Study of

Blackrock Beach

County Louth

Produced by

AQUAFACT International Services Ltd

On behalf of Blackrock Tidy Towns

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November 2009

National Development Plan

'The European Agricultural Fund for Rural Development: Europe investing in rural areas'.

An Roinn Gnóthaí Pobail, Tuaithe agus Gaeltachta
Department of Community, Rural and Gaeltacht Affairs

Table of Contents

1. Introduction 1
2. Results 3
   2.1. Compile data (Admiralty Charts, aerial photographs, terrestrial photographs) to document the change on the shore over time. 3
   2.2. Review oceanographic/meteorological data and determine direction of long shore drift. 6
   2.3. Carry out a desk study to determine what may have caused erosion of sand from Blackrock beach. 12
   2.4. Review all sand stabilisation methods and select most appropriate type given the sensitivity of the site and its conservation status; estimate likely cost of same. 13
   2.5. Carry out an Appropriate Assessment on the selected method. 29
   2.6. Implementation steps and cost 48
3. References 50

List of Appendices

Appendix 1 Historic Photographs

Appendix 2 Model Outputs

1. Introduction

Blackrock Tidy Towns Committee commissioned AQUAFACT to carry out a study to establish what might be required to improve the amenity value of the main beach in Blackrock, Co. Louth and to restore it to a condition which applied prior to the 1960s.

The beach had been an important tourist attraction in previous decades but now sand has moved off the beach and only a small portion remains at the southern end, with the result that there is no dry sand on most of the beach and the northern end has become muddier. Historic photographs of the beach show a clear and consistent band of dry sand along the full length of the promenade and reaching much higher up the promenade sea wall than it currently does (please refer to Appendix 1 for these images).

Blackrock Tidy Towns Committee want to:

- Identify what would be required to retain dry sand, to a reasonable/usable depth and to a consistent width along the length of the beach
- Identify what would be required to eliminate the deposition of seaweed/algae/debris on this area of sand
- Produce an implementation plan and cost

The mud flat begins to expose about 1 hour after High Water and Blackrock beach provides a feeding resource for a variety of waders including oystercatchers, redshank, curlew and dunlin. Due to the fact that the area is located within a Special Protection Area (SPA), any development on the shoreline should have due regard to Article 6 (3) and (4) of the EU Habitats Directive[1] which states:

3. Any plan or project not directly connected with or necessary to the management of the [Natura 2000] site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to

[1] Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora to beneficial consequences of primary importance for the environment or, further to an opinion from the Commission, to other imperative reasons of overriding public interest.

appropriate assessment of its implications for the [Natura 2000] site in view of the [Natura 2000] sites conservation objectives. In the light of the conclusions of the assessment of the implications for the [Natura 2000] site and subject to the provisions of paragraph 4, the competent national authorities shall agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the [Natura 2000] site concerned and, if appropriate, after having obtained the opinion of the general public.

4. If, in spite of a negative assessment of the implications for the [Natura 2000] site and in the absence of alternative solutions, a plan or project must nevertheless be carried out for imperative reasons of overriding public interest, including those of a social or economic nature, Member States shall take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected. It shall inform the Commission of the compensatory measures adopted.

In its proposal to Blackrock Tidy Towns Committee, AQUAFACT recommended the following approach to be taken.

A. Compile data (Admiralty Charts, aerial photographs, terrestrial photographs) to document any changes on the shore over time.
B. Review oceanographic/meteorological data and determine the direction of long shore drift.
C. Carry out a desk study to determine what may have caused erosion of sand from Blackrock beach.
D. Review all sand stabilisation methods and select the most appropriate type given the sensitivity of the site and its conservation status; estimate likely cost of same.
E. Carry out an Appropriate Assessment of the selected method. This is the most expensive part of the work as it requires close liaison with National Parks and Wildlife and also a predictive model to demonstrate that the proposed technique will not have a significant impact on the functioning of the SPA.
F. The implementation plan and cost will be produced once the above points have been addressed.

2. Results

2.1. Compile data (Admiralty Charts, aerial photographs, terrestrial photographs) to document the change on the shore over time.

Looking at the navigation chart and aerial photographs attached (Figure 2-1 - British Admiralty chart – data collected in 1843; Figure 2-2 – aerial image of the Fane estuary taken in 1954 by the Irish Air Corps; Figure 2-3 – aerial image taken in 2004), it can be seen that the course of the river has not changed much over a time-scale of approximately 160 years. The overall morphology of the river bed east of the mouth looks much the same in the three images and the seaward section of the estuary as shown in Figures 2-1 and 2-3 are also quite similar even down to the detail of small drainage channels that run from the mud flats into the bed (Figure 2-2 does not extend as far to the east as does Figure 2-3). The width of the river bed in Dundalk Bay is narrower in the Admiralty Chart than in the 2004 aerial image. It is uncertain what effect this may have on sediment distribution/removal from the Blackrock beach site. The banks that are exposed at low water just east of the mouth of the river are somewhat similar over the 160-year time scale. One small feature that is present in the area of the sand banks on Figure 2-3 is not marked in Figure 2-1 – this is a small drainage channel that runs from the north to join the river channel. This may have been too small to have been surveyed by the Hydrographic Office in 1843.

The Admiralty chart has sedimentological information on it that was collected at the time of the original survey, i.e. early 1840s, and a review of this information shows that at that time Dundalk Bay was characterised by sandy substrates. It appears therefore that the nature of the sediment that makes up the intertidal areas of the bay has altered over this period of time, becoming muddier. The reasons for this are not immediately obvious. However, there is anecdotal information that the overall morphology of the bay has changed over time but this cannot be substantiated.

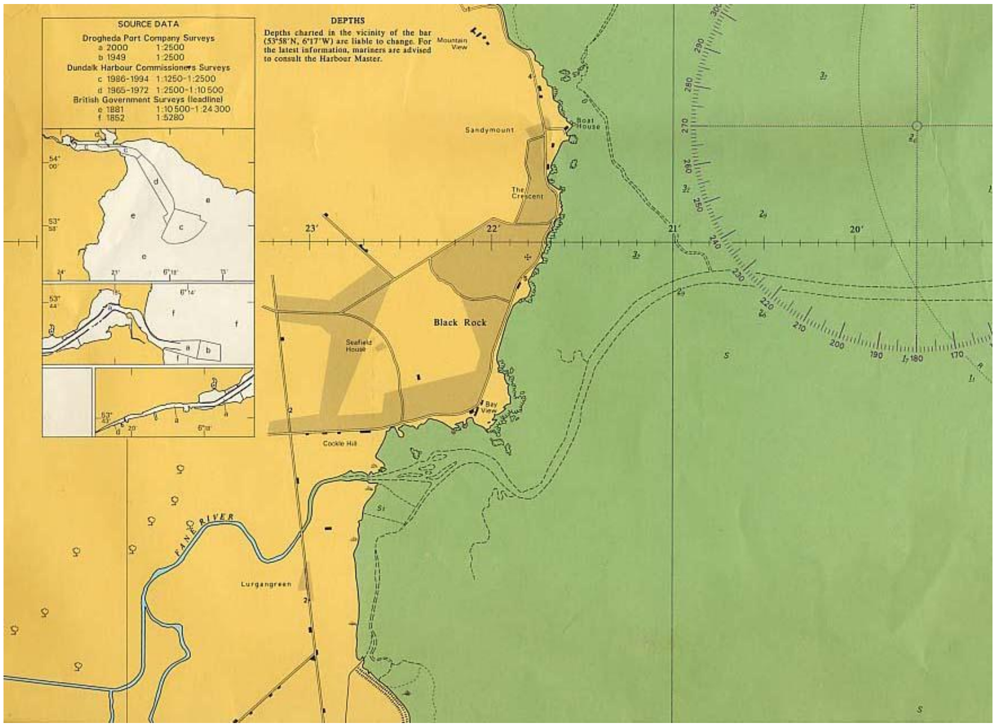


Figure 2-1: **British Admiralty Chart No. 1431 (1843) showing the area around Blackrock and the intertidal route of the River Fane.**

Figure 2-2: Aerial photography of area of interest (1954). (The eastward route of the river into Dundalk Bay is not shown in this image).

Figure 2-3: Aerial photography of area of interest (2004).

The suite of photographs presented in Appendix 1 shows how the profile of the beach has altered since the earliest image was taken in the late 1890s. In the photos up to the 1960s, there is a clear band of sand *circa* 15 m wide that extends seaward from the promenade wall. In addition, it is clear that the width of the beach at the northern end is *circa* twice as wide as it is at the southern end. This indicates possible accretion at this end of the beach. In the above image (Figure 2-3), taken in 2004, this situation had changed quite obviously with the northern end of the beach now *circa* half as wide as the southern end. This is also clearly evident in Photos 5 and 6 in Appendix 1. One notable alteration in the local shore line morphology is the new car parking area at the northern end of the promenade. This is visible in both Figure 2-3 above and Photos 5 and 6 in Appendix 1. The outfall pipe at the southern end of the beach is also visible in both these images. What is also noticeable is the rate of accretion to the south of this outfall between the 1998 and 2005 images.

2.2. Review oceanographic/meteorological data and determine direction of long shore drift.

Tides

The greater part of the Irish Sea has a strong tidal regime with tidal range increasing in general from south to north and from west to east. The tides enter the Irish Sea from the Atlantic Ocean through both the St. George's and North Channels, with the two paths meeting in the vicinity of the Isle of Man. The tidal range within the Irish Sea varies from 6.0m in the west to 8.0m in the east.

Figure 2-4 shows the variation in tidal heights in Dundalk Bay based on an offshore tide gauge located at 06° 03' 06.17682" W, 53° 56' 48.23905" N. Figure 2-5 shows the location of the tidal gauge. The data show a range of 5.5m during spring tides and less than 2m during neap tides.

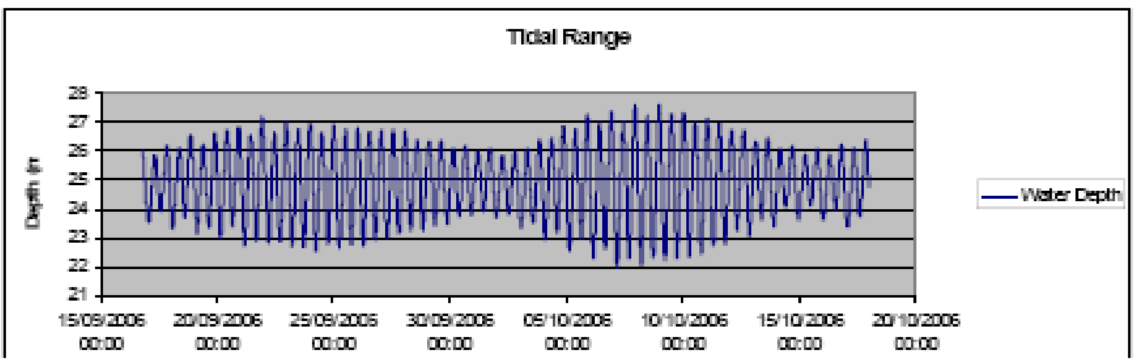


Figure 2-4: Measured tidal data from Dundalk Bay from the 16-9-06 to the 17-10-06 showing 1.5 lunar cycles.

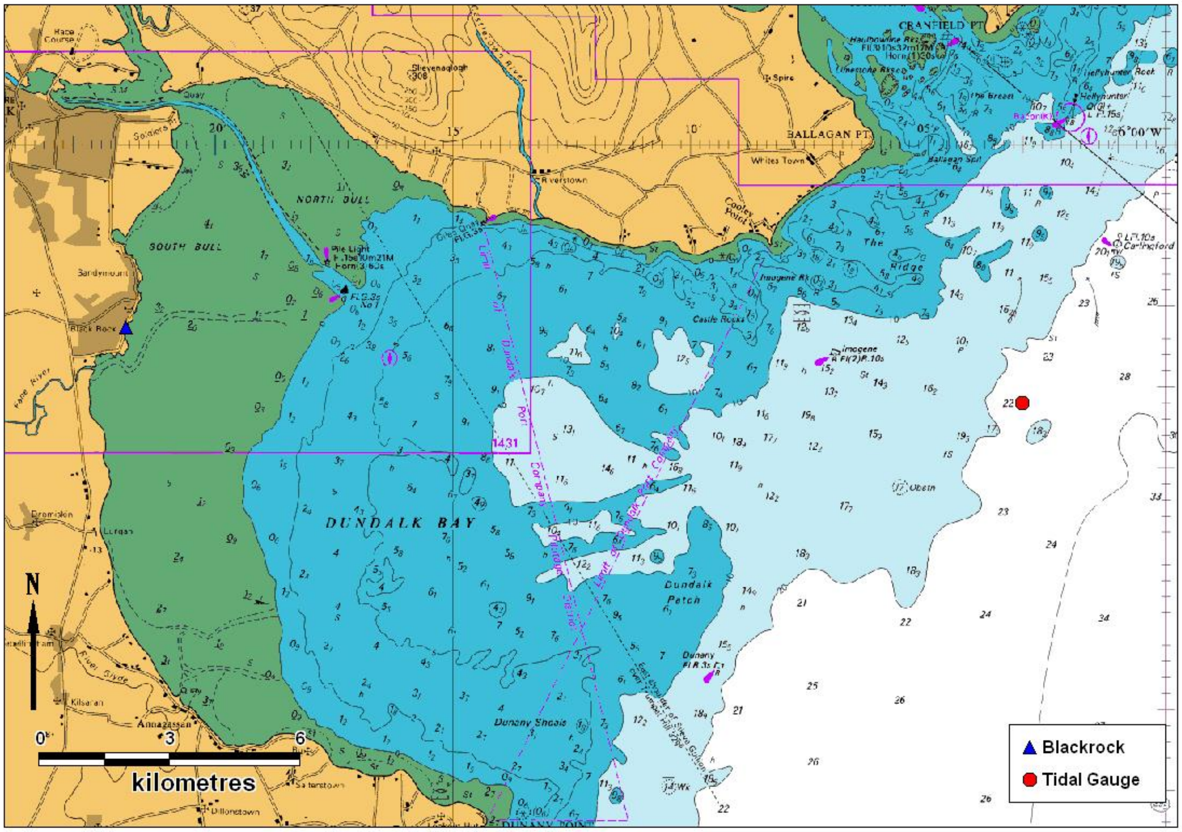


Figure 2-5: Location of tidal gauge.

