



## **Protecting the lower Mawddach valley from tidal flooding**

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### **Summary**

Tidal flooding currently affects a number of locations around the Mawddach estuary and is likely to increase in severity and frequency with climate change. This will threaten main roads and other vital infrastructure, and will present a significant risk to homes and businesses.

This paper suggests the construction of a tidal barrage across the mouth of the Mawddach estuary between the Ro Wen shingle spit and Barmouth harbour. This would prevent the inflow of extreme high tides and eliminate tidal flooding in the lower Mawddach valley. The barrage would be equipped with turbines to generate electricity during the rising and falling tidal phases. The Mawddach estuary forms the sea outlet for several large rivers, and the water discharged from these rivers will increase the power generation potential of the tidal barrage.

There is a proposal by Gwynedd County Council to decommission and demolish Fairbourne village, situated at the mouth of the Mawddach estuary, in response to predicted sea level rise. Construction of a tidal barrage would protect Fairbourne from estuary tidal flooding and make decommissioning unnecessary.

Averaged over the long expected lifetime of the tidal barrage, electricity is likely to be produced at a cost comparable to wind generation and more cheaply than nuclear power. A cost benefit analysis, taking into account the reduction in flood risk for the whole of the lower Mawddach valley and protection of Fairbourne village, suggests that the project is worthy of serious consideration.

## Tidal flooding

Tidal flooding currently affects a number of locations around the Mawddach estuary. The flood risk to the area is likely to increase further as a consequence of climate change. The Welsh Government is making plans for coastal protection based on a predicted sea level rise of approximately 1.11 metres and an increase in rainfall intensity causing increased peak river flows of up to 30% by 2120. These increases would present a significant risk to the lower Mawddach valley.

The main road from Barmouth to Dolgellau is already liable to tidal flooding at Aberamffra (fig.1) and Glandwr (fig.2). Please note that these and other locations mentioned in the text are marked on the area map in fig.10.



**Figure 1:** Tidal flooding of the A496 at Aberamffra.



**Figure 2:**  
Tidal flooding of the  
A496 at Glyndwr.



The main road from Dolgellau to Fairbourne is liable to flooding at several points, including Penmaenpool (fig.3).



**Figure 3:**

Flooding of the A493 at Penmaenpool.

These main A-roads are vital communication links and are necessary for emergency services. Closure during floods can cause serious problems.

A number of businesses and residential properties are situated alongside the estuary, and may already be liable to tidal flooding. Examples are: the George III Hotel at Penmaenpool (fig.4) and Mawddach Crescent at Arthog (fig.5).



**Figure 4:**

Tidal flooding at the George III Hotel, Penmaenpool.





**Figure 5:**  
Tidal flooding at  
Mawddach Crescent,  
Arthog.

Low lying streets around Barmouth harbour are already liable to tidal flooding (fig.6).



**Figure 6:**  
Tidal flooding near  
Barmouth harbour.

Farming activities in the Mawddach valley can be badly disrupted by floods (fig.7).



**Figure 7:** Tidal flooding of low lying farm land between Penmaenpool and Dolgellau.



As sea level rises, additional locations around the Mawddach estuary are likely to be at risk.

The main sewage treatment plant serving the town of Dolgellau is built on low lying land at the head of the estuary and could experience tidal flooding (fig.8).



