Wicklow Disposal Site Dispersion Assessment

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Wicklow Disposal
Site Dispersion
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Contents

Tables

Figures

1 Introduction

Wicklow County Council have set out an eight-year maintenance dredging programme for Wicklow Harbour which aims to maintain the advertised charted depths of the navigation channel, turning basin, and berthing pockets within the harbour, ensuring safe navigation for vessels travelling to and from the Port. It is proposed that the dredged material could be disposed of at a potential disposal site where depths are 15-20m, approximately 3km offshore from Blackditch, Co. Wicklow and 9km north of Wicklow Harbour, as illustrated in Figure 1.1.

A 2024 report by Gavin and Doherty Geosolutions Ltd, documented modelling of the dispersion of dredging operations in Wicklow Harbour [1] as well as the dispersion of the disposal of the associated material at the Arklow Offshore disposal site, 0.75km offshore from Arklow and 23km south of Wicklow Harbour [2]. An earlier 2012 report by Hydro Environmental Ltd also documented the modelling assessment for a disposal site 1.5km northeast of Wicklow Harbour [3].

In order to update existing dredging applications for Wicklow County Council, Tetra Tech have been commissioned by Ayesa to assist in the material dispersion modelling at the newly proposed disposal site, to determine the feasibility of the site. As part of the licensing for dredging operations, modelling was required to determine the fate of the suspended fractions of the disposed material. This was undertaken using numerical modelling techniques which provided information on tides and sediment dispersion.

This technical report presents the findings of the numerical modelling programme and describes the dispersion of dredge material suspended during the disposal at the proposed disposal site.

The modelling here represents a worst-case scenario for the sediment dispersion. This ensures that alternative dredging methods with lower disposal volumes and rates will have a lower environmental impact.

Figure 1.1: Location of proposed disposal site off the Wicklow coast

2 Description of Disposal works

An eight year maintenance dredging program of Wicklow Harbour is due to take effect. It is proposed that the dredged sediments will be disposed of at this potential disposal site northeast of Wicklow Harbour. There will be a variation in the disposal volumes throughout the eight year licence/permit duration, with disposal at sea quantities ranging from 23,100 dry tonnes up to 80,850 dry tonnes per year. It is anticipated that a dredger with bottom doors will be used for disposal operations.

2.1 Disposal Events

Details provided to Tetra Tech for modelling purposes are summarised in Table 2-1. The frequency of disposal events is 2.7 hrs. Each disposal event has "doors open" for 5 minutes and takes place at one location in cyclical order in each of the areas labelled 1, 2 and 3 shown in Figure 2.1 below. The spill rate is 3,020 kg/s for the 5 minutes duration. This results in approximately nine disposal events over a one day period. In section 1 of the dump site, depths decrease from 25m to 18m, in section 2, depths are in the range 17m to 20m while at the southern side of the site, typical depths are between 14m and 18m, as can be seen in the bathymetry plot in Figure 3.1.

Table 2-1: Summary of Disposal events

Disposal details	
• Doors open time	5 minutes
• Disposal frequency	Every 2.7 hrs
• Spill rate	3,020 kg/s
• Disposal locations	Sequential in areas 1, 2, 3

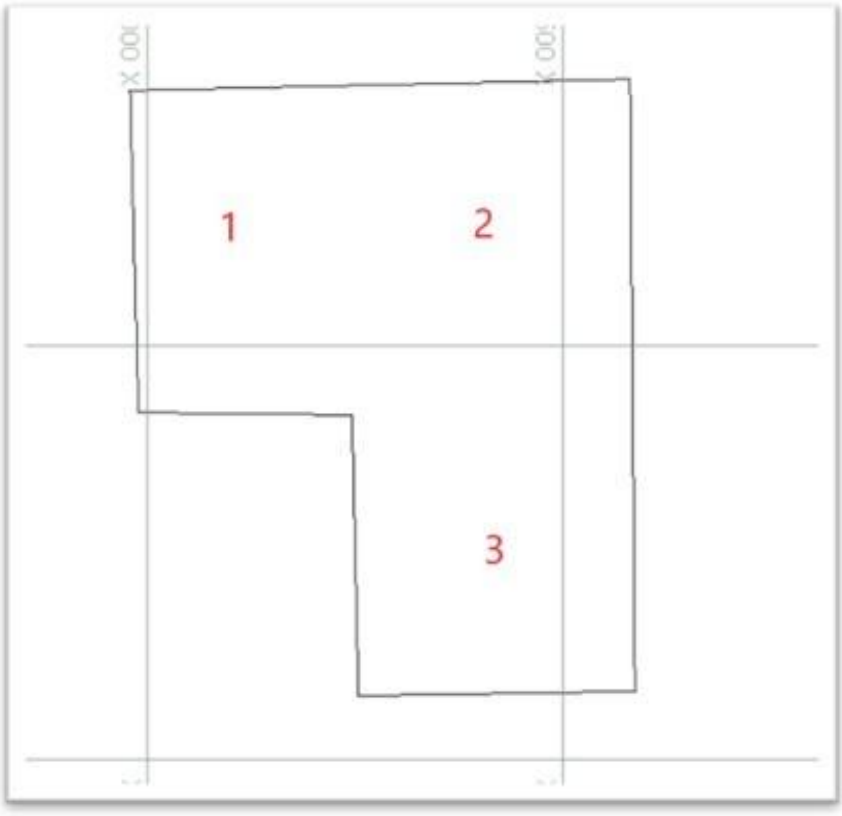


Figure 2.1: The three sectors within the disposal site

2.2 Sediment Characteristics

Sediment samples were collected from within Wicklow Harbour in 2021 to provide the Marine Institute with insights into the physical and chemical properties of the materials in the designated dredging zones and to provide Wicklow County Council with information pertaining to potential future areas of interest. Extensive details of the sample locations and compositions are provided in the 2024 disposal study [2].

For modelling purposes, here and in the 2024 disposal study [2], representative parameters relating to the material to be disposed of was utilised in the studies and is summarised in Table 2-2.