It is worth noting that the ranges recorded are higher than those obtained from the POLPRED (**P**roudman **O**ceanographic **L**aboratory Tidal **Pred**ictions) predicted tide model for the area. The model predicts a highest astronomical tide of 4.77m. While some discrepancy between predicted and measured tides is expected, 0.7m is quite high. The difference is attributed to storm surges associated with south-easterly gales in the Irish Sea.

Tidal currents do not exceed 0.5m/s. The current flows northwards on a flooding tide and southwards on the ebb. This regime is complicated from May to October by the Irish Sea Western Gyre, which circulates within the northwestern part of the Irish Sea.

Waves

Wave heights in Irish waters can get very large in western and southern areas, but the land mass of Ireland offers considerable protection to the Irish Sea, and therefore less wave energy will penetrate this area. In general, there is a reduction in wave height as the water depth decreases. However, waves may be focused by refraction as they pass into shallower water. In very shallow coastal waters, the effect of seabed friction and wave breaking also act to reduce wave heights. Finally, tidal levels and currents can affect wave conditions at a particular site.

Surface waves depend on the duration and fetch of the wind. As the Irish Sea is sheltered with only two relatively narrow entrances, along the axes of the St. George's and North Channels, the majority of waves are locally generated and are of fairly short period and hence steep. The maximum 50-year return value of the mean period varies between about 10m within the Irish Sea to about 15m at its outer entrances (Lee & Ramster, 1981). Similarly the 50-year return value of the significant wave height varies between about 8m within the Irish Sea to about 12m at its outer entrances. The effect of waves on other processes is significant during storms, especially on sediment movement in the shallow areas of the eastern Irish Sea. The closest recording station is the M2 weather buoy situated over the Lambay Deep east of Dublin. Hourly readings from this buoy dating from May 2001 to October 2006 were made available by the Marine Institute. The data were analysed to derive the average and maximum wave height for each month and to establish the direction of maximum height.

The average wave height for each month (Figure 2-6) shows that the highest average wave height is in January at 1.73m.

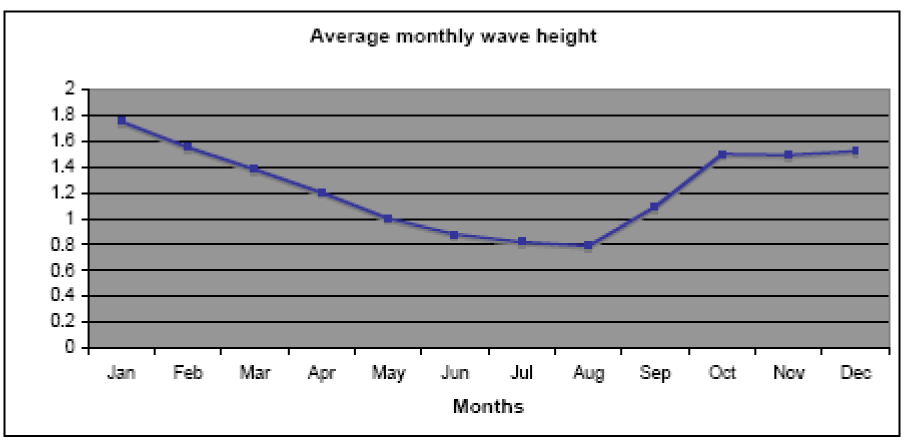


Figure 2-6: Average monthly wave height recorded at the M2 weather buoy, 2001 – 2006.

The average wave height drops consistently through the spring and early summer before levelling off at between 0.84 and 0.795m during June, July and August. Average wave height then climbs rapidly in September before levelling out at 1.5m for October, November and December.

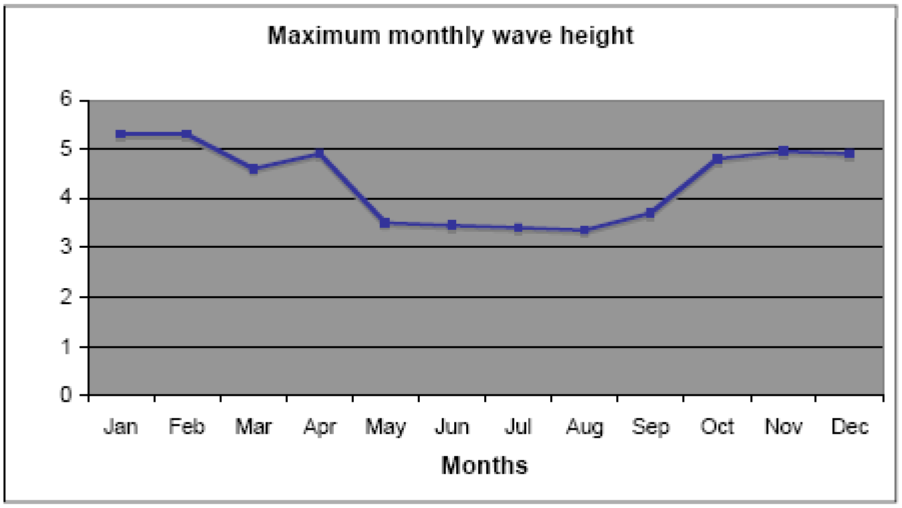


Figure 2-7: Maximum wave heights recorded at MS wave buoy in the Irish Sea.

The maximum monthly wave heights (Figure 2-7) were highest in January and February both with wave heights of 5.3m. The values dropped considerably during late spring and summer with values in the range of 3.2 to 3.5m recorded between May and August. Values increase again to between 4.8 and 4.9m in October, November and December.

The wave climate at Blackrock beach relates not only to the wind direction/strength but also tidal height at any time. Even if the wind is blowing directly onshore and is strong (e.g. Force 6), if the tide is out, there will be no effect to the beach at Blackrock. It is only at high tide that the sediment at the beach can be mobilised.

Currents

The maximum currents in the area are 0.5m/s on a flooding spring tide. There is a certain amount of information available from published modelling of the area. Horsburg *et al.* (2000) have suggested that there is a seasonal evolution of the three-dimensional density field in the western Irish Sea. A cold, dense pool flanked by strong, near seabed horizontal density gradients is present from May until October. Storm surges are manifested by water piling up at the coast through the combined actions of wind and atmospheric pressure variations.

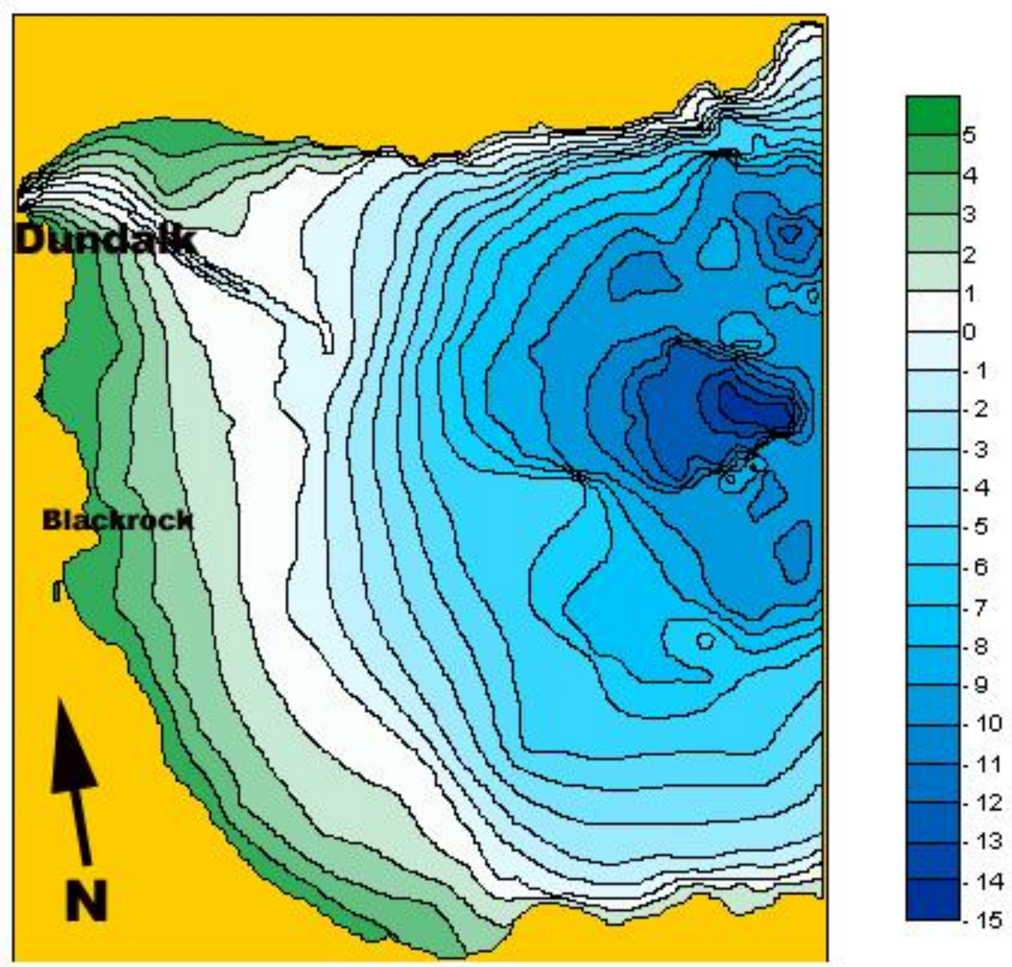
Maximum surge levels of about 2m are predicted to occur on the Lancashire and Cumbrian coast and levels between 1.25m and 0.75m are predicted on the Irish coast and across St. Georges's Channel (Flather, 1987). As the Irish Sea is semi-enclosed the associated currents are weak, arising both directly from wind drag at the sea surface and indirectly from sea-surface gradients. The former are limited to a surface layer about 10m in depth and have a maximum speed at the surface of about 3% of the wind speed (Brown, 1991). The latter are predicted to have a maximum depth-mean current away from the coast of 0.5m/sec (Flather, 1987). Their direction is largely determined by topography rather than by wind.

Currents in Dundalk Bay are generated for the most part by tides. Spring tides extend to *circa* 5m above chart datum while Neaps only reach *circa* 2m over datum. These variations give rise to relatively weak velocities, and Orren *et al.* (1989) and MSC (1994) record velocities of up to a maximum of *circa* 20 cms/sec. Dickson and Boelens (1988) note that residual currents in the area are weak and that there is little movement in Dundalk Bay. The inner bay is quite shallow throughout and, because of this, stratification of the water column cannot occur. Orren *et al.* (1989) and Hydrographic Surveys (1989) both carried out drogue and dye release studies in Dundalk Bay and the results of these studies also showed that velocities in the area are slack and that dye and drogue movements were not extensive - i.e. *circa* 1 km over a flooding or ebbing tide.

Prevailing wind direction in the area is from the southeast around to the southwest. This indicates that the net long shore drift is northwards. However, this situation is very much dependant on wind conditions on any one day and this will be an important factor in relation to the build up of weed on the beach (see Photo 7 in Appendix 1).

Bathymetry

Figure 2-8: Bathymetry of Dundalk Bay based on Admiralty chart data (depth in meters relative to Malin Head).



2.3. Carry out a desk study to determine what may have caused erosion of sand from Blackrock beach.

Coastal sands develop where there is an adequate supply of sand (sediment within the size range 0.2 to 2.0 mm) in the intertidal zone, and where onshore winds are prevalent. The critical factor is the presence of a sufficiently large beach plain whose surface dries out between high tides. The dry sand is then blown landwards and deposited above the high water mark where it is trapped by specialised dune-building grasses that grow up through successive layers of deposited sand. The changes at Blackrock beach over time, and the fact that on shore winds do not predominate, mean that the accretion rates at the site are not likely to be strong.

The seaward accretion of a beach takes place through the accumulation of wind-blown sand caught by material along the drift line, or obstacles such as driftwood or a sand fence. These reduce wind speed allowing sand to accumulate. It appears that this situation may be happening at the southern end of Blackrock each where the storm water outfall pipe is located.

During storms, sand erodes from the beach-dune system and re-deposits as shallow sandbars offshore. In a stable beach system, the sand moved offshore during storms is returned during calm weather. The fact that the sand has been lost from Blackrock indicates that such on-shore currents do not occur.

The shape or morphology of the shore is constantly changing in response to the varying forces acting upon it. This response is in the form of sediment movement in order to dissipate the energy acting on the coast. The changes may be merely oscillations around a long term average or they may be part of a continuous erosion or accretion pattern. They can be rhythmic or cyclical or can show dramatic changes from long periods of relative stability to periods of progressive erosion, sometimes triggered by a particularly severe storm or the building of structures on the coastline. Collection of short term data on the variables affecting erosion provides a platform for sensible analysis and further study, but it is vital that long-term coastline change be assessed.