**Figure 8:**  
Sewage treatment  
plant, Dolgellau.

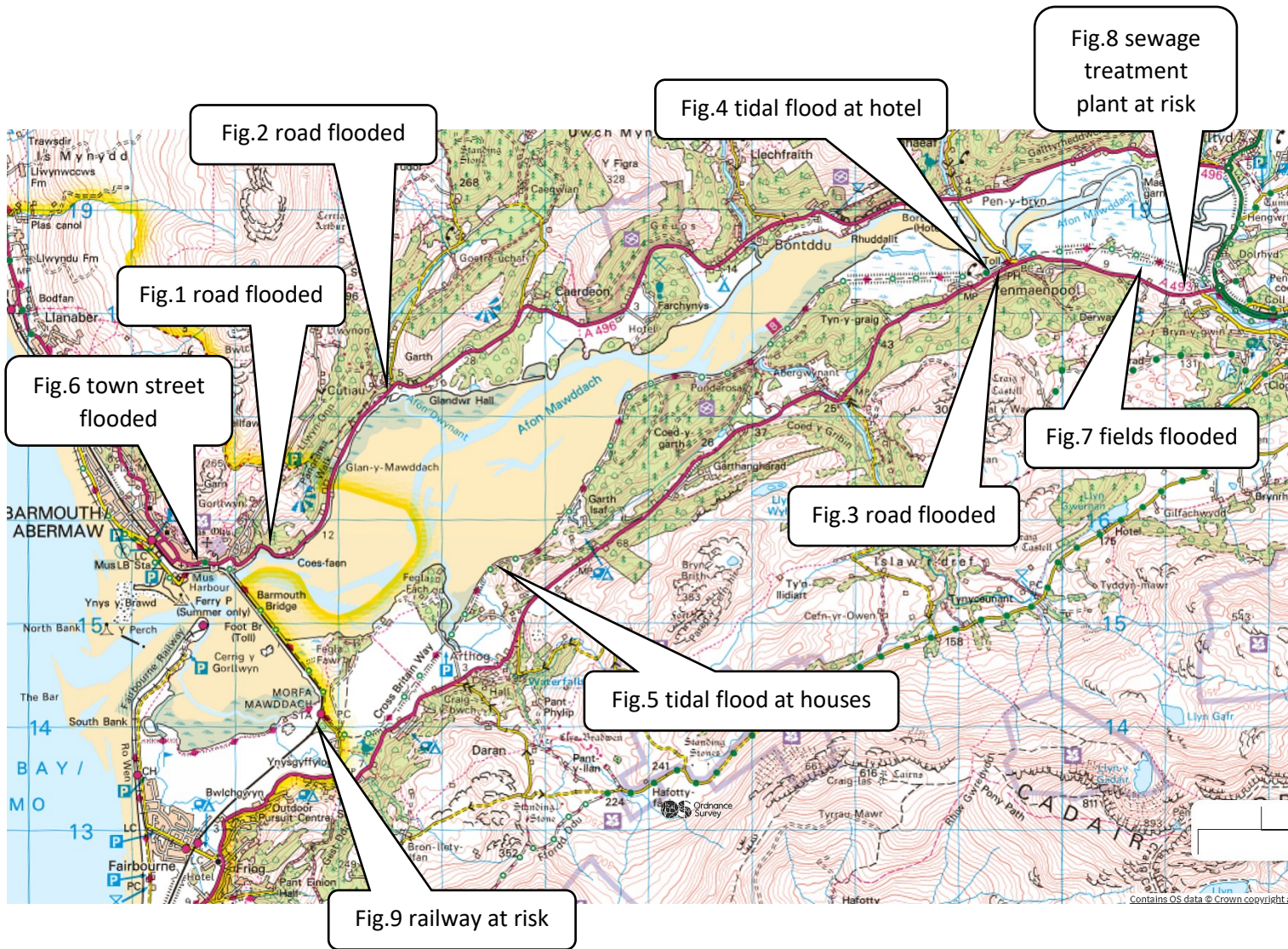
The Cambrian Coast railway between Fairbourne and Morfa Mawddach crosses the coastal lowland at a very low elevation, and may become vulnerable to tidal flooding as sea level rises (fig.9).



**Figure 9:**  
Morfa Mawddach  
station.  
The Cambrian Coast  
railway line crosses low  
lying land alongside the  
estuary between Morfa  
Mawddach and  
Fairbourne.

The locations mentioned as already experiencing floods, or at risk of tidal flooding if sea level increases, are marked on the map in fig.10 below.