Table 2-2: Representative properties of the material for disposal operations

Sediment properties						
Material Type	Fraction name	Grain size (mm)	Settling Velocity (m/s)	Shield's parameter	Critical Shear Stress for deposition (N/m2)	Proportion (%)
• Very fine gravel • Medium sand • Medium Silt	1 2 3	2 0.375 0.0156	0.2996 0.04202 0.0001636	0.039 0.041 0.25	1.25 0.24 0.06	8.0 53.5 38.5

3 Modelling Methodology

It was necessary to develop a suitable numerical modelling study to assess and quantify the sediment plumes generated from the proposed disposal operations. The computational modelling was undertaken using the suite of MIKE coastal process modelling software developed by the Danish Hydraulic Institute. A description of the modelling software used in this study is presented in Section 3.1.

3.1 Modelling Software

3.1.1 Hydrodynamic Module

The Hydrodynamic Module simulates water level variations and flows in response to a variety of forcing functions in lakes, estuaries and coastal regions. The effects and facilities include:

- Flooding and drying
- Momentum dispersion
- Bottom shear stress
- Coriolis force
- Wind shear stress
- Barometric pressure gradients
- Ice coverage
- Tidal potential
- Precipitation/evaporation
- Wave radiation stresses
- Sources and sinks.

The Hydrodynamic Module in two-dimensions is based on the shallow water equations, the depth-integrated incompressible Reynolds averaged Navier-Stokes equations.

3.1.2 Mud Transport (MT) Module

The Mud Transport (MT) module of the MIKE 21 Flow Model FM describes erosion, transport and deposition of mud or sand/mud mixtures under the action of currents and, if appropriate, waves. The hydrodynamic basis for the MT Module is calculated using the Hydrodynamic Module of the MIKE 21 Flow Model FM modelling system and the MT is implemented as a coupled model with the two running concurrently. The MT module is applicable for mud fractions and sand/mud mixtures.

The following processes may be included in the simulation:

- Forcing by waves
- Salt-flocculation
- Detailed description of the settling process
- Layered description of the bed
- Morphological update of the bed.

In the MT module, the settling velocity varies, according to the salinity if included, and the concentration considering flocculation in the water column. Bed erosion can be either non-uniform i.e. the erosion of soft and partly consolidated bed, or uniform i.e. the erosion of a dense and consolidated

bed. The bed is described as layered and is characterised by the density and shear strength. For this study, flocculation was active for the medium silt, the smallest grain size, which tends to cohere in water bodies.

3.2 Model Domain

Existing Tetra Tech data was collected and reviewed by the study team. The relevant data on bathymetry, current flows, sediment grading etc., were analysed and prepared for use in the modelling study. For the purposes of this assessment, Tetra Tech utilised an existing two-dimensional hydraulic model of the Wicklow coastal area and updated it to include higher resolution both of the proposed disposal site and of Wicklow Harbour. As described in 4.1, this model has been fully calibrated and is considered fit for purpose.

The model domain includes the Wicklow, Dublin and Wexford coastline and extends fully across the Irish Sea to Wales. The bathymetry, as shown in Figure 3.1Figure 1.1, was based on data from the Irish National Seabed Survey, INFOMAR and other local bathymetry surveys undertaken around Wicklow. The model was developed using flexible mesh technology, so that it was possible to define the disposal site using a high-resolution mesh. This is also shown in Figure 3.1 where element edges have a length of 10m and are 60m along the North Wicklow coast. At the open boundaries, element length is 2.5km and the domain consists of 70,985 elements.

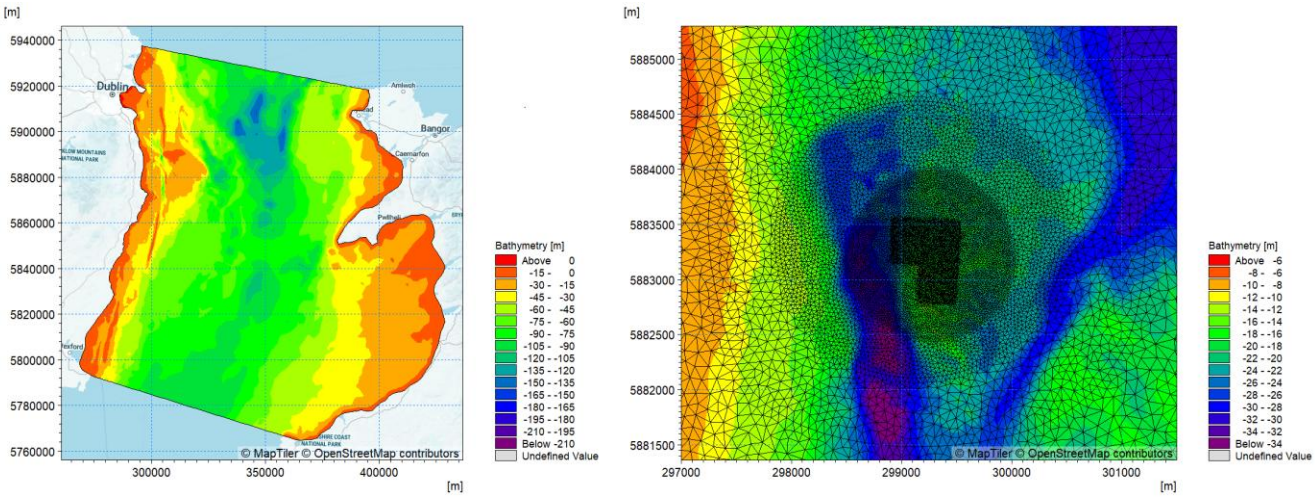


Figure 3.1: Extent and bathymetry of the Wicklow model with high resolution mesh around the disposal site

3.3 Boundary Conditions

The tidal boundary data used for the Wicklow dispersion model was generated using RPS' Irish Sea Tidal and Storm Surge model. This model stretches longitudinally from the North-western end of France, including the English Channel as far as Dover, out into the Atlantic to 16° west, including the Porcupine Bank. In the latitudinal direction it stretches from the northern part of the Bay of Biscay, taking in Rockall to just south of the Faroe Bank. Overall, the model covers the Northern Atlantic Ocean and UK continental shelf up to 600km from the Irish Coast as illustrated in Figure 3.2.

