentation.

- **Analysis and scoring:** A previously produced data layer for mean wave height (m), was utilised for this purpose. This was extracted from ABPmer's SEASTATES hindcast model in 2021. The saltmarsh sites were attributed the nearest wave height value from the layer, or where there were multiple values, the average of these was used. The selected scoring thresholds (see Table 3) reflect the range and spread of the values observed in the dataset.
- **Limitations:** It is acknowledged that this national dataset, extracted from a global model, is not at a resolution suited to characterise the local wave height that the polders may need to withstand, and some results up the estuaries may not reflect estuarine conditions. In this context, considering the 1:1 yr wave height instead of the mean wave height might be preferable (noting that a data layer for this was not available). It is therefore recommended that future investigations use a 1:1 yr wave height and include further refinement/calibration within estuaries.

## Currents

- **Key principle:** Assign scores based on peak surface currents. Sites with more moderate conditions may be preferred; extreme conditions could reduce feasibility/likelihood of success.
- **Purpose:** Assesses risk to polder infrastructure and likelihood of successful sedimentation.
- **Analysis and scoring:** A previously produced data layer for peak spring surface currents was utilised for this purpose. This was extracted from the ABPmer SEASTATES hindcast model in 2021. The saltmarsh sites were attributed the nearest current velocity value from this layer, or where there were multiple values, the average of these was used. The selected scoring thresholds (see Table 3) reflect the range and spread of the values observed in the dataset.
- **Limitations:** It is likely that this dataset extracted from a global model (without detailed bathymetry of local intertidal areas) does not accurately represent the current speeds in the upper intertidal, and thus the values derived likely represent an overestimate of current speeds. However, this was the best available dataset and the data appeared broadly representative of what would be expected.

## Suspended solids in the water column

- **Key principle:** Score sites by average suspended solids / turbidity (e.g. very high, high, medium, low), using available data. Higher turbidity is beneficial for sedimentation.
- **Purpose:** Prioritise sites with better sediment supply for polder formation.
- **Analysis and scoring:** A new internal data layer was derived for this purpose. This used the Water Framework Directive (WFD) waterbody data layer and then assigned a turbidity score to each of the waterbodies. The turbidity score was informed by two datasets: A 2005-2025 sediment / turbidity dataset provided by NRW and the Cefas suspended particular matter layers. The dataset provided by NRW was point data giving results of turbidity sampling surveys undertaken in the past (point data; coverage was often sporadic). In contrast, the Cefas layers show predicted turbidity for different seasons, but the data does not tend to extend into estuaries. Each WFD waterbody was then assigned a turbidity value (see Table 3 for categories and thresholds). Expert judgment informed the scoring, and a confidence value assigned to each score.
- **Limitations:** NRW survey data was often limited to specific locations within a waterbody or absent altogether; in such cases, scores from nearby waterbodies and/or Cefas data layers were consulted. Confidence ratings accompanied each score.

## Non-scored supporting information

### Protected status and designations

- **Key principle:** Capture level of protection and designation afforded to a saltmarsh site.
- **Purpose:** Highlights areas with greater sensitivities / protection.
- **Analysis and scoring:** The percentage overlap with SAC, SPA and SSSI sites was calculated for all saltmarsh sites/complexes. This information was captured, but not scored, so it could be considered when prioritising the sites.

### Saltmarsh condition

- **Key principle:** Capture condition assessment data (e.g., SAC condition, Nature Networks data) from [Natural Resources Wales / Indicative feature condition assessments for European marine sites \(EMS\)](#) and updated according 2025 condition assessments from [Natural Resources Wales / condition assessments for Welsh European marine sites](#).
- **Purpose:** Focuses effort on sites with the greatest potential for resilience or improvement.
- **Analysis and scoring:** The information captured was not scored, as scores could be deemed as either high or low, depending on restoration aim (e.g. increased resilience of sites in better ecological condition or enhancement of those in poor condition). Instead, the information (favourable or non- favourable) was included as a separate column in the data layer so that it could be considered within the prioritisation

### Proximity to Blue Mussel beds

- **Key principle:** Identify sites within 200 m of mussel beds and capture this within the attributes table (i.e. not scored).
- **Purpose:** Ensures protection of blue mussel beds.  
**Analysis and scoring:** Information on whether a saltmarsh site is in relatively close proximity (200 m) to a mussel bed was captured as a binary (yes / no) value, but not scored, so that this could be taken into consideration during site prioritisation.

### Shoreline Management Plan (SMP) policy

- **Rule:** Capture SMP policy along each saltmarsh frontage.
- **Purpose:** Flag frontages with Managed Realignment (MR), No Active Intervention (NAI).
- **Analysis and scoring:** The SMP policy was derived for each saltmarsh site, for the medium-term Epoch 2 (20-50 years) only, as agreed with NRW. This was done by carrying out an intersection of the saltmarsh frontage with the SMP layer. In some cases, two or three policies were captured for each site, and there were also sites with no policy attached. This information was not scored, but provided so it could be taken into account during prioritisation.

### Historical saltmarsh

- **Rule:** Identify sites that could be extended.
- **Purpose:** Determine locations with potential historical saltmarsh presence to assess the feasibility of expanding sedimentation fields in these areas.
- **Analysis and scoring:** This information was obtained from the saltmarsh layer refinement exercise (see Section 2.4.1), whereby an expert judgment was made as

to whether or not there is likely to have been saltmarsh either side of the frontage in the past, and a sedimentation field may thus be extended beyond the saltmarsh frontage (yes / no). This information was provided for consideration during prioritisation and was not scored.

#### Proximity to landfill sites

- **Rule:** Capture sites which are close to a landfill site.
- **Purpose:** Determine locations close to landfill sites, as protecting such sites could add to the case for a polder being installed.
- **Analysis and scoring:** This information was obtained from the datalayer from Robbins et al., 2023, extracting whether the site is backed by a landfill (within 50m) (binary yes / no); the name and type of the landfill sites was added to the data layer.

### 2.4.3. Scoring (and attribution)

To inform the prioritisation exercise, each saltmarsh site was scored according to each of the benefits and constraints parameters described above. The parameters provided for information were not scored, but the information has been captured within the attributes table of the GIS data layer deliverable, for each included saltmarsh site.

The parameters which have been scored are identified in Table 2 for the opportunities, and Table 3 for the constraints categories, together with the scoring thresholds for each parameter. The approach and rationale for the scoring of each parameter are provided in Section 2.4.2 above. The individual and combined scores, and values these were based on, have been included in the attributes table of the GIS data layer deliverable, and in Appendix A.