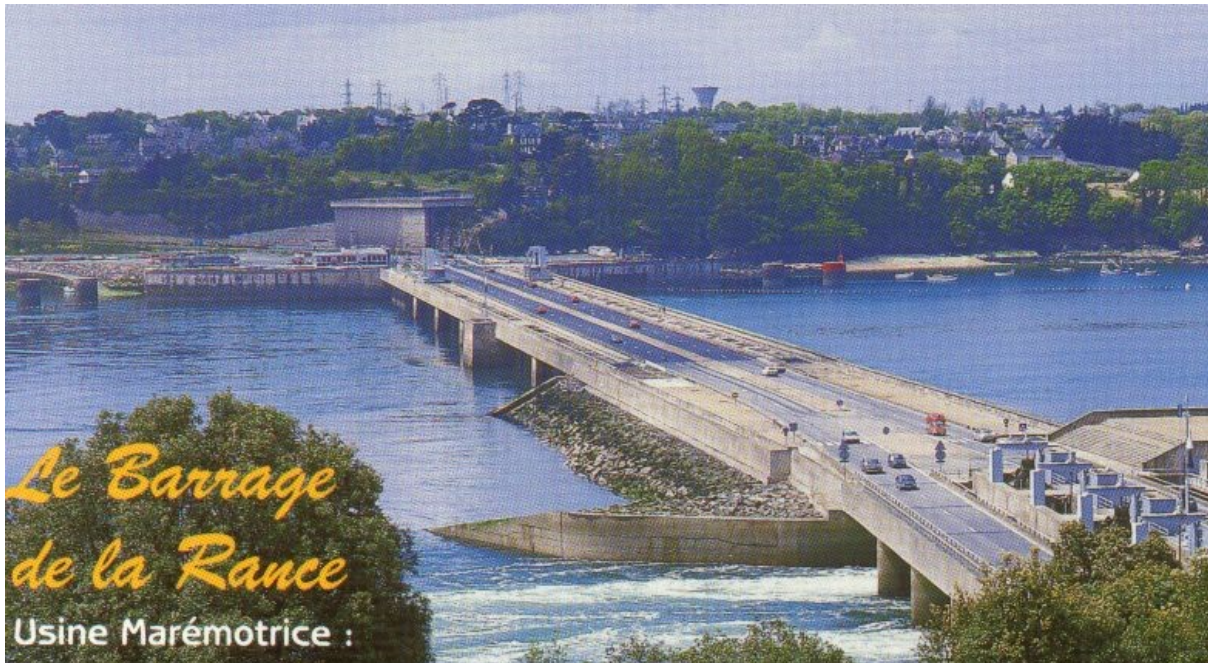
**Figure 10:** Locations around the Mawddach estuary mentioned in the text, where tidal flooding currently occurs or where there is a risk of tidal flooding due to climate change.

### Mawddach tidal barrage

A solution to the increasing problem of tidal flooding around the Mawddach estuary would be to construct a tidal barrage across the estuary mouth. This would span the relatively narrow water channel between the end of the Ro Wen shingle spit and Barmouth Harbour. The barrage would allow tidal flows into and out of the estuary to continue, but would limit the maximum tidal height within the estuary.

The barrage would be equipped with turbines to generate electricity during the rising and falling tidal phases. This could be based on the design of the tidal barrage across the Rance estuary in Brittany, France (fig.11) which has been operating successfully since its construction in 1967. Taken over the lifetime of the project, the cost per kilowatt hour of electricity produced by the Rance barrage is now lower than for onshore wind, offshore wind or nuclear generation.





**Figure 11:** Rance tidal barrage, showing the turbine inlet/outlet in the foreground.

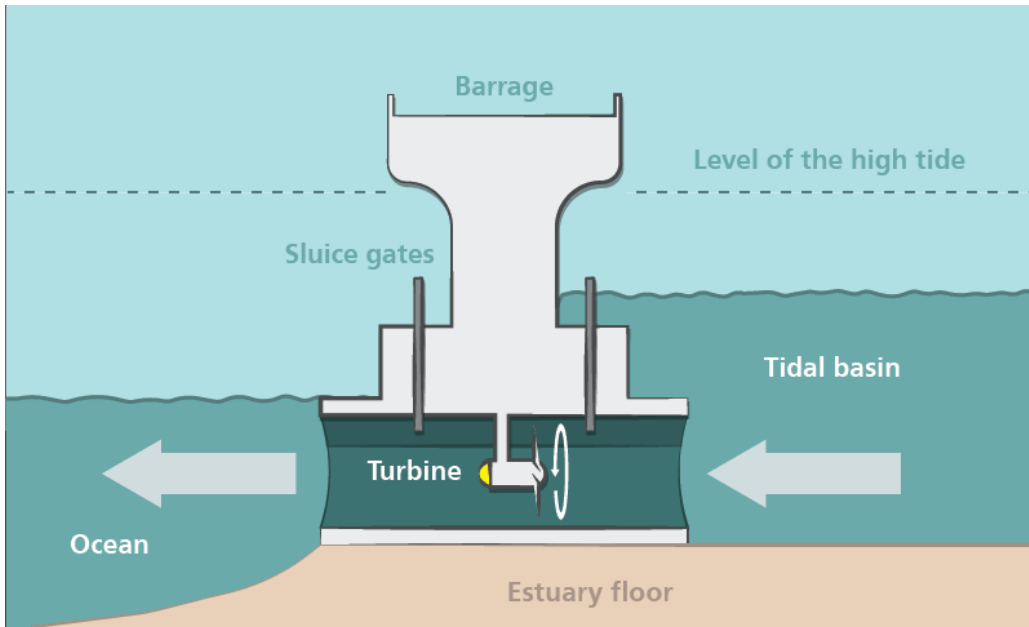
The barrage would run from the end of the Ro Wen spit to the harbour in Barmouth. A lock would allow boats to pass through the barrage, and a road could run along the top of the structure (fig.12).