This model was also constructed using flexible mesh technology; along the Atlantic boundary the model features a mesh size of 13.125' (24km). The Irish Atlantic coast has been described using cells of on average 3km size while in the Irish Sea the maximum cell size is limited to 3.5 km decreasing

to 200m along the Irish coastline. The bathymetry of this model was generated from several different sources including digital chart data and surveys of several banks and coastal areas. This model is driven by astronomic tides generated from a global tidal model designed by a team at the Danish National Survey and Cadastre Department (KMS) and includes wind and pressure fields based on forecast data from the ECMWF.

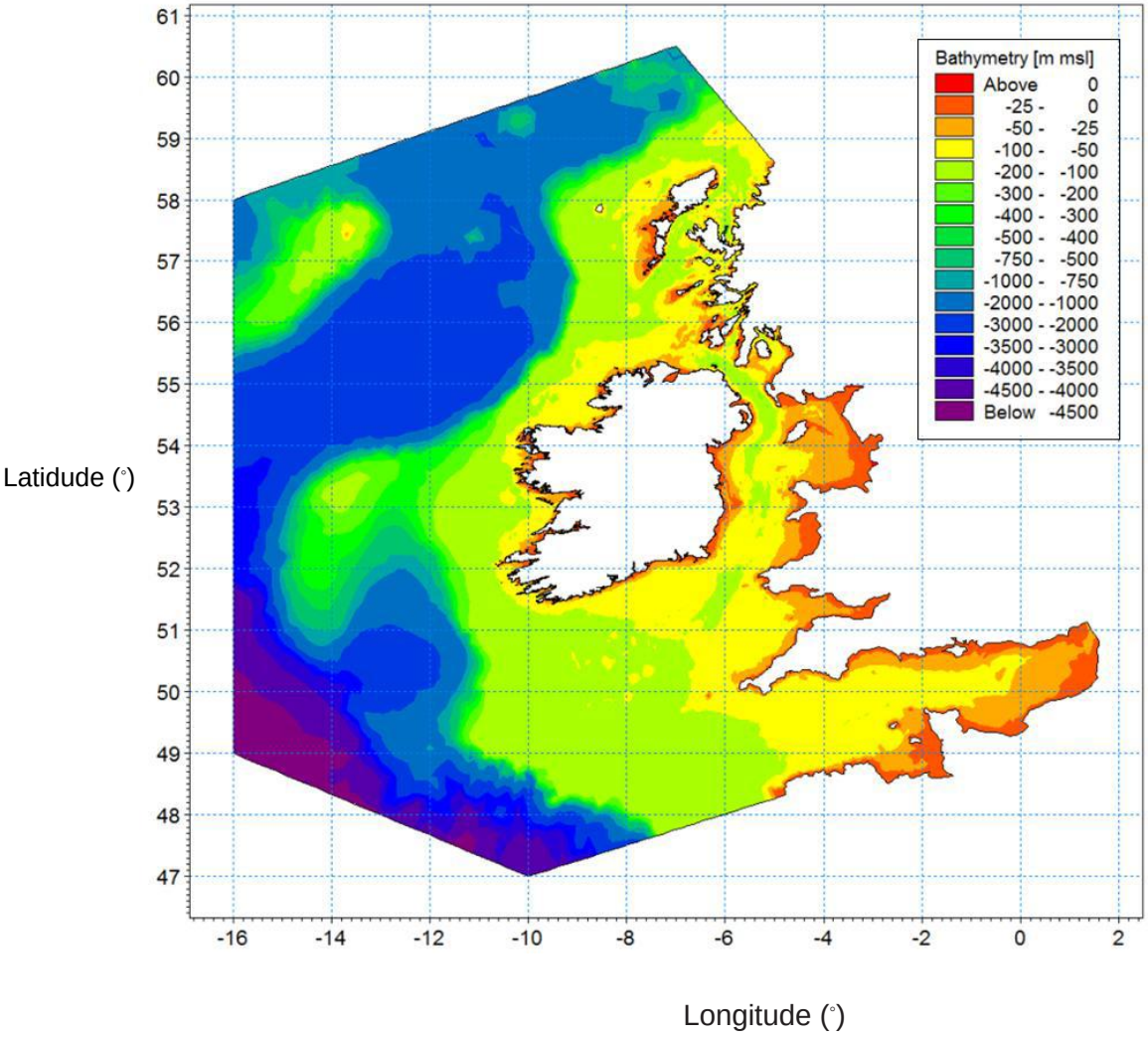


Figure 3.2: Extent and bathymetry of Tetra Tech's Irish Sea Tidal and Storm Surge model

4 Sediment Dispersion Modelling

4.1 Hydrodynamic Model validation

Tidal height gauge observations from nearby Wicklow Harbour, provided by the client, as well as tidal predictions for Wicklow Harbour, were used to validate the hydrodynamic simulation results at that location. The tidal predictions were calculated at 52.9800° N, -6.0444° W using the Admiralty components in the MIKE software.

Figure 4.1 shows very good agreement between the tidal heights from Tetra Tech' model simulations, Admiralty tidal predictions and tidal gauge observational data from Wicklow Harbour, provided by the client.