Three scores have been generated for each saltmarsh site:

- A combined opportunity score;
- A combined constraints score; and
- An overall score.

In developing the above scores, no weighting of any kind has been applied. Instead, the individual scores, and also absolute values, have been provided in the attributes table of the data layer deliverable and in Appendix A, to facilitate flexible data interpretation in the future.

Table 2. Opportunities categories and their scores

<b>Criterion</b>	<b>Score 0 (Very Low)</b>	<b>Score 1 (Low)</b>	<b>Score 2 (Medium)</b>	<b>Score 3 (High)</b>	<b>Score 4 (Very High)</b>
Restoration extent	< 1.5 ha	1.5 to 3 ha	3 to 5 ha	5 to 10 ha	more than 10
Flood Risk/ Economic Benefit	None	Low and Very Low (Robbins et al. 2025) or fronting B road	Medium (Robbins et al. 2025) or fronting A road or railway	High (Robbins et al. 2025)	Very High (Robbins et al. 2025)
Foreshore width	< 150 m	150-300 m	300-450 m	450-600 m	>600 m
Recent saltmarsh change %	substantial gains >10%	minor gains <10%	No change	minor losses <10%	major net losses >10%
Predicted coastal squeeze losses %	≤0 (gain)	0-25% loss	25-50% loss	50-75% loss	75-100% loss

Table 3. Constraints categories and their scores

<b>Criterion</b>	<b>Score 0 (Very Low)</b>	<b>Score 1 (Low)</b>	<b>Score 2 (Medium)</b>	<b>Score 3 (High)</b>	<b>Score 4 (Very High)</b>
Mean Spring Tidal Range	>8 m	6-8 m	4-6 m	2-4 m	< 2m
Mean Wave Height	>1.0 m	0.8 - 1 m	0.5-0.8 m	0.25-0.5 m	0 to 0.25 m
Currents	>1.5 m/s	1-1.5 m/s	0.5-1 m/s	0.25-0.5 m/s	0-0.25 m/s
Turbidity/Sediment Supply (mg/l)	0-10	10-50	50-100	100-300	>300
Foreshore slope (1:X)	< 1:10	1:10 to 1:20	1:20 to 1:50	1:50 to 1:100	>1:100

## 2.5. Prioritisation Process

In order to prioritise sites, a recommended shortlist was first developed; this was then discussed during a prioritisation workshop, which led to a revised shortlist of possible polder sites.

### 2.5.1. Development of recommended shortlist

The overall prioritisation “score” for each site has been visualised by applying ‘red, amber, green’ ‘heat’ mapping; noting that the individual scores, and values these were based on, are also available within the attributes table of the GIS deliverable.

The 93 saltmarsh sites were classified according to their combined total score (noting that the maximum possible score was 40), so that:

- Green sites are those with a combined score greater than 25. These comprise the initial shortlist of priority sites, a total of 17 sites fall within this category;
- Amber sites are those with a combined total score between 21 and 25; a total of 38 sites fall within this category; and
- Red sites are those with scores of less than 20; a total of 38 sites fall within this category.

A histogram of the total scores for the saltmarsh sites is provided in Figure 1. Note that in the x axis, there is a combination of brackets: open brackets, ( ), include the end points whereas closed brackets, [ ], do not. For example (20,25] represents the interval including numbers greater than 20 and smaller or equal than 25.

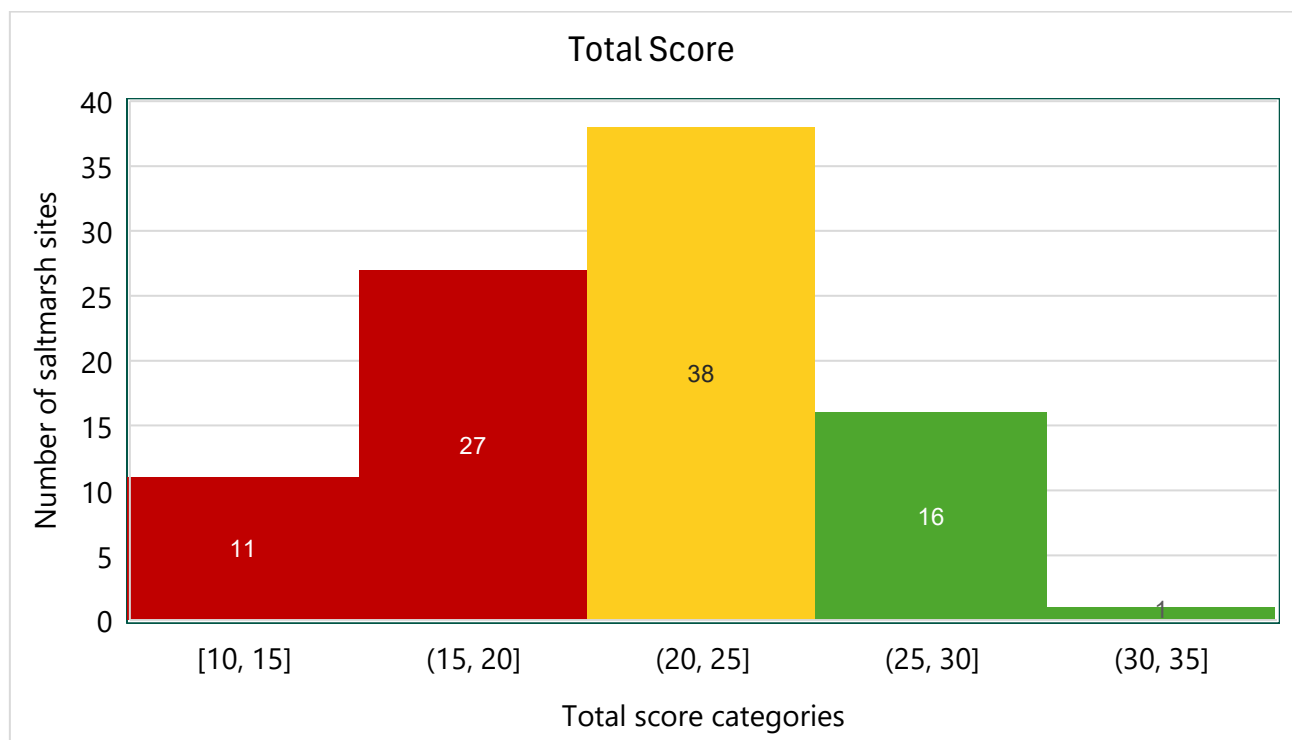


Figure 1. Histogram of total score for saltmarsh sites. The histogram categories have been coloured according to the shortlist criteria (green for those short-listed as potential sites, amber for those that could be considered and red for rejected sites).

