BACTON SANDSCAPING: QUANTIFIED BENEFITS 4 YEARS AFTER CONSTRUCTION

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INTRODUCTION

The Bacton Sandscaping Scheme was constructed in August 2019 at the Norfolk coast to protect the Bacton Gas Terminal from severe damages due to cliff erosion, while reinstating the beach for the neighbouring villages. A traditional option was not possible here, as the Shoreline Management Plan (SMP) would not allow an engineered solution to aggravate the situation for the downdrift communities, where the seawall is expected to reach its end of life soon. The adopted solution was a mega-nourishment with an expected lifetime of 15 to 20 years, designed so that natural processes would feed the beaches at the villages to buy the time that the communities need for adaptation to coastal change, whilst protecting the terminal against storm impacts. Clipsham (2021) provides an overview of the design (process) and Borsje (2023) an overview of the morphological development since construction.

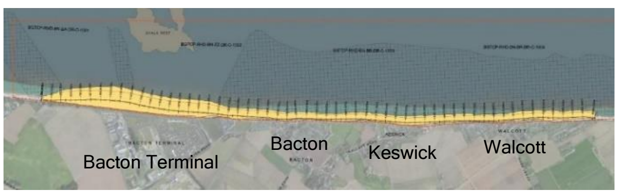

Figure 1: Impression of the implemented Bacton Sandscaping Scheme.

The Bacton scheme was designed to deliver a wide range of benefits. It is very rare that the actual outcomes of coastal schemes are assessed and reported, but in order to support the development of the Sandscaping concept, Royal HaskoningDHV is working with The Crown Estate to review this full range for the Bacton scheme. The study considers prevented damages due to flood and erosion, but also local economic growth, reduced mental health impacts and habitat enhancements. This abstract focusses only on the prevented damages due to storm impacts. This consists of three elements: the prevention of damages due to cliff erosion at the terminal, the prevention of flood damages following overtopping of the seawall at the villages, and the prevention of failure of the seawall resulting in coastal erosion at the villages. For all of these elements, no damages have occurred since the implementation of the scheme. Therefore, the generated benefits are the damages that would otherwise have occurred if the scheme would not have been in place.

CLIFF EROSION AT BACTON TERMINAL

Cliff erosion is a serious risk to the Bacton Gas Terminal; not only due to the potential cost of repairing damages to the infrastructure on top of and inside the cliffs, but also due to the disruption in gas supply to the UK. Pöyry (2014) estimates that these damages could be in the order of £50bn.

During the design stage of the scheme, historical storms were analysed to determine their impact on the cliffs (in terms of number of wave hits per meter running vertical cliff face) and whether that impact had caused erosion. The resulting distributions were referred to as "demographics" (Environment Agency, 2019) This resulted in an upper limit, above which cliff erosion is expected to occur, and a lower limit, under which cliff erosion is not expected to occur. To determine whether cliff erosion has been prevented by the scheme, the same approach was taken for the most severe storms between 2019 and 2023. Wave data between 2019 and 2023 was extracted at 10m depth from a MIKE21 Spectral Wave model driven by offshore wave data from the ERA5 hindcast. Water levels from the tidal gauges at Cromer and Lowestoft were used to derive a water level at Bacton, by averaging these records based on their distance from Bacton. The storms with the highest potential impact on cliff erosion were selected based on wave height, water level, storm duration and wave power. These storms were then modelled in AMAZON (Hu, 2000) for a representative situation without the scheme in place to determine the number of hits at each level vertically along the cliff face. These empirical distributions were then compared to the hits during the historical storms, indicating whether one of these storms would have caused erosion. Figure 2 presents this comparison, showing it is unlikely that these storms would have caused cliff erosion.

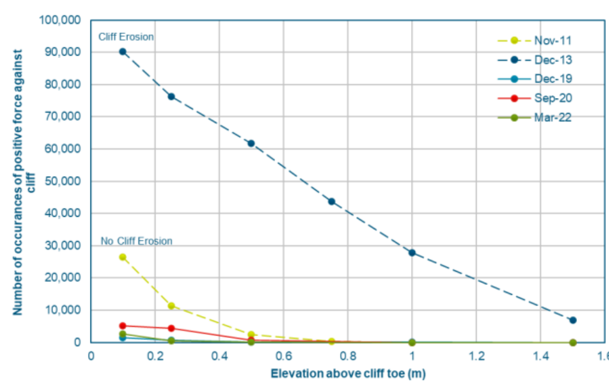

Figure 2: Demographics of the selected storm events over the last 4 years. The November 2011 (green, dashed) demographic indicates the boundary beneath which there is a high likelihood that no erosion of the cliff face will take place, whereas the December 2013 (blue, dashed) demographic indicates the boundary above which there is a high likelihood that erosion of the cliff face will take place.

DAMAGE TO THE SEA DEFENCES PREVENTED

To determine the benefits associated with the prevention of coastal erosion, a risk-based approach was used based on the chance of failure of the defences over their lifetime. Using an estimation of the residual life based on the latest Coastal Defence Condition Survey (Mott MacDonald, 2012), the cumulative probability of failure of the defences between 2019 and 2023 was calculated (acknowledging that failure had not occurred before 2019). Using the National Receptor Dataset (NCD), properties were identified that would have been affected by erosion by 2023 following defence failure in the 2019 to 2023 period. The cumulative probability of defence failure was combined with the value of the property to calculate the expected damage between 2019 and 2023 had the Bacton scheme not been in place. A similar exercise was carried out for the B1159 coastal road directly behind the defences.

FLOODING AT BACTON AND WALCOTT

Timeseries of wave data and water levels were analysed to select the storms most likely to have resulted in significant overtopping. In addition to the data used for the overtopping assessment, wave data was acquired from the Happisburgh wave buoy, which was transformed to the toe of the structure using Goda (2000). A simple estimator for the vertical run-up level was used in combination with a peak-over-threshold analysis to select storms with the highest potential for overtopping. For these storms, a peak wave overtopping discharge was then calculated using EurOtop (2018) for a representative pre-scheme defence cross-section. A corresponding flooding extent for each of these discharges was then determined from detailed modelling that was performed for the design of the Bacton scheme (RHDHV, 2018) in order to estimate the number of properties in the NRD that might have flooded. The expected damage in each historical storm event was estimated using an average damage value per property per event. The results of the analysis showed that there were several storms during which damage would have been expected in a situation without the Bacton scheme. This included one major event, and several minor events. To calculate the total damage, the minor events were discounted as these would likely have only affected houses directly behind the seawall, which were likely to have some resilience against these minor events.

Figure 3: Estimated flood extent during 30th January 2022 storm event, based on a 1.4 l/s/m peak overtopping discharge.

CONCLUSIONS

Since placement, the beach has provided protection against flooding and erosion at the terminal and villages of Bacton and Walcott. The scheme prevented potential failure of the seawall at the villages, generating over £1M in benefits from 7 properties as well as the B1159 highway which have all remained untouched by erosion. It prevented overtopping by waves at the villages, resulting in approximately 56 properties not being flooded. This results in a benefit of over £1.5M. The analysis suggests that no storms have occurred yet that would have caused erosion of the cliff face at the terminal, so the scheme has not yet generated this type of benefits. This brings the amount of generated flood and erosion prevention benefits over the period 2019 – 2023 to approximately £3M. This does not include the wider social, economic and environmental benefits (e.g. Lorenzoni (2024)). All these benefits are likely to increase further in future. For reference, the UK government's Grant in Aid (GiA) funding acquired for the scheme was £5M, and the total cost of the scheme was approximately £19M. The damage reduction benefits over the first 4 years since placement are therefore significant.

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