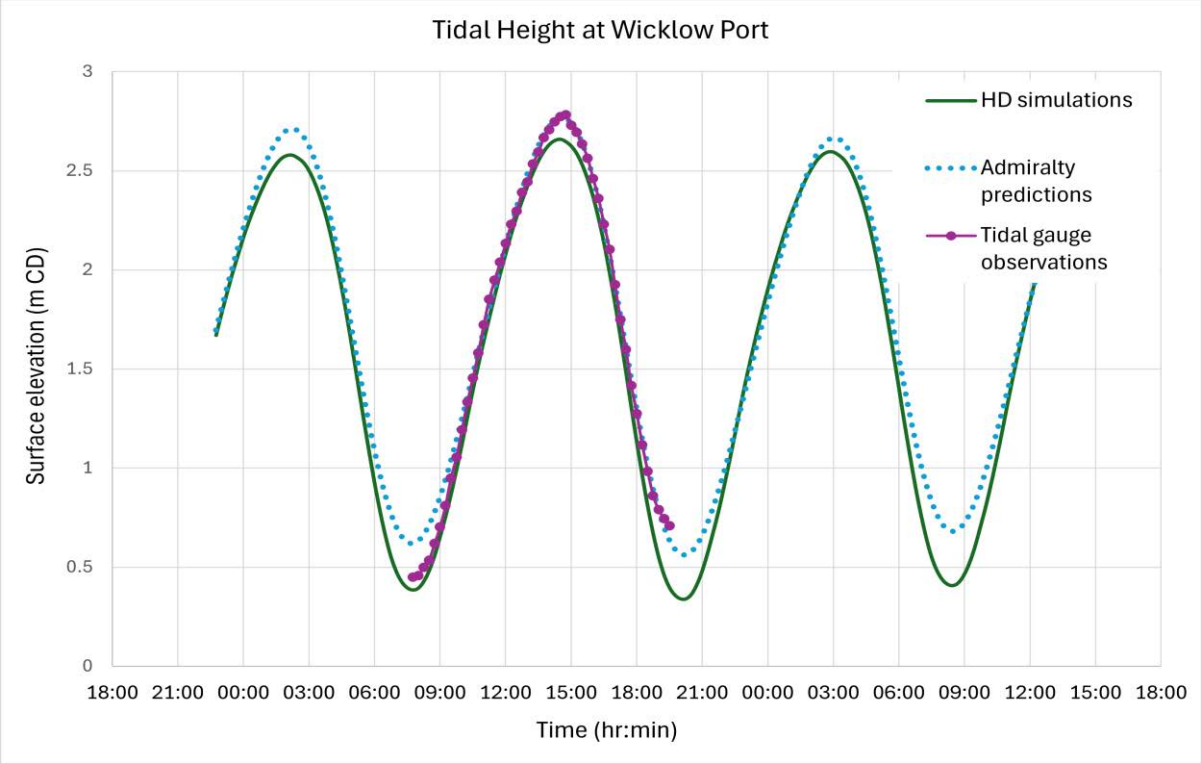


Figure 4.1: Comparison of tidal height at Wicklow Harbour from hydrodynamic simulations, Admiralty predictions and tidal gauge observations

In addition, the client provided Acoustic Doppler Current Profiler (ADCP) observation data at the Wicklow Harbour disposal site [3] at three different depths. Figure 4.2 again shows very good agreement between these observations and the hydrodynamic simulations.

Furthermore, this model was previously validated using recorded data from the Office of Public Works tidal gauge in Arklow Harbour [4]. The model correlated well through both the spring and neap tidal phases over a period of six weeks. Tetra Tech therefore deem that the hydrodynamic model is 'fit for purpose' in providing the basis of the sediment dispersion modelling.

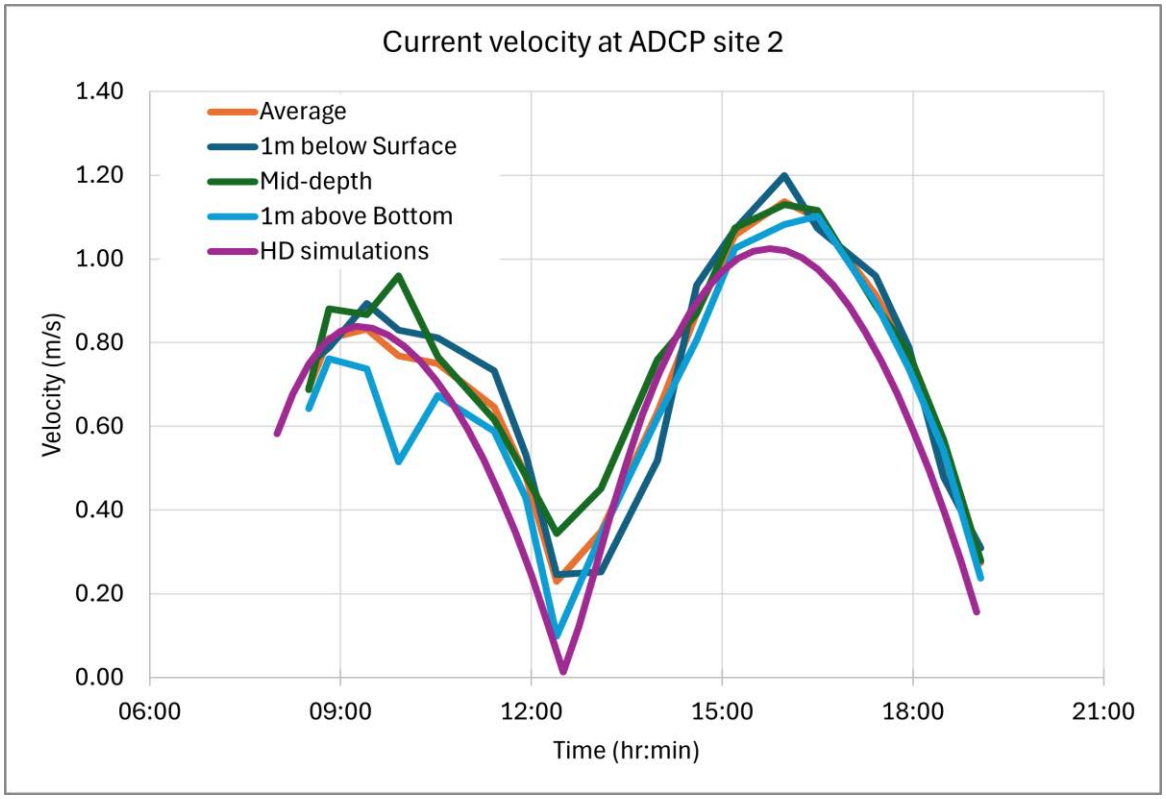


Figure 4.2: Comparison of current velocity between hydrodynamic simulations and ADCP observations east of Wicklow Harbour

4.2 Sediment plumes generated from disposal activity

Tetra Tech RPS assessed the dispersion and settlement of sediment material released from the dumping operations at the potential disposal site northeast of Wicklow Harbour. Disposal activities would last for five minutes in every 2.7 hour disposal event. The appropriate sediment fractions and characteristics, as defined in Table 2-2, were correspondingly set up in the numerical model. This disposed material was introduced as a source term at one point in each of the three areas illustrated in Figure 2.1 and amounted to approximately 81,000 dry tonnes for the total simulation time.