## 2.5.2. Prioritisation workshop

An online prioritisation workshop was held in mid-February 2026, to discuss the results of the heat mapping and scoring processes.

One of the main outcomes of the workshop was the introduction of an **overarching rule**. This rule states that, if one of the shortlisted sites has a turbidity score of 0, it should not remain in the shortlist but be re-assigned as having a relatively low suitability for the potential implementation of polders. It is worth noting however that, whilst brushwood fencing would be unlikely to lead to extensive trapping of sediment in a very low turbidity estuary, it could still provide a protecting function.

## 3. Results

### 3.1. Polders opportunity prioritisation data layer

The main deliverable of this project consists of a data layer with the 93 potential polder sites; key content from its attribute table is provided in Appendix A. Information on various pertinent parameters, such as SMP policy and condition, have been captured in this appendix A, along with the respective Opportunities and Constraints attribute scores.

The project has resulted in a possible shortlist of sites being drawn up, where the introduction of polders to facilitate saltmarsh creation could be considered. When creating this data layer, no weighting was applied to the different parameters. It is acknowledged that the application of different weightings could produce a different shortlist. Therefore, the data layer deliverable has been set up so as to facilitate flexible sensitivity testing of category weightings and scoring going forward. Appendix B contains the attribute definitions of the prioritisation data layer. Furthermore, the results of two sensitivity tests are discussed in Appendix C and D; these test alternative scoring for economic value and weighting for two values respectively.

### 3.2. Shortlist of possible polders sites

The final shortlist of possible polder sites consists of 16 sites. The opportunities, constraints and combined scores for each site are shown in Table 4, Table 5 and Table 6 respectively. The respective SMP policy (Epoch 2) is also presented in Table 6. A colour-coded map, indicating the level of prioritisation assigned to the saltmarsh sites (i.e. green, amber or red), is provided in Figure 2. This highlights that there are many potentially suitable sites around Wales that warrant further investigation.

For example, the results show one of the Dyfi sites (52\_1) as the highest scoring potential polders site, mainly due to this having the greatest opportunities scores (e.g. restoration extent, foreshore width and flood risk benefit) and fewer constraints (e.g. tidal range and foreshore slope). Number 2 and 3 on the priority list (Goldcliff Marsh, 4\_3 and Flint, 29\_1) share second position in terms of their combined score. The Goldcliff Marsh site scores one point higher in the Opportunities score (the difference being in the foreshore width), and the Flint site scores one point higher in the constraints score. This highlights the importance of considering site specific parameters within the next phase of the prioritisation process.

Although the methodology applied, and the shortlist produced, focusses on individual saltmarsh sites, it is recommended that, when sites are evaluated, the broader saltmarsh complexes they are situated in are also considered.

Two additional, alternative, shortlists for potential polders have been derived from two separate sensitivity tests shown in:

- Appendix C– Sensitivity test: alternative scoring for economic value; and
- Appendix D – Sensitivity test: alternative scoring involving weighting of two scores.

These appendices demonstrate how the dataset can be interrogated, whereby multiple scenarios can be tested to help prioritise potential polders sites.

Table 4 Opportunities scores for shortlist of possible polder sites

Key: The highest scores (4) have been coloured as green and the lowest score (0) as orange.

Priority	Saltmarsh site name (Split ID from complex)	Restoration extent	Foreshore width	Saltmarsh change	Coastal Squeeze	Flood Risk Benefit	Opportunities Score
1	Dyfi (52_1)	4	4	3	3	4	18
2	Goldcliff_Marsh (4_3)	4	4	3	2	4	17
3	Flint (29_1)	4	3	3	2	4	16
4	Artro (Shell Island) (51_1)	4	2	3	4	3	16
5	Peterstone Great Marsh (2_1)	4	4	3	1	4	16
6	Peterstone Great Marsh (2_2)	3	4	3	2	4	16
7	Taf (71_1)	4	4	3	3	4	18
8	Cefni (43_2)	4	4	1	3	4	16
9	Mawddach (92_3)	4	3	1	3	3	14
10	Goldcliff_Marsh (4_1)	3	4	3	1	4	15
11	Uskmouth (3_1)	2	4	1	3	4	14
12	Magor (6_6)	4	4	1	2	4	15
13	Dee East (94_1)	4	3	1	1	4	13
14	Talacre (27_1)	4	4	1	1	4	14
15	Llanrhidian (61_4)	4	4	1	4	3	16
16	Foryd (86_1)	1	3	3	2	4	13

Table 5 Constraints scores for shortlist of possible polder sites

Key: The highest scores (4 except in the tidal range category which is 2) have been coloured as green and the lowest score (0) as orange.

Priority	Saltmarsh site name (Split ID from complex)	Tidal Range	Wave Height	Currents	Foreshore slope	Turbidity	Constraints Score
1	Dyfi (52_1)	2	2	3	4	2	13
2	Goldcliff_Marsh (4_3)	0	3	2	3	4	12
3	Flint (29_1)	1	3	4	3	2	13
4	Artro (Shell Island) (51_1)	2	2	4	3	1	12
5	Peterstone Great Marsh (2_1)	0	3	2	3	4	12
6	Peterstone Great Marsh (2_2)	0	3	2	3	4	12
7	Taf (71_1)	1	2	3	3	1	10
8	Cefni (43_2)	2	2	2	4	1	11
9	Mawddach (92_3)	2	2	3	4	2	13
10	Goldcliff_Marsh (4_1)	0	3	1	3	4	11
11	Uskmouth (3_1)	0	3	2	3	4	12
12	Magor (6_6)	0	3	0	4	4	11
13	Dee East (94_1)	1	3	4	3	2	13
14	Talacre (27_1)	1	4	1	4	2	12
15	Llanrhidian (61_4)	1	2	2	4	1	10
16	Foryd (86_1)	2	2	4	4	1	13

Table 6 Shortlist of possible polder sites to enhance saltmarshes in Wales

Priority	Saltmarsh site name (Split ID from complex)	SMP Policy (Epoch 2: 20-50 years)	Opportunities Score	Constraints Score	Total score
1	Dyfi (52_1)	HTL	18	13	31
2	Goldcliff_Marsh (4_3)	HTL	17	12	29
3	Flint (29_1)	HTL	16	13	29
4	Artro (Shell Island) (51_1)	MR	16	12	28
5	Peterstone Great Marsh (2_1)	HTL, HTL	16	12	28
6	Peterstone Great Marsh (2_2)	HTL	16	12	28
7	Taf (71_1)	MR	18	10	28
8	Cefni (43_2)	HTL, NAI	16	11	27
9	Mawddach (92_3)	MR, MR, MR, HTL	14	13	27
10	Goldcliff_Marsh (4_1)	HTL	15	11	26
11	Uskmouth (3_1)	HTL	14	12	26
12	Magor (6_6)	HTL	15	11	26
13	Dee East (94_1)	None	13	13	26
14	Talacre (27_1)	MR, HTL	14	12	26
15	Llanrhidian (61_4)	HTL	16	10	26
16	Foryd (86_1)	MR	13	13	26