The reasons why the profile of the beach at Blackrock has changed may be due to a number of factors. These include sea level rise, land subsidence or the effect of a new structure at or close to the site. Because this effect has only occurred at the Main Beach and not at Priest's beach (compare Photos 2 and 3 with Photo 5 in Appendix 1), it is most likely that a very localised physical change in either the shore line or the sea wall is the reason for the alteration of the beach profile. The most likely cause may have been the introduction of the car parking area at the northern end of the promenade in the 1960s. What had previously been a rocky, weed covered area of shallow sloping and variably pitched intertidal shore line was changed into a hard, even sided, upright sea wall. This sort of structure would have very different wave reflective characteristics to that of the conditions that were originally present. Rather than the waves being gradually dissipated with varying depths and surface types, the waves strike a solid structure and reflect off it. If the waves approach this new structure from the south east or east, they will be reflected to the southwest along the face of the beach and thereby increase the level of scour.

Another alteration also took place in the early 1990s - the construction of the storm water outfall at the southern end of the beach. This has acted like a groyne, and sediment has built up to the south of it. This material would previously have had access to the beach area, and the fact that it now does not, along with the increased scour effect of the new car park, may have exacerbated the change of the beach.

2.4. Review all sand stabilisation methods and select the most appropriate type given the sensitivity of the site and its conservation status; estimate likely cost of same.

Beach sands are readily moved and shaped by wind and water action. A series of options for the stabilisation of sandy shores is outlined below. The pros and cons of each are discussed in the context of Blackrock and the overall benefits analysed.

Option 1: Planting for stability

Beach restoration usually begins with the establishment of pioneer plants. Beaches that are only slightly damaged may be repaired by planting vegetation in bare areas, giving stressed grasses a judicious amount of fertilizer and protecting the area from trampling and traffic. Vegetated sand is recognised as providing the best stablilisation of all. However, due to the physical conditions at Blackrock, the beach does not support any vegetation and this option is not a possibility.

Option 2: Wave barriers

Wave barriers (see Figure 2-9) can be utilised to reduce the wave energy before it reaches a beach. In general, sand moves offshore during storm events and onshore during periods of low wave energy. The standard wave barrier is a Dutch fence made up of brushwood or sunken poles and arranged in the form of a box. The inner line protects the beach while the outer line acts as the main barrier to wave attack. While the primary purpose of this fence is to absorb wave energy to protect the sand at the base, it will also encourage sand build up. Although such structures will temporarily block onshore access of flotsam and jetsam (including floating weed), once the sea overlaps wave barriers, the floating material will then be brought on the beach with the rising tide.

Straw bales can also be used to protect vulnerable beaches against wave attack. This is not a wave fence proper but merely a mechanism for protecting the beach directly. This is a variation on the method used successfully in Dollymount beach, Co. Dublin, where alga is collected from the strandline, gathered into mounds in front of the foredunes and covered with sand.

Railway sleepers have also be used as wave barrier fencing. However, wave barriers should be of porous rather than solid construction so that they slow the waves and cause them to lose energy and drop their load of suspended sediments. Non-porous structures cause local scour or the unequal build-up of beach material on either side of the barrier.

Wave barriers are also constructed using large boulders (*circa* 3 tonne), placed at right angles to the incoming waves. The irregular nature of this construction helps to diffuse the energy in the wave before deflecting it away from the shore.

Offshore wave barriers in the form of man-made reefs are another method of dampening energy levels at a distance from a beach. Due to the very gradual deepening of water depths at the site in question, in order for this to be effective the reef would have to be within *circa* 100m of the beach and should be *circa* 4m in height and *circa* 400m in length.

A successful wave fence is one that will protect the beach from the severe erosive effects of winter storms and will encourage any beach formation that occurs resulting in net accretion, as opposed to erosion. At the same time, the fence will not seriously impede sediment transport whether alongshore or aeolian. Its environmental impact is considered benign.

The use of Dutch fences at Blackrock is not regarded as a viable option due to the interference of such structures on the amenity value of the beach and the possibility that the posts protruding above the sand might cause a hazard.

Figure 2-9: Example of a rock wave barrier

Option 3: Sand stabilisation

Sand stabilisation as a technique is used in conjunction with a number of other complementary techniques. These include:

- grass planting
- dune recontouring
- sand trap fencing

a) Biodegradable jute and coir matting work very well in stabilising loose sand. They are rolled out and pinned at regular intervals. Typically, they biodegrade after 2-7 years. Soil blankets can also be utilised successfully as a means of stablilising soil slopes from water runoff although these are not considered suitable for coastal work and are not recommended for this project. Chopped straw can also be used as an inexpensive material that successfully binds loose sand. This can also be used to stabilise the sand surface after seeding.

b) Tackifiers, sometimes called binders, form a semi-permeable layer on the sand surface. This allows germination to take place while helping prevent the sand from blowing away. Some are short-lived, remaining on the surface for a few months, while others may last a number of years. A tackifier is usually used in a seeding programme. It can either be sprayed over a pre-seeded area to prevent wind blow, or be used as part of a hydroseeding mix. Both organic and inorganic tackifiers are available. One of the first choices for sand dune work is the tackifier developed from wood pulp by-products.

c) Sand trap fencing breaks the natural flow of sand within the dune transport system and allow for some stability to provide a basis for further vegetative colonisation. Fences nearer the strand line ensure a measure of winter protection for vulnerable fore dunes and offer the best long term dune protection Sand-trap fencing can be used where there is across-shore aeolian sand movement or where human interference has damaged fore dunes. The actual trapping mechanism involves fixing a barrier with a 40-50% porosity about 1.25m on the windward side of where sand build up is required.

Beach nourishment is a method whereby sand is imported on an annual basis and placed where it is required during the spring months. This is a costly exercise and, as the area is designated as an SPA, State bodies (NPW) and NGOs (Birdwatch Ireland, An Taisce) may object to such a proposal.

For the same reason as noted for Option 1 above, planting, contouring and trap fencing are not feasible in the Blackrock beach situation.

Option 4. Groynes

A groyne (see Figure 2-10) is a rigid structure, built from a shore line, that interrupts water flow and limits the movement of sediment. They can be built of concrete, wood or rock. Rock is regarded as the more suitable for Blackrock as it is cheaper, longer lived and is not uniform in surface finish and is therefore not as reflective as concrete or timber. In the marine environment, groynes help to stabilise sands, create beaches or avoid having them washed away. Groynes typically run perpendicular to the shore line and extend from the upper shore to varying lengths down the shore. The ECOPRO manual (1996, p. 264) gives a length to spacing ratio for sandy beaches as 95m : 130m. Groynes require little maintenance, but they may cause a shoreline to be perceived as unnatural and ugly.

A groyne creates and maintains a wide area of beach or sediment on its updrift side, and reduces erosion on the other. It is a physical barrier that reduces sediment transport in the direction of longshore transport. Groynes do not add additional material to a beach but merely retain some of the existing sediment on the updrift side of the groynes. If a groyne is correctly designed, the amount of material it can hold is limited. However, if a groyne is too large it may trap too much sediment which can cause severe beach erosion on the down-drift side.

In relation to rock structures on the shoreline, the rock size, face slopes, crest elevation and crest width must be designed with care. Rock size is dependent on incident wave height, period and direction, structure slope, acceptance of risk, cross-sectional design and the availability/cost of armour rock from quarries. In general 1-3 tonne rocks are sufficient for the landward parts of the groynes, provided that they are placed as at least a double layer with a 1:1.5 to 1:2.5 face slope, and there is an acceptance of some risk of failure. Larger rocks, probably 3-6 tonne, may be needed for the more exposed body and seaward head of each structure.

Randomly dumped rock with a high void to solid ratio is hydraulically more efficient than placed and packed rock. However, rock structures on recreational beaches should be built with a view to minimising the potential for accidents involving beach users slipping between rocks.

The groyne berm should be built to the anticipated crest level of the beach. The groyne berm length should equal the intended crest width of the updrift beach. The groyne should extend down the beach at a level of about 1m above the anticipated updrift beach, normally at a slope of about 1:5 to 1:10. The groyne head should extend down into the sand beach, allowing for some future erosion.

Groynes may be permeable, allowing the water to flow through at reduced velocities, or impermeable, blocking and deflecting the current. Permeable groynes are large rocks or timber, whereas non-permeable groynes (solid groynes or rock armour groynes) are constructed using rock, gravel or gabions. The non-permeable type is considered as being the more appropriate option for Blackrock, as semi-permeable groynes allow for some level of sediment removal from the site.

One environmentally positive aspect of groynes constructed using boulders is that the three dimensional spaces that are created when the rocks are piled together provide niches for a high diversity of plants and animals. As such, they act like artificial reefs and increase biodiversity and both primary and secondary production.

Figure 2-10: Example of a groyne

Option 5: Localised contouring and wave barriers at the car park.

As the new car park structure has been identified as the most likely cause for the change in shore profile and therefore beach amenity, it is recommended that methods to either change the reflective properties of its facade or a method to protect the beach from scouring effects generated by it be examined. The latter solution is regarded as the simplest with a wave barrier being constructed in a southeasterly direction off the sea wall. This would have a rounded terminal section to further reduce scour effects along the beach. This structure is shown in Figure 2-11.

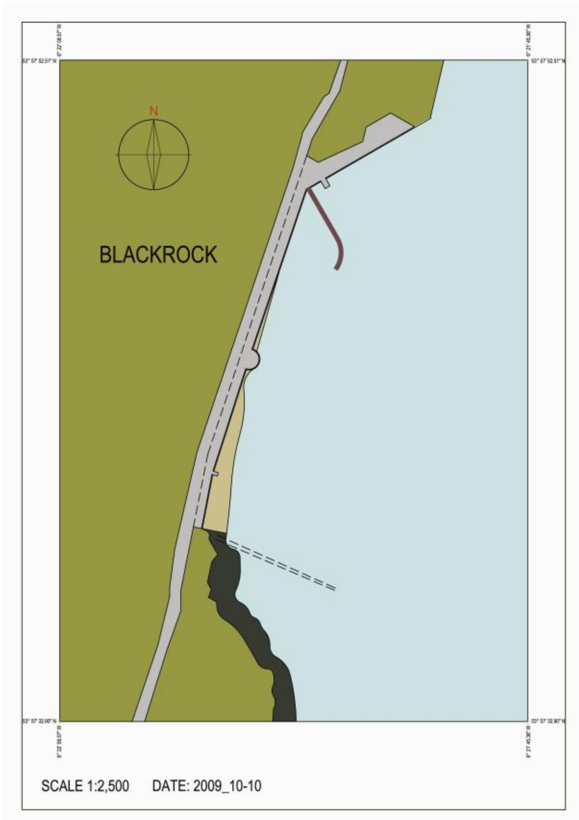


Figure 2-11: New wave barrier built off car park wall to protect the beach from scour

Figure 2-12 and 2-13 show possible designs that would change the reflective properties of the car park wall. However, as they are considerably larger in size and would therefore have cost implications, they are not recommended.

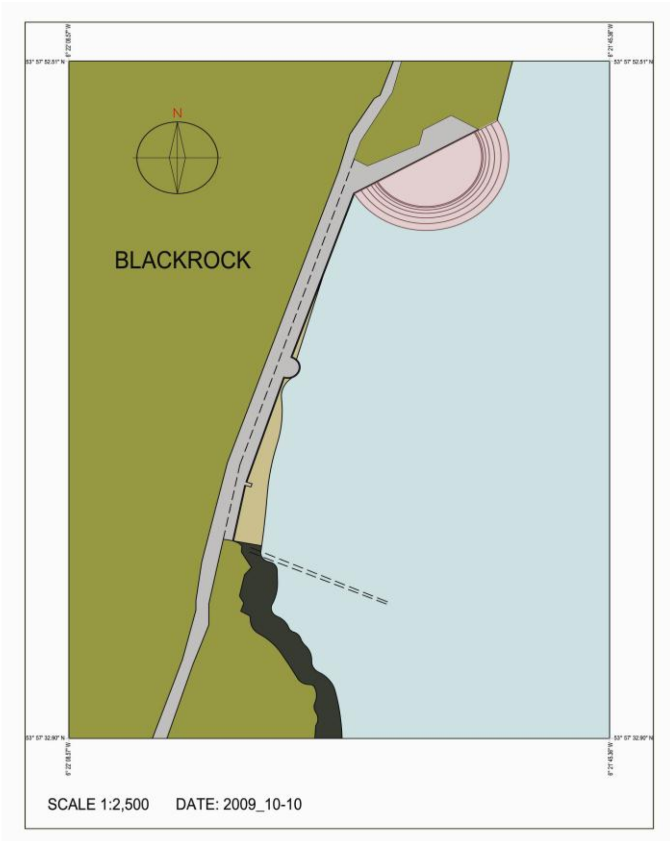


Figure 2-12: Semicircular infilled area to SE of car park wall to reduce wave-induced scour at the beach.

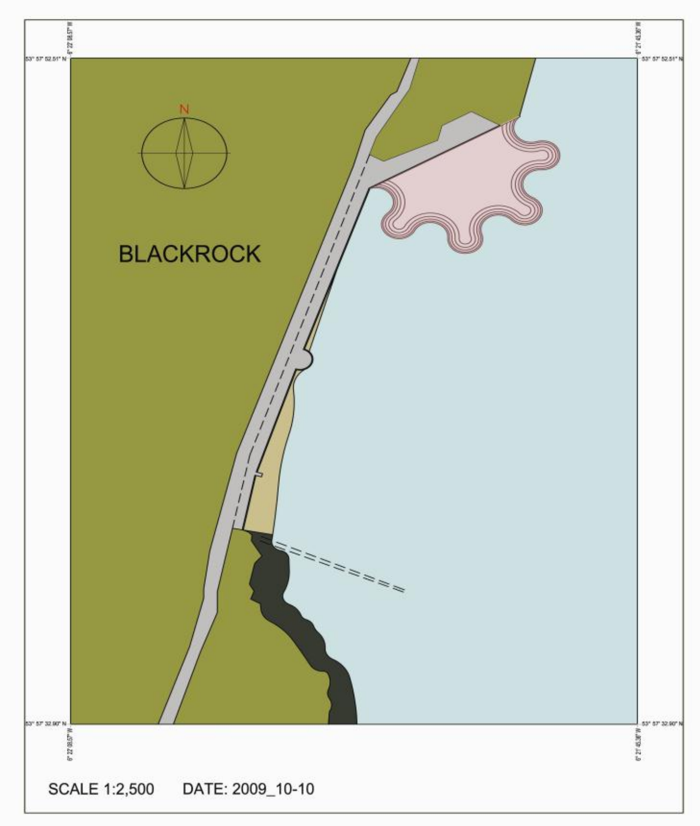


Figure 2-13: Palmate infilled area to SE of car park wall to reduce wave-induced scour at the beach.