The total suspended sediment concentrations (SSCs) during typical tidal conditions are presented in Figure 4.3 to Figure 4.6. A summary of these plots is presented in Table 4-1. The total SSC includes all three grain types as defined in Table 2-2. The SSC associated with the coarser fractions 1 and 2 which are comprised of very fine gravel and medium sand, are negligible in comparison to fraction 3, registering values lower than 1×10^{-10} mg/l and 1×10^{-13} mg/l respectively. This is in agreement with the Arklow Offshore disposal dispersion modelling [2].

Table 4-1: Summary of sediment plumes

Tidal Phase	Total SSC
Mid flood	Figure 4.3
High water	Figure 4.4
Mid ebb	Figure 4.5
Low water	Figure 4.6

Since the disposal events take place every 2.7hrs, they occur at various stages of the tidal cycle and sediment plumes are therefore visible from the most recent disposal event and from previous events which have not yet fully dispersed or settled. Sediment dispersion can be summarised in general as follows:

- At mid flood conditions, the maximum total SSC of sediment of approximately 11mg/l from the most recent dump event has dispersed approximately 2km to the north of the disposal site while the previous events have now dispersed to *c.*7mg/l approximately 4km south.
- As evident from Figure 4.3, the wider envelope of the sediment plume with total SSC *c.*1mg/l, nearing background levels, reaches north to Greystones and south to Wicklow Head, taking in the Wicklow reef area during mid flood tidal conditions.
- At high water the maximum total SSC of *c.*7mg/l from previous events has dispersed approximately 6km north while the maximum total SSC of *c.*11mg/l from the most recent dump event begins to disperse south of the disposal site. The wider envelope of the sediment plume reaches a few kilometres beyond Greystones and Wicklow Head as shown in Figure 4.4.
- At mid-ebb tidal conditions, the entire sediment plume moves south of the disposal site, encompassing the Wicklow Reef area, as evident from Figure 4.5.
- At low water tidal conditions, the sediment plume extends almost 25km southwards from the disposal site as shown in Figure 4.6.
- The very fine gravel disperses approximately 10km north and south, albeit with SSC of the order of 10^{-10} mg/l.
- The medium sand settles quickly in close proximity to the disposal site.