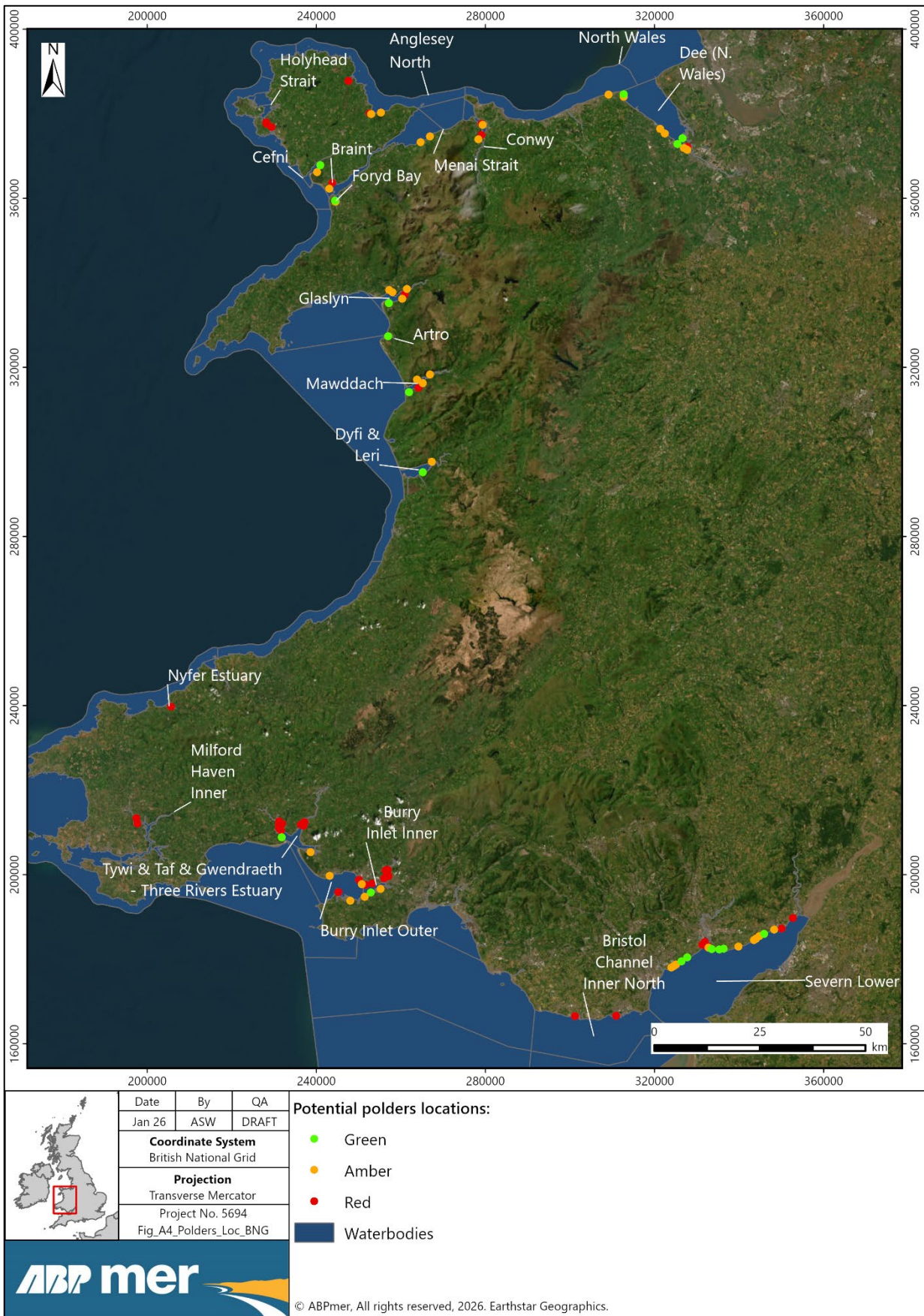


Figure 2. Potential polders locations categorised according to their combined score (green for those short-listed as potential sites, amber for those that could be considered and red for rejected sites)

## 4. Discussion and next steps

This project has resulted in the development of a national data layer for Wales, which can help identify saltmarsh complexes that may benefit from installing sedimentation fields or polders. This is set in the context of the fully acknowledged limitations and assumptions required for a such a national scale project. A number of these could only be addressed through the collation/collection and analysis of site-specific data. The 2021 review on marine habitat restoration opportunities (Armstrong et al., 2021a) provides further information on what additional data might be needed to inform a feasibility project at a local scale.

For example, as discussed in Section 2.4.2, it would be beneficial to consider additional wave parameters, use more locally specific models for currents and waves, and gather more turbidity data. Moreover, certain aspects could not be assessed due to lack of available data, such as historic saltmarsh presence; these could potentially be addressed by creating new national spatial datasets.

In retrospect, the exclusion of seagrass and reef at the scales considered within this project might have been overly precautionary. For example, the application of this constraint removed areas of Rumney Great Wharf from being suitable for polders, where they have in fact been implemented. This re-emphasises the importance of considering each saltmarsh complex as a whole, and not just the individual sites, when assessing the potential suitability of locations for the implementation of polders.

Another important consideration when reviewing potential polder sites is the respective SMP policy, and as such, these have been included within Appendix A. For example, the polders at Rumney Great Wharf are helping to deliver a HTL policy in conjunction with a more traditional flood defence embankment. In contrast, it may be undesirable to install polders in locations where there is a NAI or MR policy.

Additionally, when considering sites on an individual basis, it is possible that some locations that were originally excluded due to size might in practice be suitable for the use of polders. This is because fences are often positioned much closer to the shore than the high level 100-metre assumption used in this study. It is also important to note that polders may offer benefits beyond sedimentation, including erosion protection, and this would be a particularly pertinent consideration for sites in lower turbidity estuaries.