Option 6: Do nothing approach

Although doing nothing may appear like irresponsible abandonment in the face of difficult coastal erosion problems, it is a deliberate, logical strategy. It is designed to facilitate a degraded coastline to rebuild its natural defences and achieve a state of reasonable dynamic equilibrium.

In the case of Blackrock, as the do nothing approach would allow the current situation of sand depletion at the main beach area and accretion at the storm overflow to continue, it is therefore not regarded as a viable option. Temporal build up of floating weed would also continue.

Recommendation

Reviewing the likely cause for changes at the beach, and the six possible remedial options, it is recommended that the best option for returning the beach to its former condition would be to either prevent waves reflecting onto the beach or alter their reflective angle away from the beach as detailed in Option 5. The former approach is regarded as the least obtrusive and the most cost effective, and a design option has been included in Figure 2-11. Furthermore, if the structure is constructed of rock rather than concrete or wood, it will increase biodiversity and both primary and secondary production locally.

A mathematical model study to show current velocities at Blackrock beach was undertaken in order to predict the current speeds and direction, both without and with the proposed wave barrier in place. The model output was validated using the measured tidal data presented earlier. The model domain is shown in Figure 2-14. This large area was chosen in order to be able to ensure that an accurate prediction of the current regime at Blackrock could be achieved. Bathymetry is based on the 1843 Admiralty Chart and it is extremely likely that present day elevations are different. For this reason, the output of the present model must be viewed with this caveat. In order to be able to resolve the effects of the proposed wave barrier on current directions, a grid spacing of 20 m was chosen. Detailed modelled data of currents at High Water at Blackrock beach are shown in Figures 2-15 and 2-16.

Figure 2-14. Extent of model domain.

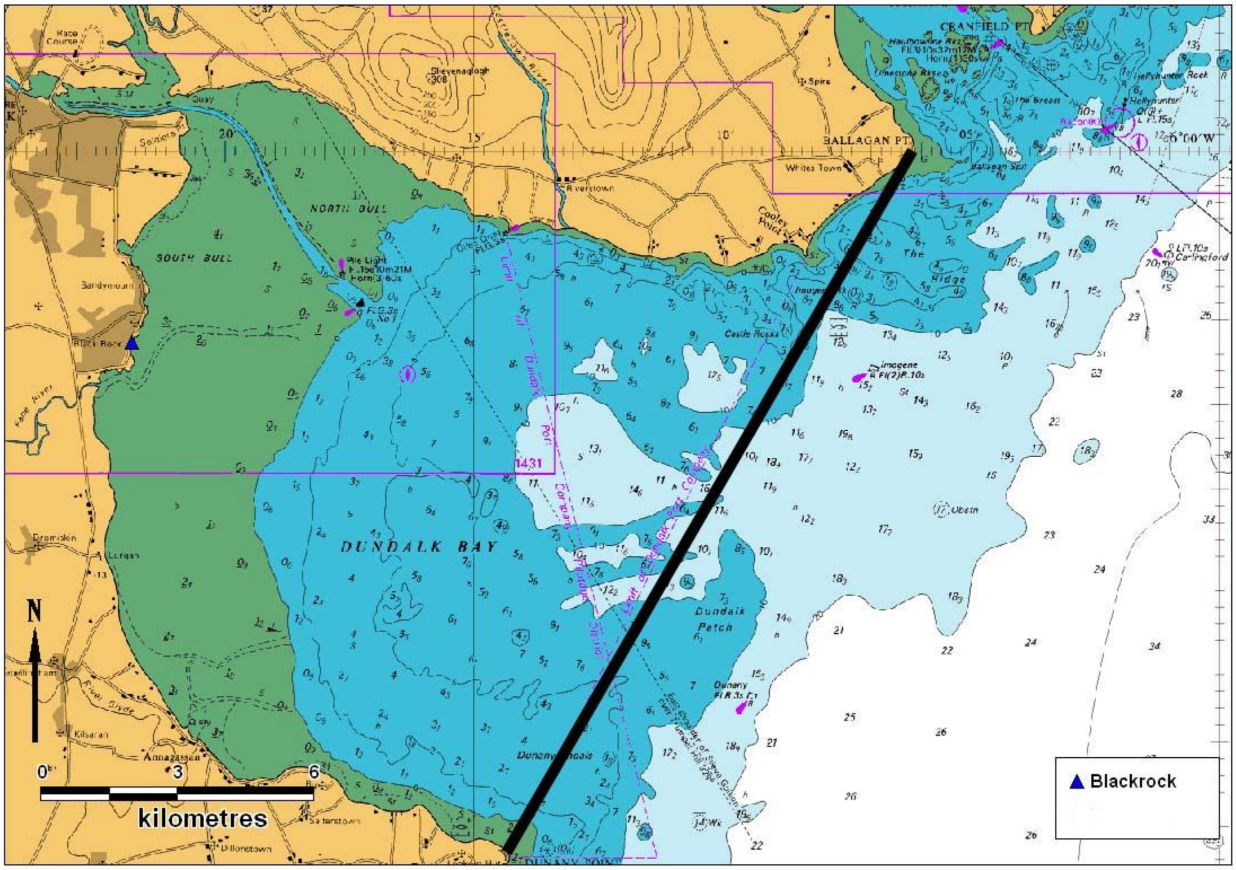


Figure 2-15. Currents at High Water – 1.55 hour at Blackrock.

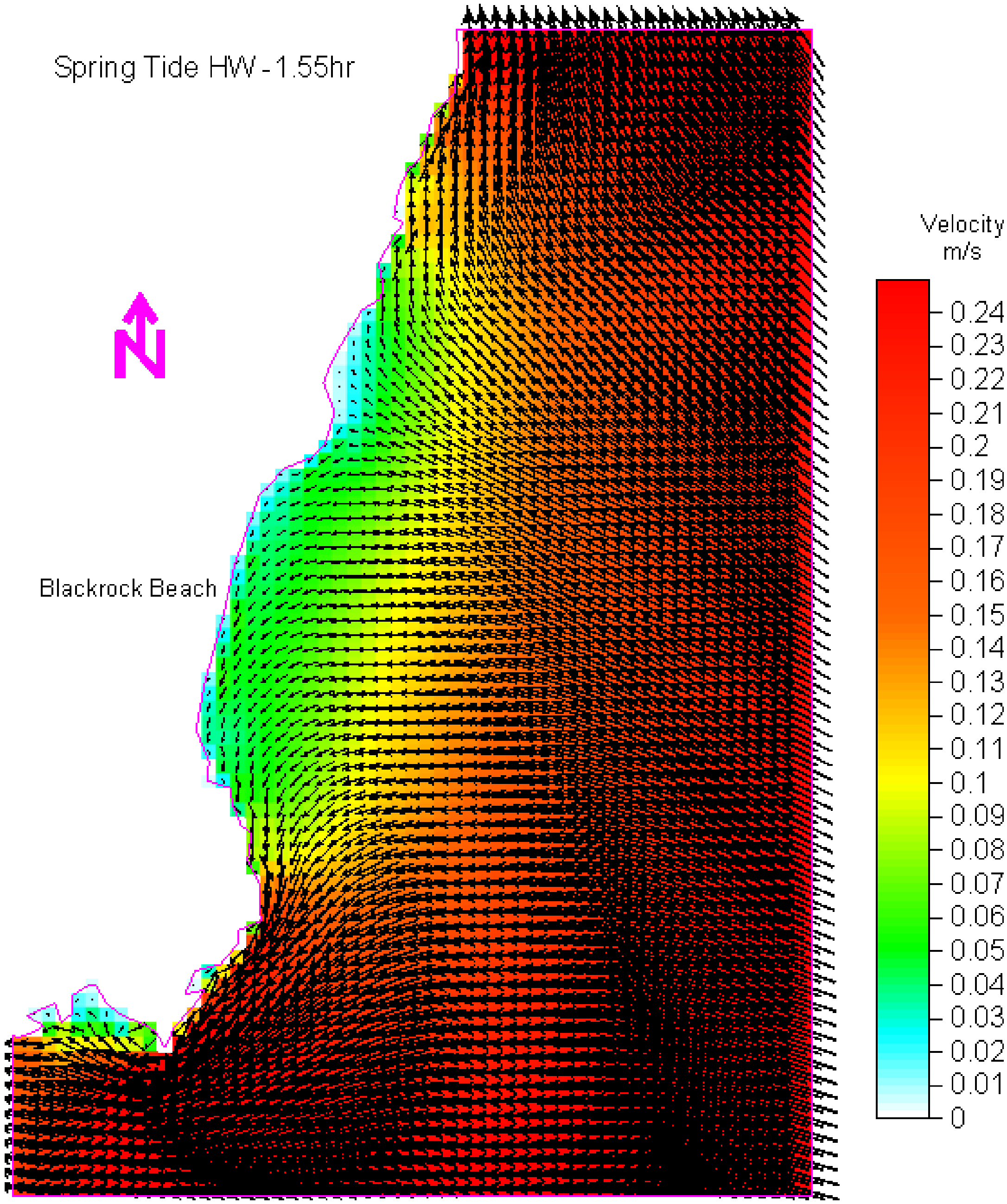
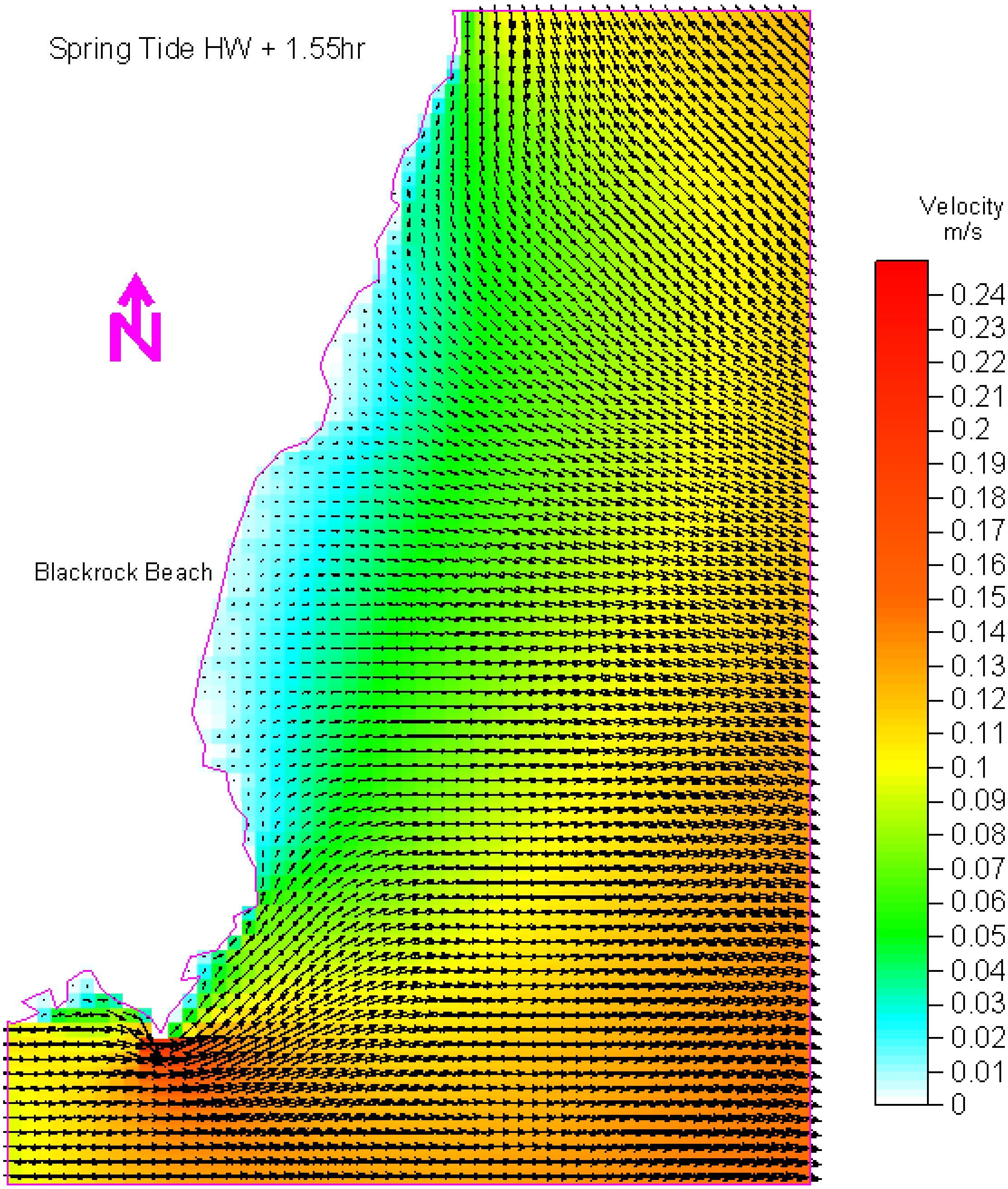


Figure 2-16. Currents at High Water + 1.55 hour at Blackrock.