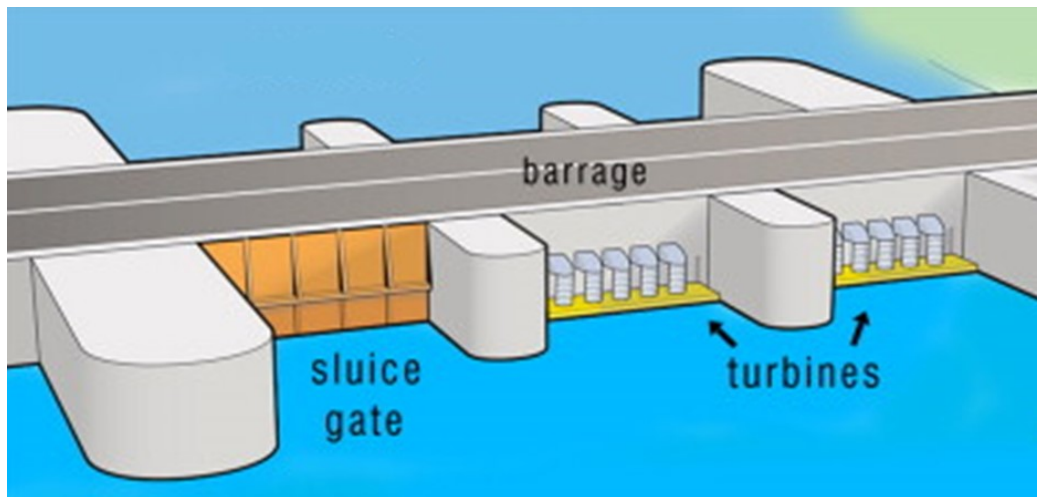
**Figure 12:** An impression of the tidal barrage linking the northern end of the Ro Wen shingle spit (right) to Barmouth harbour (left).

Electricity would be generated during the full rising phase of the tide, and through the upper half of the falling tide (fig.13). A sluice gate would be opened for the lower half of the falling tide cycle (fig.14). This would ensure full drainage of the estuary and allow sand and silt to be discharged into the sea.





**Figure 13:**  
Power generation by the tidal barrage.



**Figure 14:**  
Arrangement of sluice gates to allow discharge of estuary sediment into the sea.

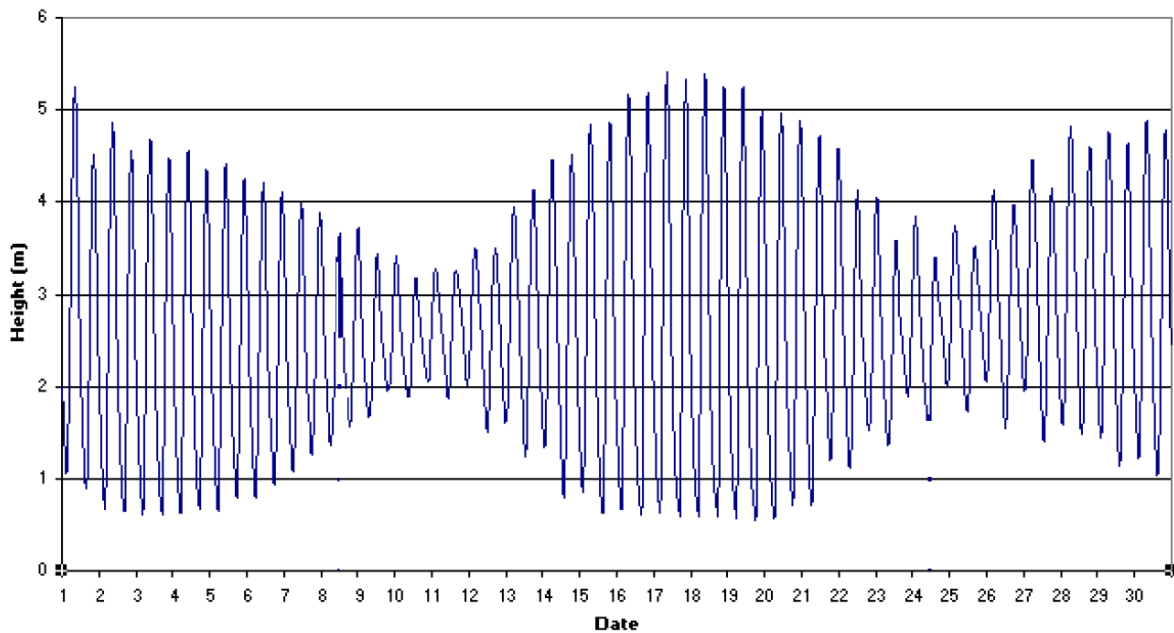
At low tide, the estuary would drain in a similar way to the present day, exposing tidal flats and salt marsh which provide a habitat for wading birds (fig.15).