Despite these caveats, the resulting data layer provides a useful tool for identifying suitable sites. Ultimately, as with any national scale opportunity mapping, this tool should be regarded only as an initial aid in identifying potential saltmarsh complexes for polder placement. Detailed local investigations and site-specific studies will always be necessary to determine actual feasibility. When assessing local suitability and value, factors like proximity to landfill sites, other assets that may benefit from protection, minor channels on the foreshore, access issues, and local uses of the foreshore, etc., should all be carefully examined. Learning from other case studies would also be advantageous.

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# Appendices

## A. Results for all scored saltmarsh sites scored

This appendix contains a table, Table 7 with all of the opportunity and constraint scores, along with the additional information parameters, assigned to each of the 93 saltmarsh sites. The saltmarsh sites have been ordered alphabetically.

Table 7. Opportunity and constraints scores, additional information parameters and total scores for the 93 saltmarsh sites

Key: The highest scores (4 except in the tidal range category which is 2) have been coloured as green and the lowest score (0) as orange. Coloured scaling has been used for the opportunities, constraints and total scored. These are coloured in shades of green, the darkest corresponds to the highest score. The scoring category has been coloured according to the combined total score as green, amber and red.

Saltmarsh site name (Split ID from complex)	SMP Policy (Epoch 2: 20-50 years) (Non-scored)	Restoration extent (Opportunity)	Foreshore width (Opportunity)	Saltmarsh change (Opportunity)	Coastal Squeeze (Opportunity)	Flood Risk Benefit (Opportunity)	Flood Risk Benefit (Alternative considering £/ha) (Opportunity)	Tidal Range (Constraint)	Wave Height (Constraint)	Currents (Constraint)	Foreshore slope (Constraint)	Turbidity (Constraint)	Confidence in Turbidity (Constraint)	Opportunities Score	Constraints Score	Total Score	Scoring category
Abergwyngregyn (31_1)	NAI, MR	1	4	4	1	3	4	1	3	2	4	1	Low	13	11	24	Amber
Aberthaw (73_1)	NAI	2	3	1	1	2	1	0	2	0	3	2	Medium	9	7	16	Red
Arthro (Shell Island) (51_1)	MR	4	2	3	4	3	1	2	2	4	3	1	Low	16	12	28	Green
Bagillt (25_1)	MR	3	0	4	1	4	4	1	3	3	1	2	Medium	12	10	22	Amber
Barry Harbour (13_1)	HTL	1	4	0	1	3	1	0	2	0	3	2	Medium	9	7	16	Red
Caldicot Marsh (7)	HTL	4	4	1	1	4	2	0	3	0	4	4	High	14	11	25	Amber
Cefni (43_1)	NAI	4	4	1	0	1	1	2	2	2	4	1	Medium	10	11	21	Amber
Cefni (43_2)	HTL, NAI	4	4	1	3	4	2	2	2	2	4	1	Medium	16	11	27	Green
Connahs Quay (88_1)	HTL	3	0	3	2	4	2	1	3	3	1	2	Medium	12	10	22	Amber
Connahs Quay (88_2)	HTL	2	1	3	4	4	2	1	3	3	2	2	Medium	14	11	25	Amber
Conwy (68_1)	HTL	2	1	3	3	4	3	1	3	2	2	1	Medium	13	9	22	Amber
Conwy (68_4)	HTL, HTL	1	1	3	2	4	3	1	3	2	2	1	Medium	11	9	20	Red
Conwy (68_6)	NAI	4	1	3	2	2	2	1	3	2	2	1	Medium	12	9	21	Amber
Conwy (68_8)	HTL	1	1	3	1	3	4	1	3	2	2	1	Medium	9	9	18	Red
Dee East (94_1)	None	4	3	1	1	4	3	1	3	4	3	2	Medium	13	13	26	Green
Dee East (94_2)	None	3	0	1	1	4	2	1	3	3	1	2	Medium	9	10	19	Red
Dwyrhyd (15_1)	NAI,NAI	3	1	3	4	3	4	2	2	3	2	0	Medium	14	9	23	Amber
Dyfi (52_1)	HTL	4	4	3	3	4	2	2	2	3	4	2	Medium	18	13	31	Green
Dyfi (52_2)	HTL, HTL	2	1	3	4	3	1	2	2	3	3	2	Medium	13	12	25	Amber
Flint (29_1)	HTL	4	3	3	2	4	3	1	3	4	3	2	Medium	16	13	29	Green
Foryd (86_1)	MR	1	3	3	2	4	4	2	2	4	4	1	Medium	13	13	26	Green
Foryd (86_2)	MR	1	2	3	3	4	4	2	2	4	3	1	Medium	13	12	25	Amber
Glaslyn (85_1)	HTL	3	0	3	3	4	1	2	2	4	2	0	Medium	13	10	23	Amber
Glaslyn (85_2)	NAI, HTL	3	1	3	2	4	1	2	2	4	3	0	Medium	13	11	24	Amber
Glastraeth (16_1)	MR	3	2	0	3	3	2	2	2	3	3	0	Medium	11	10	21	Amber
Glastraeth (16_2)	MR	4	1	0	2	3	1	2	2	3	3	0	Medium	10	10	20	Red
Goldcliff_Marsh (4_1)	HTL	3	4	3	1	4	2	0	3	1	3	4	High	15	11	26	Green
Goldcliff_Marsh (4_2)	HTL	2	2	3	4	4	2	0	3	1	2	4	High	15	10	25	Amber
Goldcliff_Marsh (4_3)	HTL	4	4	3	2	4	2	0	3	2	3	4	High	17	12	29	Green
Greenfield (22_1)	MR	1	1	4	1	4	4	1	3	2	2	2	Medium	11	10	21	Amber
Gronant (89_1)	MR	4	4	0	0	4	4	1	3	2	4	1	Medium	12	11	23	Amber
Gwendraeth (30_1)	NAI, HTL, NAI	4	3	1	0	4	3	1	2	3	3	1	Low	12	10	22	Amber
Holyhead Strait (64_4)	MR	2	1	1	1	0	0	2	1	0	2	0	Low	5	5	10	Red
Holyhead Strait (64_5)	MR	2	1	1	0	3	3	2	1	0	2	0	Low	7	5	12	Red
Holyhead Strait (64_6)	MR	1	1	1	0	3	3	2	1	0	2	0	Low	6	5	11	Red
Llangennech (45_1)	NAI	4	1	1	1	4	3	1	2	2	2	1	Medium	11	8	19	Red
Llangennech (45_2)	NAI	3	1	1	2	1	2	1	2	2	2	1	Medium	8	8	16	Red
Llangennech (45_3)	NAI	1	0	1	2	0	2	1	2	2	1	1	Medium	4	7	11	Red
Llangennech (45_6)	NAI	1	0	1	2	4	3	1	2	2	1	1	Medium	8	7	15	Red