The predicted velocities at Blackrock at High Water are low, and are in the range of ca 10 cms sec and less.

The recommended wave barrier as shown in Figure 2-11 was added to the model, and Figures 2-17 and 2-18 show the predicted velocities at Blackrock beach with the structure in place. Velocities decrease to 0 cm sec on both sides of the structure.

Figure 2-17. Currents at High Water – 1.55 hour at Blackrock with wave barrier.

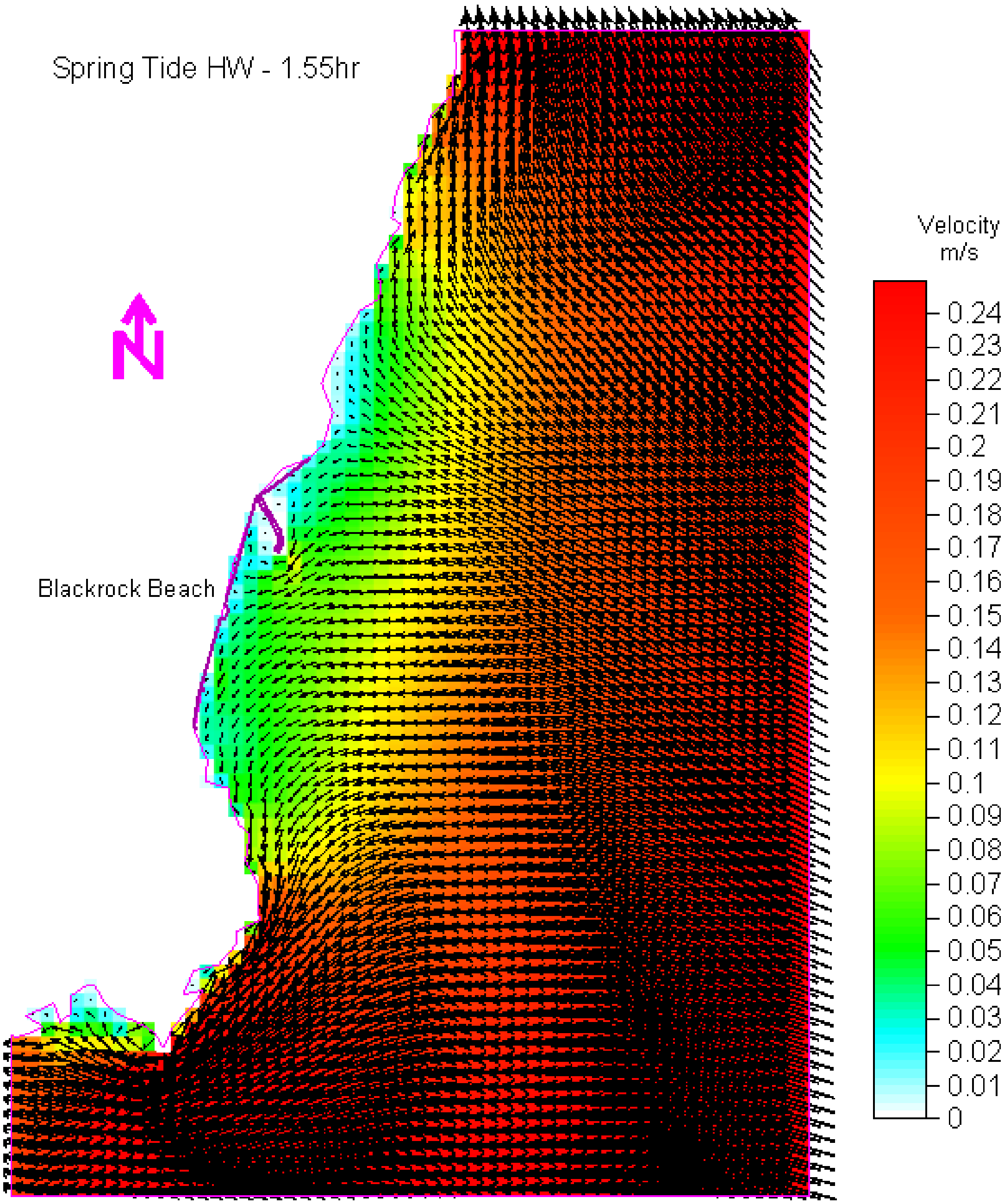
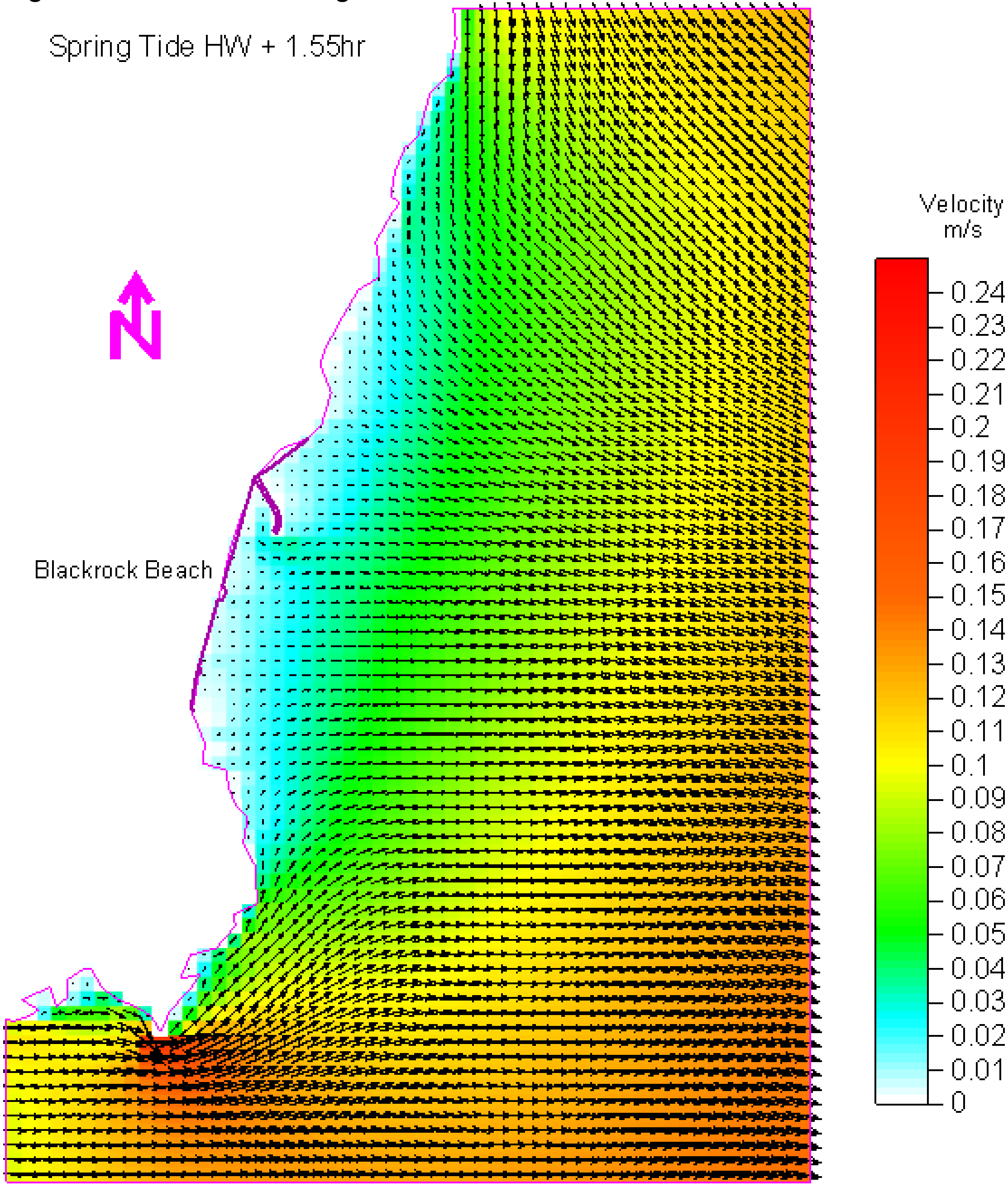


Figure 2-18. Currents at High Water +1.55 hour at Blackrock with wave barrier.



Output figures from a coarser model for Spring and Neap tides are presented in Appendix 2 at the end of this report.

In addition to the construction of a wave barrier, some level of importation of sand should be considered as a way to accelerate the rate of recovery. This option is also recommended, but careful choice of sand to be imported is required as it is likely that the National Parks and Wildlife (NPW) will require that the same sort of sand that occurs at Blackrock is used.

Consideration should also be given to altering the storm water outfall pipe, as it is quite possible that this structure is preventing sediment from having direct access to the beach area. It may be possible to either lower its profile or bury it completely.

An additional option to initially reduce wave energy at the beach would be the use of an off-shore reef (see Option 3). However, due to the required size of such a structure, it is considered unlikely that the NPW would agree to it. For this reason it has not been included in the Appropriate Assessment.

This recommended option will prevent some floating sea weed and other debris washing up on the beach. Furthermore, when the beach profile alters whereby the upper *circa* 10 m remains dry above high water, at least beach goers will not be lying on or walking through washed up weed.

Periodic weed removal by Louth County Council is a possibility but, no more than any of the options noted above, this management option would have to be agreed with by National Parks and Wildlife.

2.5. Carry out an Appropriate Assessment on the selected method.

As Dundalk Bay is designated as an SAC (000445) and an SPA (004026), it was considered necessary to carry out an Appropriate Assessment for the proposed wave barrier at Blackrock beach as per Article 6 of the Habitats Directive. There are other SACs and SPAs in the north east of Ireland and these include Rockabill, the Boyne Estuary and Carlingford Lough. However, as they are at some distance away from the proposed development site, they are considered too far away to merit consideration under this Article 6 assessment.

Article 6 (3) and (4) of the EU Habitats Directive[2] states:

3. Any plan or project not directly connected with or necessary to the management of the [Natura 2000] site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications for the [Natura 2000] site in view of the [Natura 2000] sites conservation objectives. In the light of the conclusions of the assessment of the implications for the [Natura 2000] site and subject to the provisions of paragraph 4, the competent national authorities shall agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the [Natura 2000] site concerned and, if appropriate, after having obtained the opinion of the general public.

4. If, in spite of a negative assessment of the implications for the [Natura 2000] site and in the absence of alternative solutions, a plan or project must nevertheless be carried out for imperative reasons of overriding public interest, including those of a social or economic nature, Member States shall take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected. It shall inform the Commission of the compensatory measures adopted.

   Where the site concerned hosts a priority natural habitat type and / or a priority species the only considerations which may be raised are those relating to human health or public safety, to beneficial consequences of primary importance for the environment or, further to an opinion from the Commission, to other imperative reasons of overriding public interest.

[2] Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and florato beneficial consequences of primary importance for the environment or, further to an opinion from the Commission, to other imperative reasonsof overriding public interest.

This Article 6 Assessment has been prepared in accordance with the European Commission Environment DG document "Assessment of plans and projects significantly affecting Natura 2000 sites: Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC", referred to as the EC Article 6 Guidance Document.

The guidance within this document provides a non-mandatory methodology for carrying out assessments required under Article 6(3) and (4) of the Habitats Directive, and are also viewed as an interpretation of the EU Commission's document Managing Natura 2000 sites[3]: The Provisions of Article 6 of the Habitats Directive 92/43/EEC', referred to as MN2000.

It is the responsibility of the competent authority, The Department of Agriculture, Fisheries and Food (DAFF), to make a decision as to whether or not the proposed development should be permitted, taking into consideration any potential impact upon the Natura 2000 sites in question.

In order to assist the DAFF in this decision, this Article 6 Assessment has been prepared in line with the tenets of the European Commission Environment DG methodological guidance for Article 6 assessments. This document draws together the results of the proposed development and description of the receiving environment at Blackrock beach.

Stage One: Screening

It is stated within the EU guidelines that "where, without any detailed assessment at the screening stage, it can be assumed (because of the size or scale of the project or the characteristics of the Natura 2000 site) that significant effects are likely, it will be sufficient to move directly to the appropriate assessment (Stage Two) rather than complete the screening assessments explained below."

Due to the sensitivity of the site, it was considered that an Appropriate Assessment was required.

[3] For the purposes of Article 6 assessments, Natura 2000 sites are those identified as SAC sites of community Importance under the habitats directive or classified as SPAS under the birds directive.

Stage Two: Appropriate Assessment

According to MN2000, paragraph 4.6(3)

"The integrity of a site involves its ecological functions. The decision as to whether it is adversely affected should focus on and be limited to the site's conservation objectives."

Within this stage of the summary assessment, the potential impact of the proposed development on the integrity of the SAC and SPA is examined with respect to the conservation objectives of these Natura 2000 sites and to its general structure and function.

Stage two entails five steps as follows:

Step one: Information required
Step two: Impact prediction
Step three: Conservation objectives
Step four: Mitigation measures
Step five: Outcomes

Step One: Information required

Step one serves to gather information about the conservation objectives of the sites, an understanding of the biological processes that underlie those conservation objectives, a description of the proposal and the aspects of this proposal which could affect the conservation objectives.

In order to determine the information required for this assessment, it is necessary to identify the conservation objectives of the sites and to relate them to those aspects of the proposed development which could affect those objectives. The Article 6 Guidance Document suggests that these may be obtained from the SAC / SPA site description and any site management plans which may exist.

In the absence of any published Conservation Management Plans for this Natura 2000 site, a list of suitable conservation management objectives has been prepared based on information contained in the NPWS Natura 2000 forms and files for these sites. It should be noted that these conservation management objectives have been drawn up specifically for this Article 6 Assessment and are not any reflection of NPWS approval of them.