**Figure 15:**  
The Mawddach estuary at low tide.  
The proposed tidal barrage would span the gap in the distance between the Ro Wen shingle spit and Barmouth harbour.



A typical month's tidal data for Barmouth is shown in fig.16. Tidal power generation would normally be greatest at spring tides, but would be substantially reduced at neap tides.



**Figure 16:** A typical month's tidal data for Barmouth, showing a tidal range varying between 5.5m at spring tide and 1.5m at neap tide.

However, we might note that the Mawddach estuary is the sea outlet for a large river system draining the mountains from Cader Idris to Trawsfynydd. A number of substantial rivers including the Afon Mawddach (fig.17) and Afon Wnion discharge into the estuary. These large river flows would help the tidal power basin to fill even at neap tides, so generation would be maximised throughout the monthly tidal cycle



**Figure 17:** Afon Mawddach in Coed y Brenin, north of Dolgellau.



## **Protection of Fairbourne from flooding**

Fairbourne is a coastal community at the mouth of the Mawddach estuary in Cardigan Bay. The village is built on land reclaimed during Victorian times from salt marsh and reed beds behind a large shingle spit.

As a consequence of climate change, Fairbourne is considered to be at a progressively increasing risk of flooding. A decision was taken by Gwynedd County Council that continued coastal protection for Fairbourne would not be feasible. The village would be abandoned and demolished at some time in the next 40 years, with all residents resettled elsewhere.

The decision by Gwynedd County Council was based on a report by the civil engineering company Royal Haskoning. However, this report has now been contradicted by three other expert reports: Phillips (2017), Buss (2018), and Hall (2021). It is considered that cost effective steps can be taken to protect the village from flooding, and an appeal is in progress against the decision by Gwynedd County Council. Protection of the village would be further enhanced if the tidal energy barrage were to be constructed at the mouth of the Mawddach estuary, as all flood risk to Fairbourne from high estuary tidal levels would be eliminated.

## **Cost benefit analysis of the tidal barrage project**

It seems that a Mawddach tidal barrage project is worthy of further consideration and the production of a feasibility study.

Sea level rise is likely to occur very slowly. However, if this should reach or exceed 1 metre, critical infrastructure such as the main roads, the railway, and the sewage treatment works would be at serious risk. Risks will also increase for homes and businesses situated along the length of the estuary. By this point, intervention to protect local communities would become necessary.

Construction of the barrage would provide protection from tidal flooding throughout the lower Mawddach valley, including the large village of Fairbourne. This could be more cost effective than a large number of small localised flood protection schemes.

Political events have created added urgency for Britain to become as self-sufficient in energy as possible, with renewable forms of energy generation given priority. Early construction of a tidal barrage would meet this objective. Construction costs of such a major project would be high, but it has been shown by the Rance barrage in Brittany that the system would be reliable and have a long life span, ultimately producing electricity at a lower cost than other available sources.

If the scheme was to go ahead, there could be a number of benefits for Barmouth, Fairbourne and the wider area of Gwynedd:

- The barrage could carry a road, which would improve communications along the coast. If there were concerns about too much traffic travelling through Fairbourne village, the barrage could implement a weight limit and toll charge similar to the Penmaenpool bridge.
- The Fairbourne narrow gauge railway might be extended across the barrage, with a terminus station at Barmouth harbour.
- An increase in visitors to Fairbourne could provide commercial opportunities for developing catering and retail businesses in the village.
- Fairbourne and Barmouth could provide housing for engineers and other staff operating the barrage, which would diversify the local economy.
- The operators of the barrage might take on responsibility for maintenance of the sea wall along the landward side of the Ro Wen spit. This would release Gwynedd County Council from this financial responsibility.