Saltmarsh site name (Split ID from complex)	SMP Policy (Epoch 2: 20-50 years) (Non-scored)	Restoration extent (Opportunity)	Foreshore width (Opportunity)	Saltmarsh change (Opportunity)	Coastal Squeeze (Opportunity)	Flood Risk Benefit (Opportunity)	Flood Risk Benefit (Alternative considering £/ha) (Opportunity)	Tidal Range (Constraint)	Wave Height (Constraint)	Currents (Constraint)	Foreshore slope (Constraint)	Turbidity (Constraint)	Confidence in Turbidity (Constraint)	Opportunities Score	Constraints Score	Total Score	Scoring category
Llangennech (45_7)	NAI	2	1	1	1	4	3	1	2	2	2	1	Medium	9	8	17	Red
Llanrhidian (61_1)	NAI, HTL	4	4	1	3	3	4	1	2	2	4	1	Medium; Medium	15	10	25	Amber
Llanrhidian (61_3)	NAI	4	4	1	1	3	4	1	2	2	4	1	Medium	13	10	23	Amber
Llanrhidian (61_4)	HTL	4	4	1	4	3	4	1	2	2	4	1	Medium	16	10	26	Green
Llanrhidian (61_5)	NAI	2	4	1	1	1	1	1	2	3	4	1	Medium	9	11	20	Red
Loughor (46_1)	HTL, NAI	4	3	3	2	2	4	1	2	2	3	1	Medium	14	9	23	Amber
Magor (6_2)	HTL	2	2	1	1	4	2	0	4	0	2	4	High	10	10	20	Red
Magor (6_3)	HTL	2	4	1	2	4	2	0	3	0	4	4	High	13	11	24	Amber
Magor (6_4)	HTL	2	4	1	2	4	2	0	3	0	4	4	High	13	11	24	Amber
Magor (6_5)	HTL	3	4	1	1	4	2	0	3	0	4	4	High	13	11	24	Amber
Magor (6_6)	HTL	4	4	1	2	4	2	0	3	0	4	4	High	15	11	26	Green
Mawddach (92_1)	MR	4	2	1	3	2	4	2	2	3	3	2	Medium	12	12	24	Amber
Mawddach (92_2)	MR	4	1	1	3	1	1	2	2	3	2	2	Medium	10	11	21	Amber
Mawddach (92_3)	MR, MR, MR, HTL	4	3	1	3	3	4	2	2	3	4	2	Medium	14	13	27	Green
Mawddach (92_4)	MR, MR	1	2	1	1	1	3	2	2	3	3	2	Medium	6	12	18	Red
Mawddach (92_5)	MR	4	3	1	2	1	1	2	2	3	4	2	Medium	11	13	24	Amber
Morfa Harlech (60_2)	NAI	4	3	3	1	4	2	2	2	4	4	0	Medium	15	12	27	Red
Morfa Madryn (75_1)	MR	1	4	2	1	4	4	1	3	2	4	1	Low	12	11	23	Amber
Nyfer (49_1)	NAI	2	1	1	1	0	0	2	1	2	2	1	Low	5	8	13	Red
Penclawdd (95_1)	HTL, HTL	1	1	0	2	4	3	1	2	2	2	1	Medium	8	8	16	Red
Penclawdd (95_2)	HTL	3	1	0	2	4	3	1	2	2	2	1	Medium	10	8	18	Red
Penclawdd (95_3)	HTL	4	2	0	3	4	3	1	2	2	3	1	Medium; Medium	13	9	22	Amber
Penclawdd (95_4)	HTL	3	1	0	1	4	3	1	2	2	2	1	Medium	9	8	17	Red
Penrhyn-gwyn (47_1)	MR, MR	2	4	3	0	4	3	1	2	3	3	1	Medium	13	10	23	Amber
Peterstone Great Marsh (2_1)	HTL, HTL	4	4	3	1	4	2	0	3	2	3	4	High	16	12	28	Green
Peterstone Great Marsh (2_2)	HTL	3	4	3	2	4	2	0	3	2	3	4	High	16	12	28	Green
Red Wharf Bay (87_1)	NAI, MR	3	4	0	3	3	4	1	2	3	4	0	Low	13	10	23	Amber
Red Wharf Bay (87_2)	NAI	1	4	0	1	3	4	1	2	3	4	0	Low	9	10	19	Red
Red Wharf Bay (87_3)	MR, NAI	4	4	0	2	3	3	1	2	3	4	0	Low	13	10	23	Amber
Rhymney Great Marsh (1_1)	HTL	2	4	0	3	4	2	0	3	1	3	4	High	13	11	24	Amber
Rhymney Great Marsh (1_2)	HTL	3	4	0	2	4	2	0	3	2	3	4	High	13	12	25	Amber
Rhymney Great Marsh (1_3)	HTL	1	4	0	1	4	2	0	3	2	3	4	High	10	12	22	Amber
Taf (71_1)	MR	4	4	3	3	4	4	1	2	3	3	1	Low	18	10	28	Green
Taf (71_2)	NAI	3	3	3	1	0	0	1	2	3	3	1	Low	10	10	20	Red
Taf (71_3)	NAI	1	1	3	2	0	0	1	2	3	2	1	Low	7	9	16	Red
Taf (71_4)	NAI	1	1	3	0	0	0	1	2	3	2	1	Low	5	9	14	Red
Taf (71_5)	NAI	3	1	3	2	2	2	1	2	3	2	1	Low	11	9	20	Red
Taf (71_6)	NAI	3	1	3	0	0	0	1	2	3	2	1	Low	7	9	16	Red
Talacre (27_1)	MR, HTL	4	4	1	1	4	4	1	4	1	4	2	Medium	14	12	26	Green
Talacre (27_2)	HTL	1	4	1	1	4	4	1	4	1	4	2	Medium	11	12	23	Amber
Thornwell_Portskeuett (8_1)	HTL	4	1	0	1	4	4	0	4	0	1	4	High	10	9	19	Red