Based on Aqua-Fact's knowledge of the ecology of the area, the information contained within the NPWS SPA and SAC files, and the requirements of the European Communities *(Natural Habitat) Regulations,* 1999 (SI No. 94 of 1997), the following potential conservation management objectives have been developed for the purpose of this Article 6 Assessment.

Table 2.1 on the following pages provides a summary of the information gathered in order to progress this assessment.

Dundalk Bay SAC and SPA

- To maintain and where possible increase the populations of rare and Annexed[4] bird species within the site (i.e. Brent Goose, Black and Bar tailed Godwit, Golden Plover and Red throated and Great Northern Divers).

- To maintain and where possible increase the populations of additional non-annexed migratory bird species which also occur within the site and which include nationally[4] important numbers of additional bird species.

- To maintain and where possible increase the numbers of internationally important birds within the site to at least the 5 year mean of bird numbers.

- To maintain and where possible enhance the habitats upon which birds are dependent, namely Marine Open Water, Sandy Beaches, Shingle Beaches, Mudflats and Mussel Beds.

- To conserve, protect, prevent degradation and damage to, and where possible enhance the habitats within Dundalk Bay which are important for birds.

- To conserve, protect, prevent degradation and damage to, and where possible enhance the habitats within Dundalk Bay which are important for birds.

- To ascertain what impacts, if any, that the construction of the wave barrier will have on birds within the SPA and SAC sites and to achieve effective liaison between the NPWS, The Department of Agriculture, Fisheries and Food and local aquaculture operations.

Step Two: Impact Prediction

An analysis of assessment typically requires the identification of the type and magnitude of potential impacts; both direct and indirect; short and long term; construction, operational and

[4] Species listed on Annex I of the EU Birds Directive (council Directive 79/409/EEC on the Conservation of Wild Birds! requiring special conservation measures to ensure their survival and reproduction in their area at distribution.

decommissioning effects; and isolated, interactive and cumulative effects. In this instance the construction and operational related impacts on the SPA and SAC will arise. These are summarised below in the Table 2.2.

The proposed construction works at Blackrock beach will involve placement of *circa* 3 tonne boulders from the existing sea wall out to a distance of *circa* 100 m. The structure will be *circa* 4.5 m high and *circa* 2 m wide at its crest. The construction area required will temporarily damage *circa* 2 ha of the SAC/SPA. This will however recover with time (*circa* 2 years) and the habitat will return to what it was. The foot print of the structure will permanently remove *circa* 400 m of mud flat from within the SPA and SAC. The proposed works may also include the importation of circa 6,500 tonnes of sand to accelerate the rate of recovery of the beach.

Step Three: Conservation Objectives

Upon establishing the impacts that the proposed development will present, it is necessary to assess whether or not these impacts will adversely affect the integrity of the site as defined by the conservation objectives. Table 2.3 provides a summary of the effects of the predicted impacts of the project upon the conservation management objectives for the SAC and SPA.

Step Four: Mitigation Measures

Upon establishing the impact that the proposed development will have upon the conservation objectives for the SAC and SPA, it is desirable that wherever a potential impact is identified that mitigation measures are sought to counteract this impact.

Mitigation measures are summarised below in Table 2.4.

Table 2.1 Information checklist for the assessment		
Information about project		
	Known or Available	**Details**
Full characteristics of the project which may effect the Natura 2000 sites	✓	The proposal will involve the construction of a wave barrier approximately 100m long and 4.5 m high at Blackrock beach within Dundalk Bay SAC and SPA.
The total range or area the plan will cover	✓	The development will cover a total approximate area of 400m
Size and other specifications of the project	✓	Use of local boulders placed in a line from the existing sea wall out to a distance of ca 100m, and possible importation of *circa* 6,500 tonnes of sand.
The characteristics of the existing, proposed, or other approved projects which may cause interactive or cumulative impacts with the project being assessed and which may affect the Natura 2000 sites.	✓	There are no other proposed projects in the area.
Planned or contemplated nature conservation initiatives likely to affect the status of the Natura 2000 sites in the future	✓	A conservation management plan has not yet been finalised.
The relationship between the project and the Natura 2000 site.	✓	Blackrock beach lies with Dundalk Bay SPA and SAC.

The information requirements of the authorisation body.	✓	Due to the proximity of the SPA and SAC, an assessment in accordance with Article 6(3) and (4) of the EU Habitats Directive has been undertaken in order to determine whether the proposed development would have a significant negative impact upon the areas.
Information about the site		
The reasons for the designation of the Natura 2000 sites,	✓	The SPA and SAC are designated to maintain and where possible increase the populations of rare and Annexed bird species and other rare or Annexed flora or fauna within the site and to conserve numbers of non-annexed bird species and other species of non-Annexed flora and fauna in the area.
The conservation objectives of the Natura 2000 sites and the factors that contribute to their conservation value.	✓	**Conservation Management Objectives for the SPA and SAC** • To maintain and where possible increase the populations of rare and Annexed bird species and other rare or Annexed species of flora or fauna within the site. •To maintain and where possible increase the numbers of internationally important birds within the site to at least the 5 year mean of bird numbers. • To maintain and where possible enhance the habitats upon which such species are dependent. • To conserve, protect, prevent degradation and damage to, and where possible enhance the habitats within the SPA and SAC which are important for such species.
The conservation status of the Natura 2000 sites (favourable or otherwise)	✓	The SPA and SAC areas are considered to be in a good status of conservation.

The existing baseline condition of the Natura 2000 sites	✓	Dundalk Bay is a large open shallow sea bay with extensive saltmarshes and intertidal sand/mudflats, extending some 16 km from Castletown River on the Cooley Peninsula, in the north, to Annagassan/Salterstown in the south. The bay encompasses the mouths and estuaries of the Rivers Dee, Glyde, Fane, Castletown and Flurry. The site contains five habitats listed under the EU Habitats Directive, i.e.perennial vegetation of stony banks, tidal mudflats, salt marshes, *Salicornia* mudflats and estuaries. The extensive sand flats and mud flats (over 4,000 ha) have a rich fauna of bivalves, molluscs, marine worms and crustaceans which provides the food resource for most of the wintering waterfowl. The salt marshes, which occur in four main areas at Lurgangreen, Marsh South, Dundalk Harbour/Ballymascanlan Bay and Bellurgan, are used by the roosting birds at high tide. The marshes are dominated by wide expanses of Common Cord-grass (*Spartina anglica*), while Sea Purslane (*Halimione portulacoides*), Common Saltmarsh-grass (*Puccinellia maritima*) and Glasswort (*Salicornia* spp.) are other common species. The herbivorous waterfowl (notably Brent Geese and Wigeon) feed on the salt marsh grasses, as well as on areas of *Zostera* and green algae on the mudflats. Shingle beaches are particularly well represented in Dundalk Bay, occurring more or less continuously from Salterstown to Lurgan White House in the south bay, and from Jenkinstown to east of Giles Quay in the north bay. The shingle supports such species as Spear-leaved Orache (*Atriplex prostrata*), Sea Mayweed (*Matricaria maritima*), Sea Beet (*Beta vulgaris*), Sea Rocket (*Cakile maritima*) and Sea Holly (*Eryngium maritimum*), as well as scarcer plants including Yellow Horned-poppy (*Glaucium flavum*), Sea Scutch (*Leymus arenarius*) and the Red Data Book species Sea-kale (*Crambe maritima*). At high tide, many birds roost on the shingle beaches. The outer part of the bay provides excellent shallow-water habitat for divers, grebes, and sea duck. In summer, it is thought to be a major feeding area for auks from the Dublin breeding colonies. At night the wintering Greylag and Greenland Whitefronted Geese, and Whooper Swans, from Stabannan/Braganstown (inland from Castlebelligham) and other inland sites roost in Dundalk Bay. The site is internationally important for waterfowl on the basis that it regularly holds over 20,000 birds (average peak of 40,781 over five winters 1995/96-1999/00). In the same period it also qualifies as a site of international importance for supporting populations of Brent Goose (337), Black-tailed Godwit (1,067) and Bar-tailed Godwit (1,950). There is also a range of other species which occur in numbers of national importance – these are Great Crested Grebe (302), Greylag Goose (435), Shelduck (492), Mallard (763), Pintail (117), Red-breasted Merganser (121) (over 500 have been recorded in August/September), Oystercatcher (8,712), Ringed Plover (147), Golden Plover (5,967), Grey Plover (204), Lapwing (4,850), Knot (9,710), Dunlin (11,515), Curlew (1,234) and Redshank (1,489) (all figures are average peaks over the period 1995/96 to 1999/00). Other wintering species which occur regularly in regionally important numbers include Red-throated Diver, Great Northern Diver, Cormorant, Grey Heron, Mute Swan, Wigeon, Teal, Goldeneye, Greenshank and Turnstone. The site also supports large numbers of gulls during winter. In the 1995/96 to 1999/00 period, the following were recorded (figures are average peaks over the five winters): Black-headed Gull (6,630), Common Gull (551), Herring Gull (751) and Great Black-backed Gull (185). In spring and autumn the site attracts a range of passage migrants, including LittleStint, Curlew Sandpiper and Ruff. This site is one of the most important wintering waterfowl sites in the country and one of the few which regularly supports more than 20,000 waterfowl. It supports three species in numbers of International Importance and a further 15 species in numbers of National Importance. The populations of Golden Plover, Bar-tailed Godwit, Redthroated and Great Northern Divers are of particular note as these species are listed on Annex I of the EU Birds Directive. The site is also a designated Ramsar site. The site is monitored annually as part of I-WeBS.

The key attributes of any Annex I species on the Natura 2000 sites	✓	The SPA and SAC are used for up to three quarters of the year by Annex I bird species such as Bar-tailed godwit and Golden Plover.
The physical and chemical sites composition of the Natura 2000	✓	The SAC/SPA area is characterised by shallow, estuarine, coastal waters. Water quality is moderate.
The dynamics of the habitats, species and their ecology	✓	The Dundalk Bay SPA and SAC area is subject to river flow from the Castletown River. This creates a dynamic environment, particularly in Autumn, Winter and Spring with sediment and weed being washed into the area. The flora and fauna must therefore be capable of surviving this type of disturbance.
Those aspects of the Natura change 2000 sites that are sensitive to change	✓	The beach area currently experiences some level of human-related activities (including a storm water out flow pipe) as well as environmental influences and it is considered that these activities do not impact the status of the SPA or SAC..
The key structural and functional relationships that create and maintain the Natura 2000 site's integrity	✓	The key factors which influence the SAC/SPA is the mechanical and chemical processes from the flow of the Castletown River.

Table 2.2 Impact Prediction				
	Construction Phase		Operation Phase	
Parameter	Direct (Isolated, interactive, cumulative, short-term, long-term)	Indirect (Isolated, interactive, cumulative, short-term, long-term)	Direct (Isolated, interactive, cumulative, short-term, long-term)	Indirect (Isolated, interactive, cumulative, short-term, long-term)
Ecology/sediment	Approximately 2,000m of intertidal, shallow subtidal will be temporarily lost during construction.This damaged area will revert to what it was before within *ca* 2 years. This habitat is well represented elsewhere in the vicinity. Bird populations will experience disturbance during the construction phase but once complete, birds will move back into the site.	There will be no indirect impacts to the SAC or SPA during the construction phase as any sediment which is suspended by scouring into the water column will not travel far from Blackrock beach.	There will be a permanent loss of ca 400 m of SAC/SPA	

Noise	There will be some disturbance to birds arising noise and activity during construction works and it is likely that birds will avoid areas near the site for the duration of the construction period. However, once construction is complete the birds will return to the area again.	As for direct impacts	No effect	As for direct impacts
Water	Water quality will be negatively affected by the suspension of sediment due to the effect of scouring around the new structure.	As for direct impacts	The scouring effect will stabilize with time and water quality will no longer be affected	As for direct impacts

Table 2.3 Integrity of Site Checklist		
Conservation Objectives		
Does the project have the potential to:	**Yes or No**	**Details**
Cause delays in progress towards achieving the conservation objectives of the site?	No	The construction of the wave barrier within the SAC and SPA will not have any impact in maintaining overall bird populations or on the overall integrity of the areas.
Interrupt progress towards achieving the conservation objectives of the site?	No	For the same reasons as above.
Disrupt those factors that help to maintain the favourable conditions of the site?	Yes	An area of 400 sq m of feeding ground for waders and wildfowl will be lost. This represents *circa* 0.00001 %of the designated site. The habitat which will be lost is well represented throughout the site.

Interfere with the balance, distribution and density of key species that are the indicators of the favourable condition of the site?	No	The loss of 400 sq m will not interfere with any key species.
Does the project have the potential to:		
Cause changes to the vital defining aspects (e.g. nutrient balance) that determine how the site functions as a habitat or ecosystem?	No	Due to the small size of the proposed structure, it will have no measurable effect on the functioning of the SAC/SPA.
Change the dynamics of the relationships (between, for example, soil and water or plants and animals) that define the structure and/or function of the site?	No	The development will not alter any of the relationships between the important habitats and species within the SAC or SPA or have any significant impact on the overall integrity of these areas.

Interfere with predicted or expected natural changes to the site (such as water dynamics or chemical composition)?	No	The presence of the waver barrier will not have a significant impact on dynamics or water chemistry whereby predicted or natural changes would be interfered with.
Reduce the area of key habitats?	No	There will be reduction of 0.00001% of mud flat.
Reduce the population of key species?	No	There will be no reduction in key species
Change the balance between key species?	No	There will be no change in the overall populations of any of the key species in the area nor to the overall integrity of the SAC or SPA.
Reduce diversity of the site?	No	The proposed development will increase diversity within the SAC or SPA by providing a range of microniches. Epifaunal species will quickly colonise the structure and these will prove feeding resources for mobile species and predators such as decapods and fish
Result in disturbance that could affect population size or density or the balance between key species?	No	There will be no change in the size or density of overall populations of any of species in the SAC or SPA as the habitats to be lost and those adjacent to the proposed development do not support large numbers of Annexed species and the proposed development does not fall within the main bird flight paths.
Fragmentation?	No	Due to the short, linear nature of the wave barrier, no fragmentation is expected
Result in loss or reduction of key features?	No	There will be no significant loss or reduction of key features in the SAC or SPA.