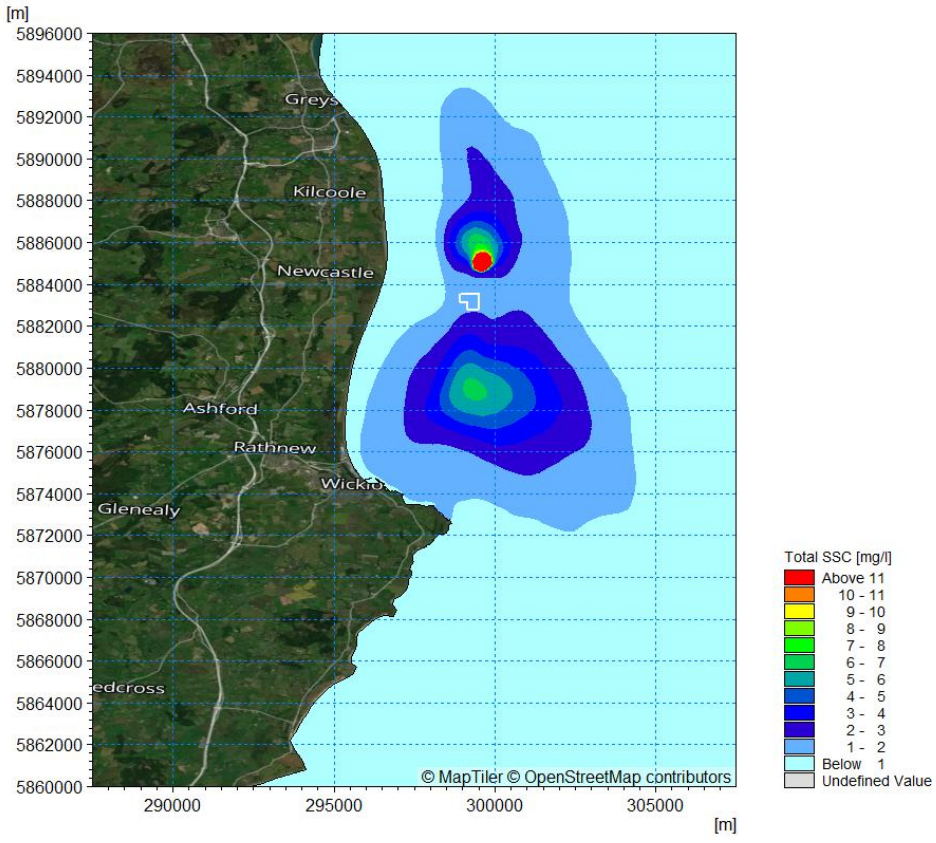


Figure 4.3: Total Suspended Sediment Concentration at mid flood

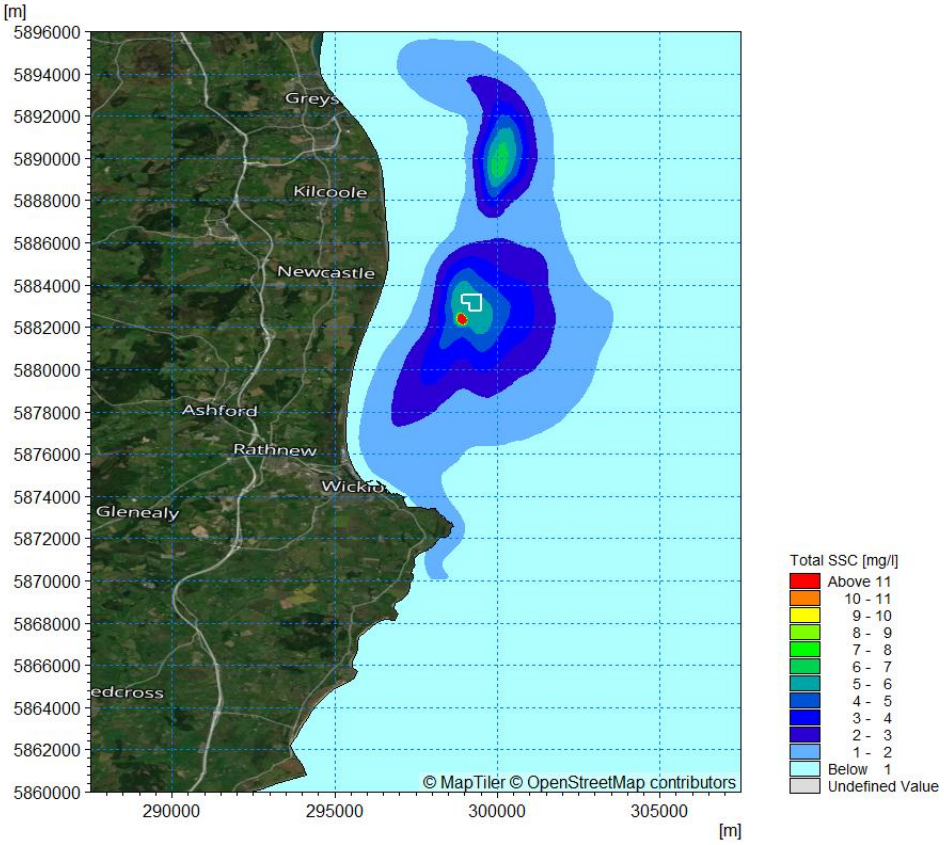


Figure 4.4: Total Suspended Sediment Concentration at high water

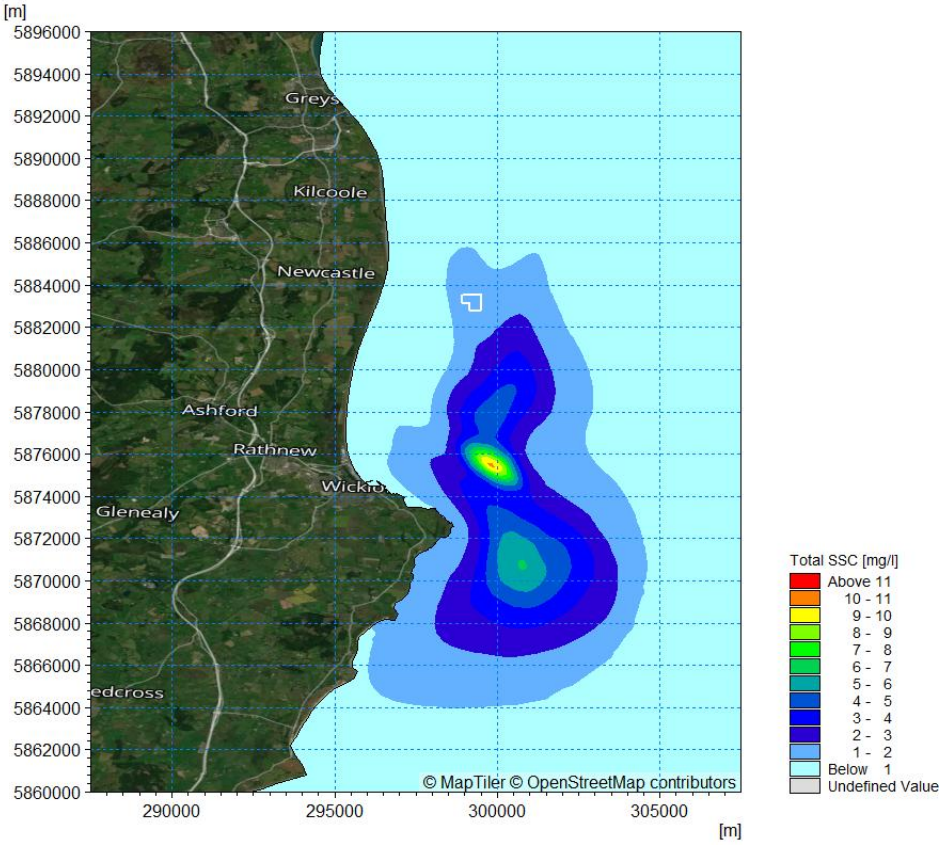


Figure 4.5: Total Suspended Sediment Concentration at mid ebb

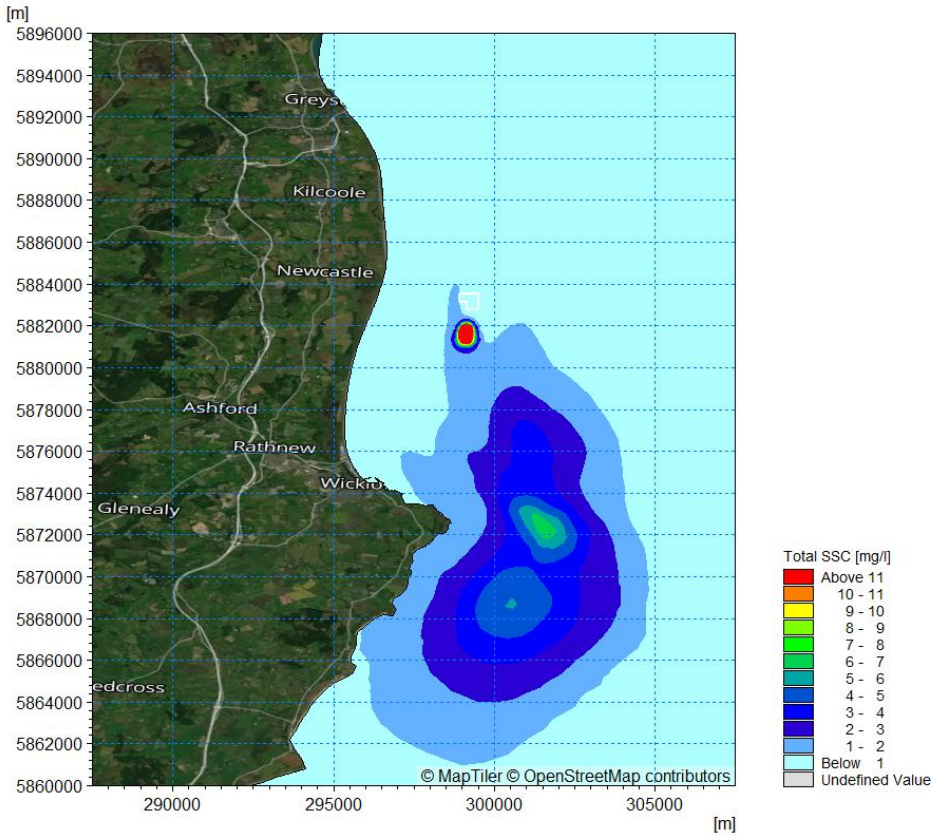
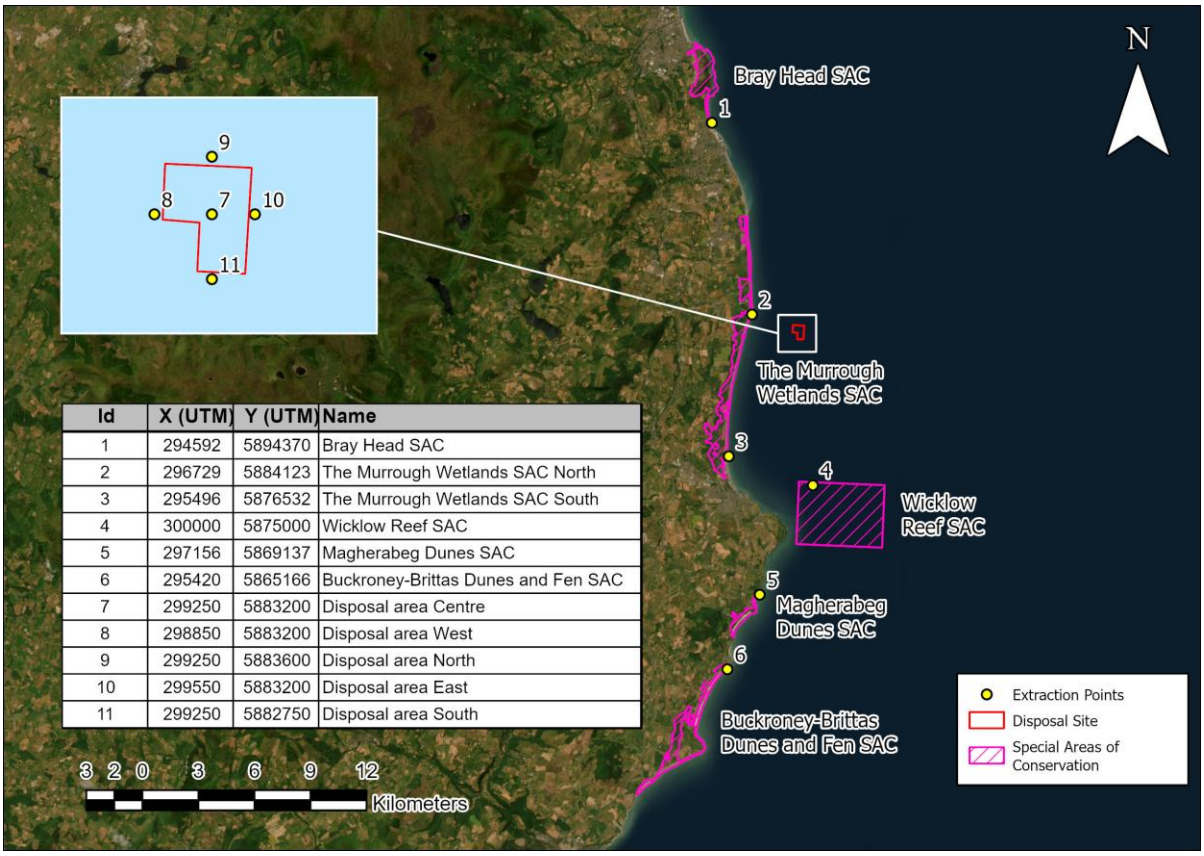


Figure 4.6: Total Suspended Sediment Concentration at low water

4.3 SSC at Special Areas of Conservation and proposed disposal site

Results were monitored at several Special Areas of Conservation (SACs) which lie along the Wicklow coast. These areas, Bray Head SAC, The Murrough Wetlands SAC, Wicklow Reef SAC, Magherabeg Dunes SAC and Buckroney-Brittas Dunes and Fen SAC and their associated monitoring points are shown in Figure 4.7.



Id	X (UTM)	Y (UTM)	Name
1	294592	5894370	Bray Head SAC
2	296729	5884123	The Murrough Wetlands SAC North
3	295496	5876532	The Murrough Wetlands SAC South
4	300000	5875000	Wicklow Reef SAC
5	297156	5869137	Magherabeg Dunes SAC
6	295420	5865166	Buckroney-Brittas Dunes and Fen SAC
7	299250	5883200	Disposal area Centre
8	298850	5883200	Disposal area West
9	299250	5883600	Disposal area North
10	299550	5883200	Disposal area East
11	299250	5882750	Disposal area South

Figure 4.7: Location of the Special Areas of Conservation and monitoring point in each

Table 4-2: Summary of Total SSC near the SACs

	Proposed Disposal Site	SACs
Maximum Total SSC	Figure 4.8	Figure 4.10
Mean Total SSC	Figure 4.9	Figure 4.11
Evolution of Total SSC	Figure 4.13	Figure 4.12

The maximum and mean total SSC in the vicinity of the proposed disposal site, as a result of the disposal operations are presented in Figure 4.8 and Figure 4.9 respectively. As shown, the maximum total SSC of *c.*2200mg/l is observed within the site itself with lower concentrations observed immediately outside the site perimeter. Figure 4.9 shows that the average total SSC at the three dumping points is approximately 22mg/l which reduces to 8mg/l at the northern and southern edges of the site boundary.