Saltmarsh site name (Split ID from complex)	SMP Policy (Epoch 2: 20-50 years) (Non-scored)	Restoration extent (Opportunity)	Foreshore width (Opportunity)	Saltmarsh change (Opportunity)	Coastal Squeeze (Opportunity)	Flood Risk Benefit (Opportunity)	Flood Risk Benefit (Alternative considering £/ha) (Opportunity)	Tidal Range (Constraint)	Wave Height (Constraint)	Currents (Constraint)	Foreshore slope (Constraint)	Turbidity (Constraint)	Confidence in Turbidity (Constraint)	Opportunities Score	Constraints Score	Total Score	Scoring category
Traeth Dulas (19_2)	NAI	3	0	1	1	0	0	1	2	1	2	0	Low	5	6	11	Red
Traeth Melynog (91_1)	NAI,NAI	4	3	3	0	1	1	2	2	3	4	1	Low	11	12	23	Amber
Traeth Melynog (91_3)	NAI	1	0	3	0	1	1	2	2	3	2	1	Low	5	10	15	Red
Tywi (65_1)	HTL	1	1	1	1	4	4	1	2	3	2	1	Low	8	9	17	Red
Tywi (65_2)	HTL	4	1	1	1	1	1	1	2	3	2	1	Low	8	9	17	Red
Tywi (65_4)	NAI	3	1	1	0	3	4	1	2	3	2	1	Low	8	9	17	Red
Usk River (50_2)	HTL	2	0	1	1	4	4	0	3	2	1	3	Medium	8	9	17	Red
Uskmouth (3_1)	HTL	2	4	1	3	4	2	0	3	2	3	4	High	14	12	26	Green
Uskmouth (3_2)	HTL	4	3	1	1	4	2	0	3	2	2	4	High	13	11	24	Amber
Uskmouth (3_4)	HTL	4	1	1	1	4	2	0	3	2	1	3	Medium	11	9	20	Red
Uskmouth (3_5)	HTL	1	2	1	1	4	2	0	3	2	2	3	Medium	9	10	19	Red
Western Cleddau (37_1)	None	3	0	3	1	0	0	1	0	2	2	1	Low	7	6	13	Red
Western Cleddau (37_2)	None	1	0	3	2	0	0	1	0	2	1	1	Low	6	5	11	Red

## B. Attribute definitions

To aid interpretation of the GIS deliverables, Table 8 provides a list of the GIS attributes columns and a description of what each contains; for further information on scoring thresholds, please refer to Table 2 and Table 3 in the main report.

Table 8 Attribute name and description

Attribute name	Description
Main_ID	Main ID of saltmarsh complex
Split_ID2	Split ID of saltmarsh complex suitable for polders
Main_Name	Name of saltmarsh complex
Area_Ha	Area of split saltmarsh complex suitable for polders
Frontage_M	Length of (smoothed) frontage in meters
Historical	Area suitable for extension considering historical saltmarsh (on the basis of expert judgment; is it likely that there was saltmarsh adjacent historically, if so yes).
NS_Designated	Percentage of site designated (SSSI, SPA, SAC)
NS_Blue_Mussel	Presence of blue mussel within 200m
NS_Cond_Feat	Condition assessment feature, from:  2025 - <a href="#">Natural Resources Wales / Condition assessments for Welsh European marine sites (EMS)</a>  2018 - <a href="#">Natural Resources Wales / Indicative feature condition assessments for European marine sites (EMS)</a> (if not updated in 2025)
NS_Condition	Condition assessment data (e.g., SAC condition, Nature Networks data) updated according to the Indicative feature condition assessments for EMS:  2025 - <a href="#">Natural Resources Wales / Condition assessments for Welsh European marine sites (EMS)</a>  2018 - <a href="#">Natural Resources Wales / Indicative feature condition assessments for European marine sites (EMS)</a> (if not updated in 2025)
NS_SMP_Name	SMP policy name

<b>Attribute name</b>	<b>Description</b>
NS_Policy_50	SMP policy type for epoch 2
NS_Landfill_within50m	Presence of landfill within 50 m
NS_Landfill_Count	Number of landfills present within 50 m
NS_Landfill_Name_Type	Name and type of each of the landfill sites present within 50 m
NS_FRV_EB_Ave_GBP_Per_Ha_AS	Per-ha flood risk value
O_RestExtent_Ha	Restoration extent in Hectares
O_FS_Width_Ave	Perpendicular distance to foreshore in meters
C_Tidal_Range_M	Spring tidal range in meters
C_Wave_Height_M	Average wave height in meters
C_Current_MPS	Average current in meters per second
O_SM_Change_Per	Percentage of recent (since 2000) saltmarsh change
O_CS_Loss_Per	Percentage of predicted coastal squeeze (%)
C_Slope_1X	Approximate slope (foreshore width/tidal range)
O_RestExtent_Ha_SCORE	Restoration extent score
O_FS_Width_Ave_SCORE	Foreshore width score
O_SM_Change_Per_SCORE	Saltmarsh change score
O_CS_Loss_Per_SCORE	Coastal squeeze score
O_FRV_EB_SCORE1	Flood risks score, directly based on Robbins et al. (2025) scoring
O_FRV_EB_SCORE2	Alternative flood risk score, based on per-ha flood risk value (for sensitivity test, see Appendix C)
C_Tidal_Range_M_SCORE	Tidal range score
C_Wave_Height_M_SCORE	Wave height score
C_Current_MPS_SCORE	Current score
C_Slope_1X_SCORE	Slope score
C_Turbidity_SCORE	Turbidity score

<b>Attribute name</b>	<b>Description</b>
C_Turbidity_Conf	Confidence in turbidity score (low, medium high)
Opp_SCORE	Total opportunity score
Con_SCORE	Total constraint score
Tot_SCORE	Total score
Scoring_Category	Scoring category (green, amber, red)

## C. Sensitivity test – alternative scoring for economic value

A sensitivity test was undertaken to determine the relative importance of changing the assumed economic benefit provided by each saltmarsh site. In this context, an alternative score was developed where the flood risk value per coastal unit was divided by the accommodation space area to remove any bias towards larger Coastal Units. This was based on the thresholds illustrated in Table 9. The number of saltmarsh sites in each of the categories is also shown.

Table 9 Alternative scoring for Flood Risk/ Economic benefit

Criterion	Score 0 (Very Low)	Score 1 (Low)	Score 2 (Medium)	Score 3 (High)	Score 4 (Very High)
Flood Risk/ Economic Benefit as damages avoided value by area (£/ha)	None	<200 £/ha (23 sites)	200 to 400 £/ha (29 sites)	400 to 600 £/ha (17 sites)	>600 £/ha (24 sites)

The alternative score per site, derived using this method, is also provided in Appendix A (under the opportunities scores).

In summary, when using this alternative score, different opportunity and total scores result, as seen in Figure 3 and the shortlist of potential polder sites changes, see Table 10; interestingly, this contains nine sites from the original shortlist (Table 6).