Table 2.4 Mitigation Measures

Proposed mitigation measures	How will the mitigation measures avoid and/ or reduce adverse effects on the integrity of the SAC andSPA?	How will the mitigation measures be implemented, when and by whom?	What is the degree of confidence in the likely success of the mitigation measures?	What proposed monitoring of the mitigation measures?
Proper management of fuel during the construction phase	Will avoid accidental pollution of the area parallel to the SAC and SPA	Appointed contractor during construction works	High	None

Step Five: Outcomes

Table 2.5 below outlines the final outcome of Stage Two of the Article 6 Assessment. As can be seen from table 2.5, providing the required mitigation measures are undertaken, there will be no residual adverse effect arising from the proposed development.

As only 0.00001% of the SAC or SPA habitat is expected to be lost and, as the barrier will increase biodiversity locally, it is unnecessary to provide compensatory habitat due to the absence of any significant impact on the overall integrity of the SPA.

Table 2.5 Assessment of the effects of the proposed wave barrier on the integrity of the SAC and SPA

Describe the elements of the project or plan that are likely to give rise to significant effects on the Natura 2000 sites (from screening assessment)	Applying the precautionary principle it was determined that the proposed development would not give rise to any significant or measurable environmental impacts to the SAC or SPA.
Set out the conservation objectives of the Natura 2000 sites.	Refer to Stage Two Step One for these.
Describe how the project will affect key species. Acknowledge any uncertainties and any gaps in information.	There will be no impacts on the populations of annexed species within the SAC or SPA as a result of the wave barrier installation.

Describe how the integrity of the Natura 2000 sites (determined by structure and function and conservation objectives) is likely to be affected by the project (e.g.loss of habitat, disturbance, disruption, chemical changes, hydrological changes and chemical changes,etc.) Acknowledge any uncertainties and any gaps in information.	The development will not result in any significant impact on the flora and fauna of the SAC or SPA or on the overall integrity of the Natura 2000 sites. It is expected that *circa* 400 m of habitat will be lost. There will not be any overall change in the natural processes which physically shape and define the SAC or SPA area.
Describe what mitigation measures are to be introduced to avoid, reduce or remedy the adverse effects on the integrity of the sites. Acknowledge any uncertainties and any gaps in information	Refer to Table 2.4 of State Two Step Four for mitigation measures which must be implemented.

2.6. *Implementation steps and cost*

Implementation

With regard the implementation for this plan, the following steps are foreseen:

1. Carry out a topographical survey of the Blackrock beach area to refine the model.
2. Deploy a current meter to collect velocity and direction data for input to the model.
3. Agree on a final design for the wave barrier taking account of the output from of steps 1 and 2.
4. Use the refined model to predict the effects of the wave barrier on storm-induced waves.
5. Develop an Environmental Management Plan for the proposed development, including a monitoring programme.
6. Obtain a foreshore licence from the relevant Government Department.
7. Construct the designed structure and implement the monitoring programme.
8. Maintain close liaison with Louth County Council throughout the project.

Costing

Cost (€)

Topographical survey of beach to refine model

Deploy a current meter to collect velocity and direction data for input to model

Re-run of model with refined bathymetry, current data and final wave barrier configuration

Wave barrier detailed design

Environmental Management Plan

Construct the designed structure and implement monitoring programme. Typical costs per meter run to *circa* €500. Using a length of 100 m, this gives an estimated cost of:

Total Cost of Wave Barrier

Optional cost for sand importation: Circa 5,000 cubic m at €10

Total Cost including Sand Importation

Optional cost of off-shore reef (2m wide at top and 4m wide at base x 4m high x 400m long = *circa* 4,800 cubic m @ *circa* €15 per cubic m)

Total Cost including Off-shore Reef

3. References

Dickson, R. and Boelens, R. 1988. The status of current knowledge on anthropogenic influences in the Irish sea. Co-operative Research Report no. 155. ICES, Copenhagen. 88pps.

Douglas, D. 1988. A report of analysis of water and sediment samples at and around the proposed effluent discharge point for Cooley Distillery, plc.

ECOPRO 1996. FORBAIRT Dublin. 320 pps.

Environmental Protection Agency, 2001. Water Quality in Ireland 1998-2000. EPA.

MCS 1994. Dundalk Waste Water Treatment Works. EIS. Chapter 4. Impact on Water Quality.

Orren, M., Furey, T. and Coyne, J. Water Quality Report for Giles Quay, Dundalk. Report to Hydrographic Surveys.

Appendix 1

Historic Photographs

Photo 1: Beach and promenade *circa* 1890. Note band of dry sand below sea wall.

Photo 2: Beach *circa* 1950. Note beach width wider at north than at south indicating possible accretion at this location. Also note High Water mark as indicated by feint black line running along the beach, narrowest at south and getting progressively wider to the north.

Photo 3: Beach *circa* 1960. Note same variation in beach width at north. Swimming pool now in place but car park not yet built.

Photo 4: Beach *circa* 1960.

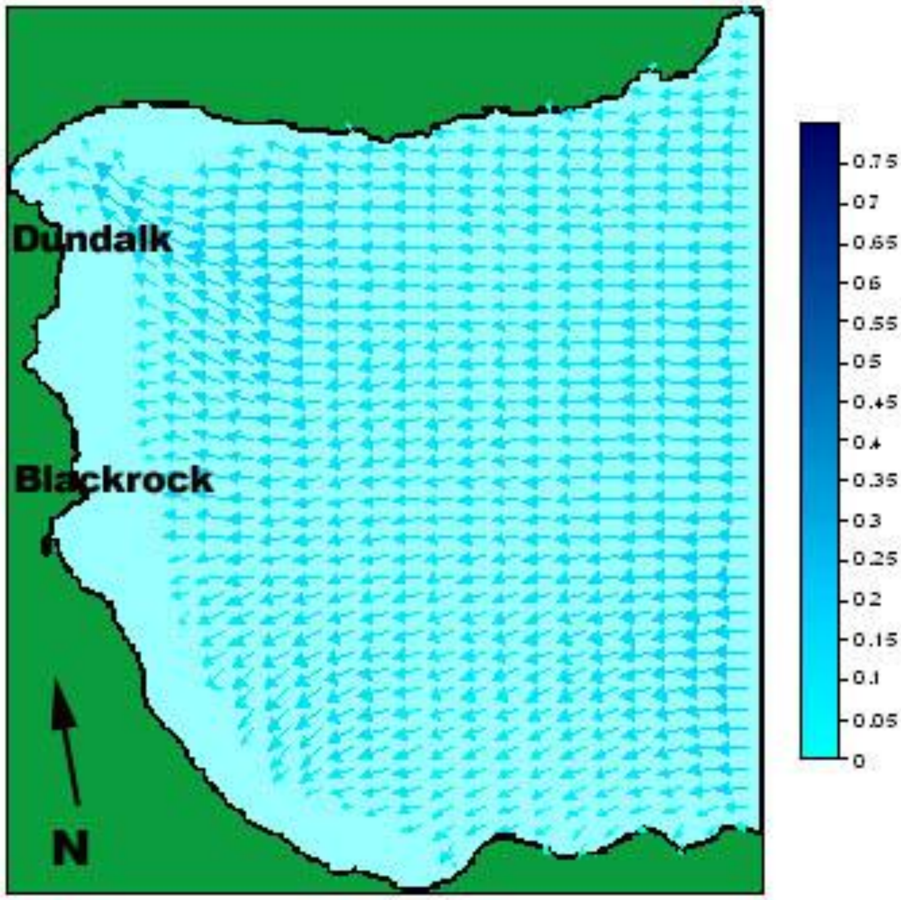
Photo 5: Beach 1998. Note eroded profile of beach at northern end, new car park, build up of material to the south of storm water outfall, and unchanged profile of Priest's beach.

Photo 6: Beach 2005. Note further build up and vegetation to the left of the outfall pipe at southern end of beach.

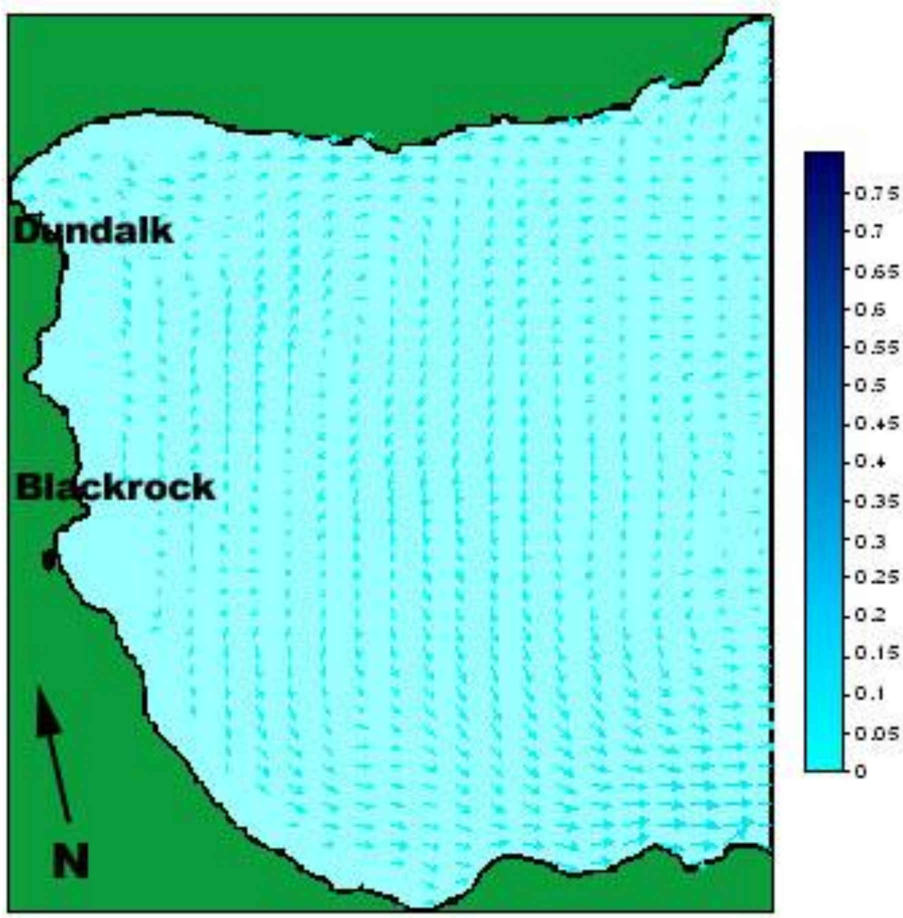
Photo 7. Washed up weed along the shoreline

Appendix 2

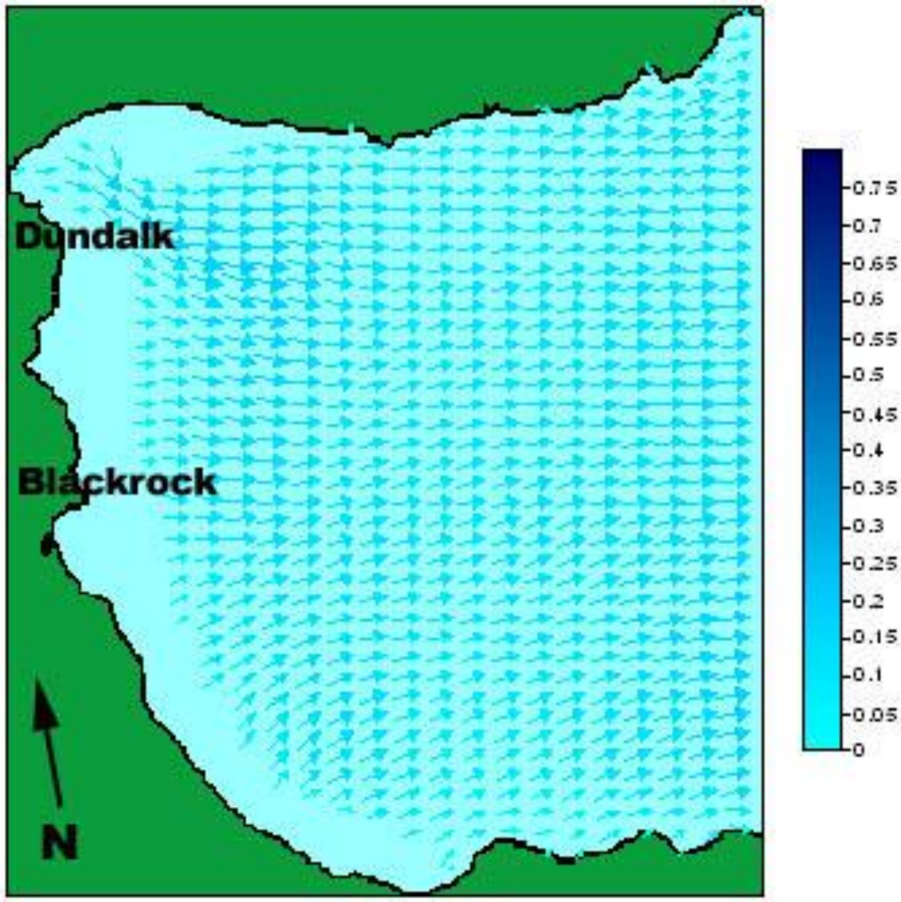
Model Outputs



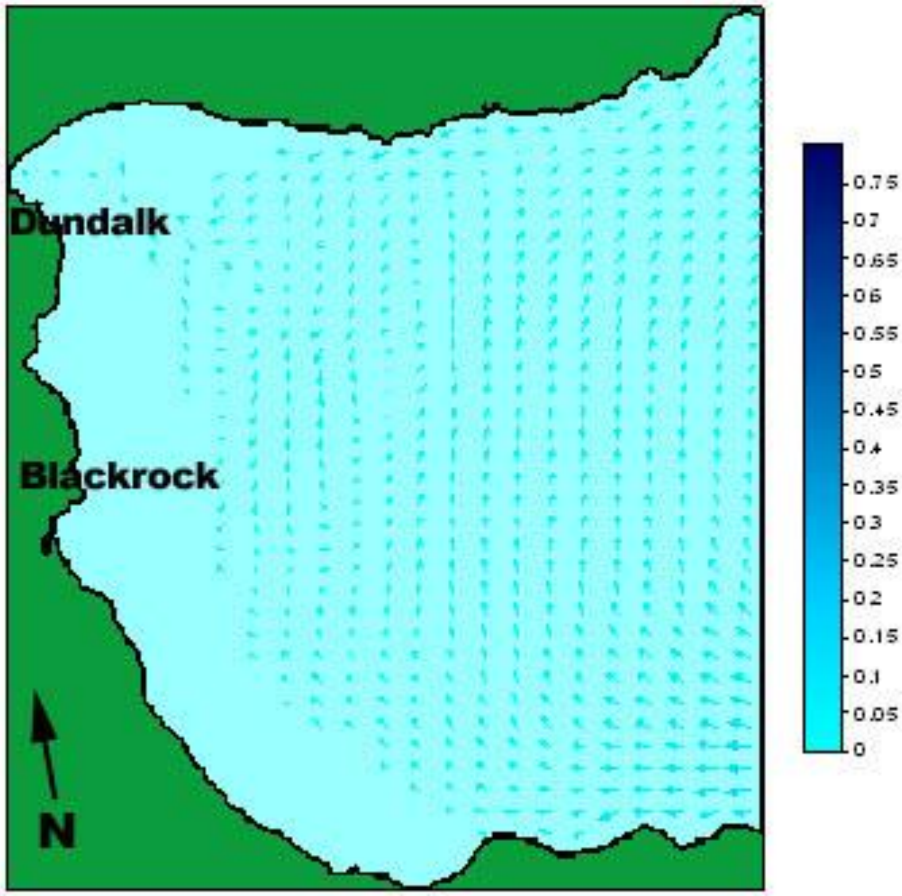
Current velocity vectors (m/sec) calculated at mid-flood on a neap tide.



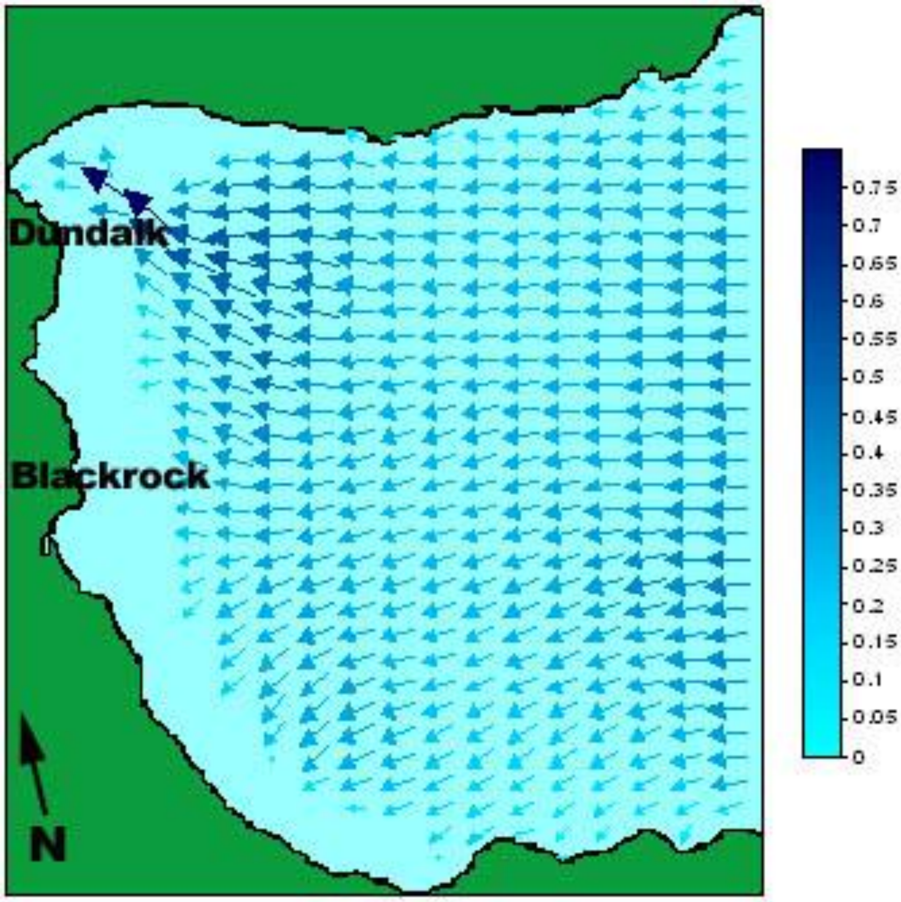
Current velocity vectors (m/sec) calculated at high water on a neap tide



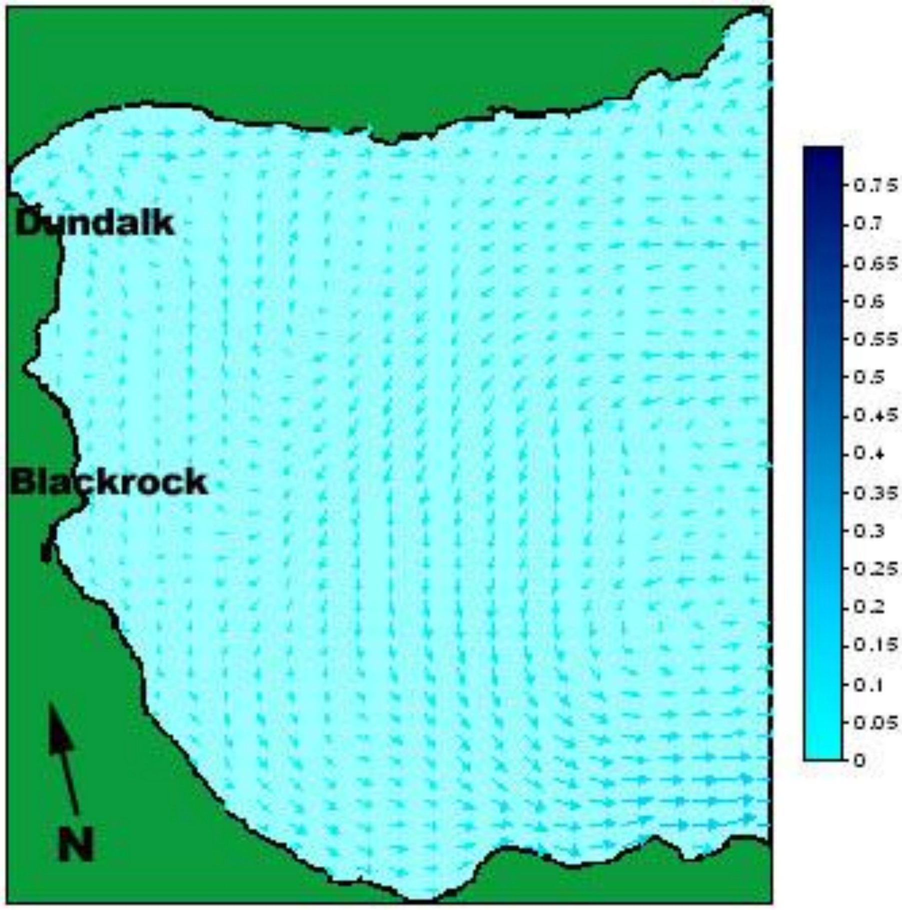
Current velocity vectors (m/sec) calculated at mid-ebb on a neap tide



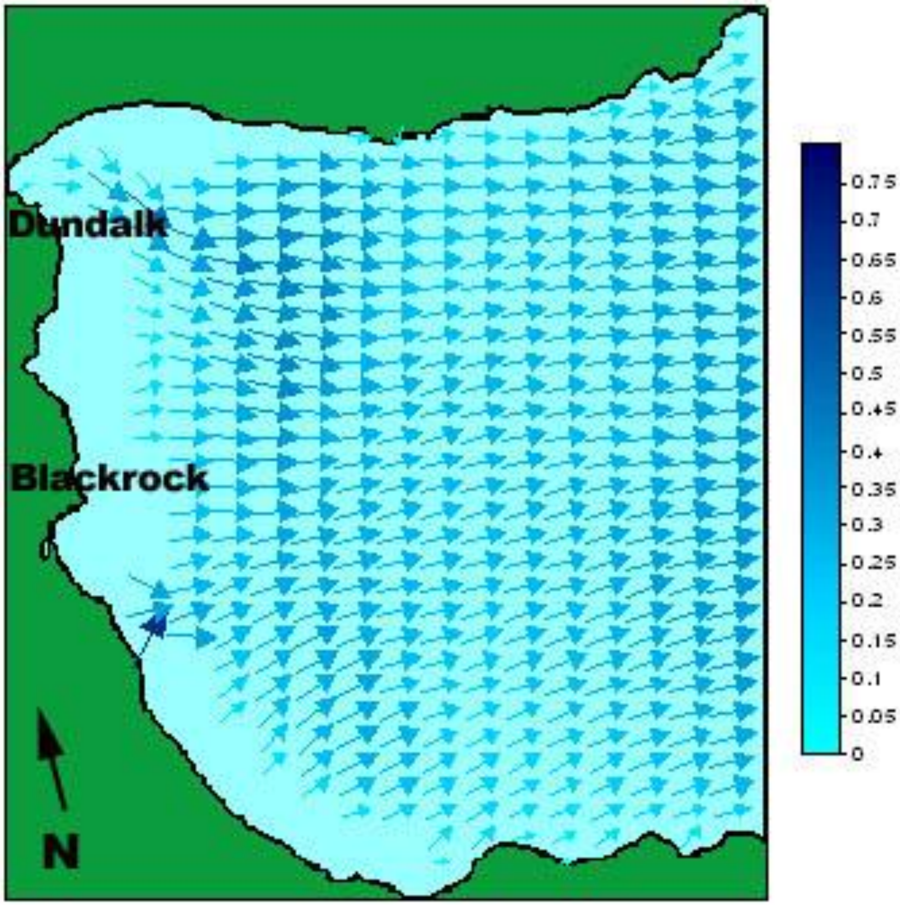
Current velocity vectors (m/sec) calculated at low water on a neap tide



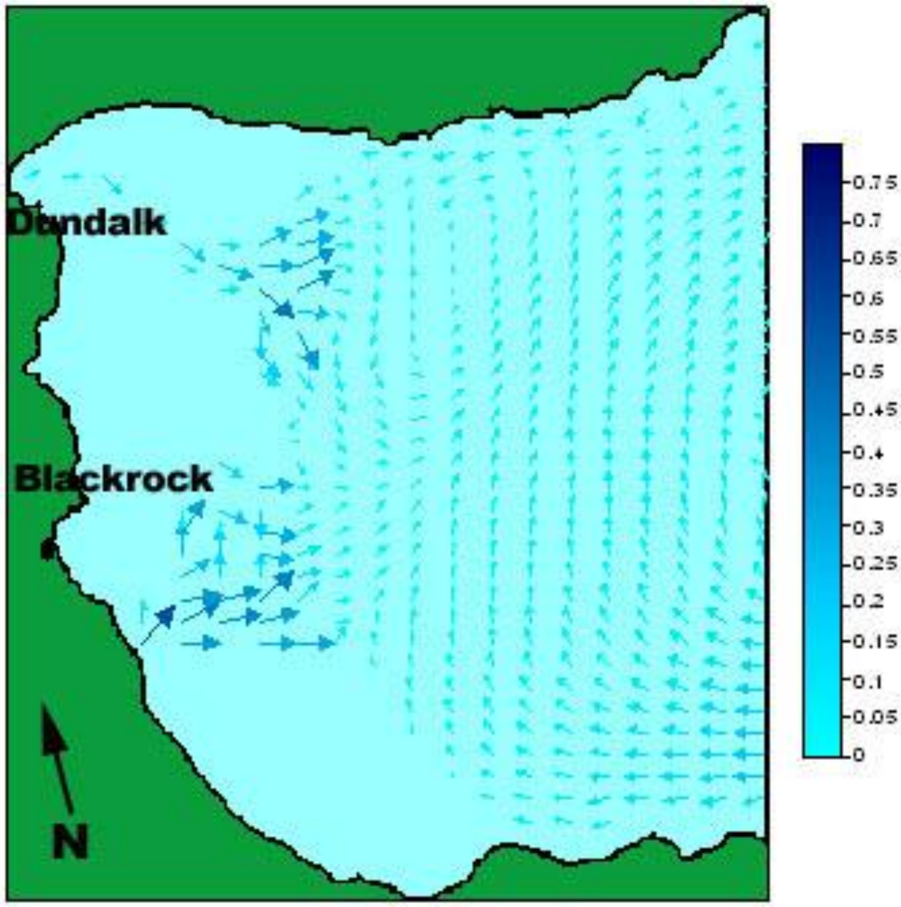
Current velocity vectors (m/sec) calculated at mid-flood on a spring tide



Current velocity vectors (m/sec) calculated at high water on a spring tide



Current velocity vectors (m/sec) calculated at mid-ebb on a spring tide



Current velocity vectors (m/sec) calculated at low water on a spring tide