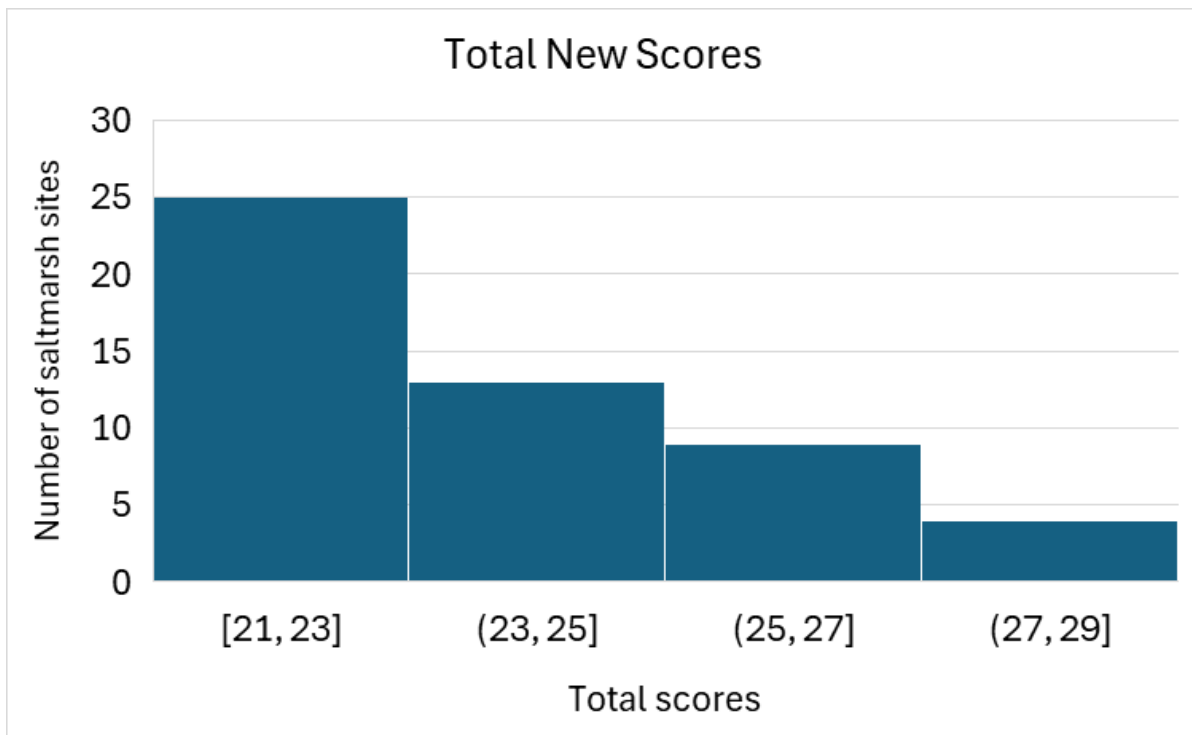


Figure 3. Histogram of total new scores for saltmarsh sites

Table 10 Shortlist of possible polder sites to enhance saltmarshes in Wales from sensitivity test on an alternative scoring for economic value

Priority	Main_ID	Split_ID2	Main_Name	New opportunities score	Total score	In original shortlist?
1	52	52_1	Dyfi	16	29	yes
2	29	29_1	Flint	15	28	yes
3	92	92_3	Mawddach	15	28	no
4	71	71_1	Taf	18	28	yes
5	4	4_3	Goldcliff_Marsh	15	27	no
6	61	61_4	Llanrhidian	17	27	yes
7	51	51_1	Artro (Shell Island)	14	26	yes
8	2	2_1	Peterstone Great Marsh	14	26	no
9	2	2_2	Peterstone Great Marsh	14	26	yes
10	27	27_1	Talacre	14	26	yes
11	86	86_1	Foryd	13	26	yes
12	61	61_1	Llanrhidian	16	26	no
13	92	92_1	Mawddach	14	26	no
14	43	43_2	Cefni	14	25	yes
15	94	94_1	Dee East	12	25	no
16	86	86_2	Foryd	13	25	no

## D. Sensitivity test – influence of weighting in the scoring

A sensitivity test was undertaken to demonstrate the implications of changing the relative importance of different parameters within the overall scoring process. In the example here, the weighting of two categories was changed, the tidal range and the foreshore slope.

A potential double-counting was introduced with the foreshore slope as it was dependant on both the tidal range and the foreshore width. In order to investigate the effects of this, the two related scores (the tidal range and the foreshore slope) were multiplied by 0.5.

This led to the new highest score to be 16 (instead of 20) for the constraints and 36 for the overall score (instead of 40). The revised shortlist of saltmarsh sites according to this new score is provided in the Table 11. When comparing this table with the non-weighted shortlist in Table 6, the following is observed:

- Most of the sites (14 out of 16) were present, albeit in a different order, in the original shortlist. Two sites are now in the shortlist that were not before.
- The top three saltmarsh sites from the original list remain in the top three in this sensitivity test.

Table 11 Shortlist of possible polder sites to enhance saltmarshes in Wales from sensitivity test on the weighting

Priority	Main_ID	Split_ID2	Main_Name	Total score	In original shortlist?
1	52	52_1	Dyfi	28	yes
2	4	4_3	Goldcliff_Marsh	27.5	yes
3	29	29_1	Flint	27	yes
4	2	2_1	Peterstone Great Marsh	26.5	yes
5	2	2_2	Peterstone Great Marsh	26.5	yes
6	71	71_1	Taf	26	yes
7	51	51_1	Artro (Shell Island)	25.5	yes
8	4	4_1	Goldcliff_Marsh	24.5	yes
9	3	3_1	Uskmouth	24.5	yes
10	4	4_2	Goldcliff_Marsh	24	no
11	94	94_1	Dee East	24	yes
12	92	92_3	Mawddach	24	yes
13	43	43_2	Cefni	24	yes
14	6	6_6	Magor	24	yes
15	88	88_2	Connahs Quay	23.5	no
16	1	1_2	Rhymney Great Marsh	23.5	yes

This therefore demonstrates the importance of undertaking sensitivity tests to the scores and weighting in order to explore the robustness of the shortlist of sites. This will be particularly important during the process of selecting sites for a more detailed review of feasibility.

# Data Archive Appendix

Data outputs associated with this project are archived in Y:\Marine\Polders Prioritisation on server-based storage at Natural Resources Wales.

The data archive contains:

- A series of GIS layers on which the maps in the report are based

Metadata for this project is publicly accessible through Natural Resources Wales' Data Discovery Service <https://metadata.naturalresources.wales/geonetwork/srv> (English version) and <https://metadata.cyfoethnaturiol.cymru/geonetwork/cym/> (Welsh Version). The metadata is held as record no NRW\_DS161535.

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