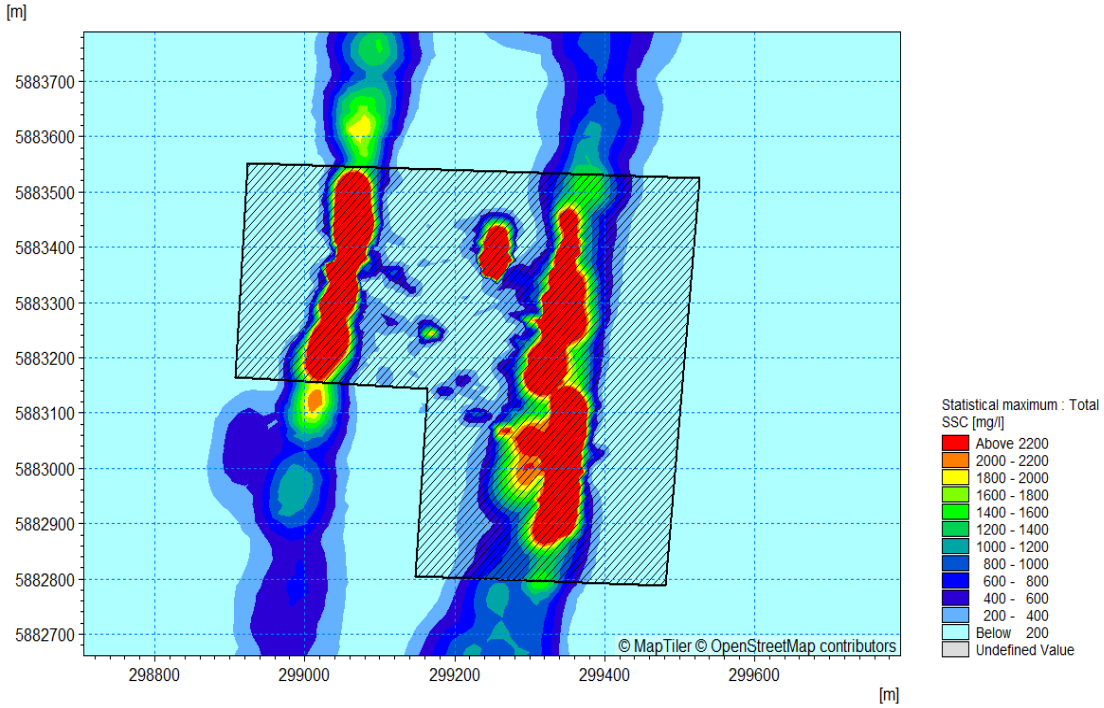


Figure 4.8: Maximum Total SSC at the proposed disposal site

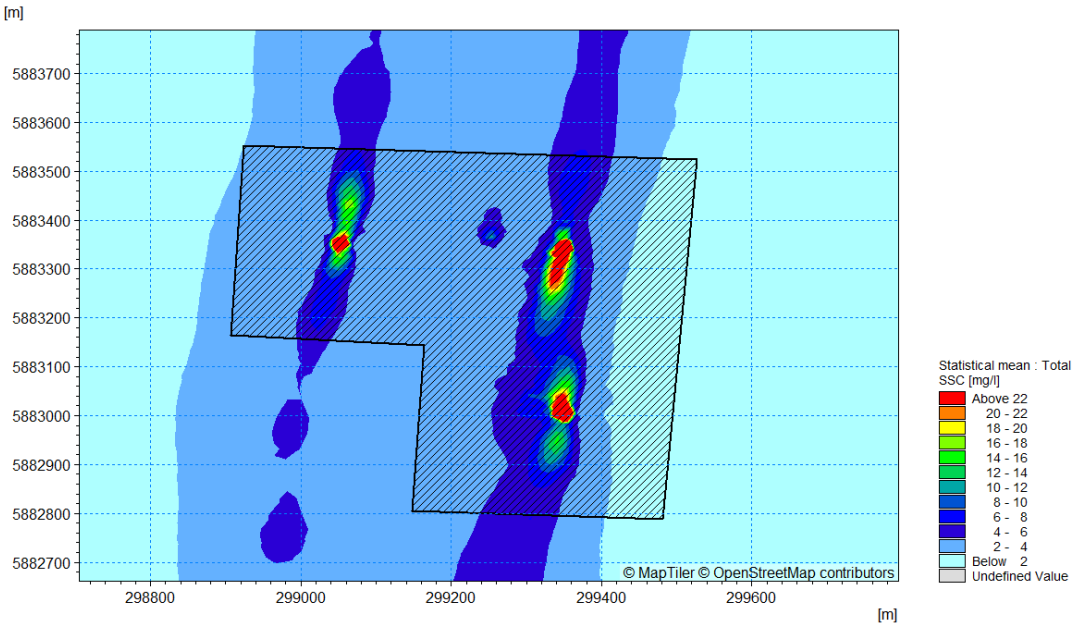


Figure 4.9: Mean Total SSC at the proposed disposal site

As shown in Figure 4.10, the central plume with largest maximum total SSC is observed within a distance of 7km to the north and 8km to the south of the proposed disposal site. The plume maximum SSC is greatly reduced before reaching the Wicklow Reef SAC. Along the north coast, close to The Murrough Wetlands, the maximum total SSC is below 2mg/l.

South of Wicklow, the plume envelope of maximum Total SSC is 2-4mg/l as it reaches the northern tip of the Magherabeg Dunes SAC, reducing to less than 2mg/l as it reaches the Buckroney-Brittas Dunes and Fen SAC and has already dispersed to background levels along the greater part of this SAC.

The average total SSC within 3km north and south of the proposed disposal site does not generally exceed 4.5mg/l while the greater plume envelope has an average total SSC of less than 1 mg/l as

evident in Figure 4.11. Within the Wicklow Reef SAC, the average total SSC is less than 2mg/l during the disposal activity. Along the north coast, the average total SSC is equivalent to background levels near to Bray Head SAC and The Murrough Wetlands SAC. Along the south coast, the average total SSC along the Magherabeg Dunes SAC is less than 1mg/l while it has dispersed to background levels before reaching the Buckroney-Brittas Dunes and Fen SAC.

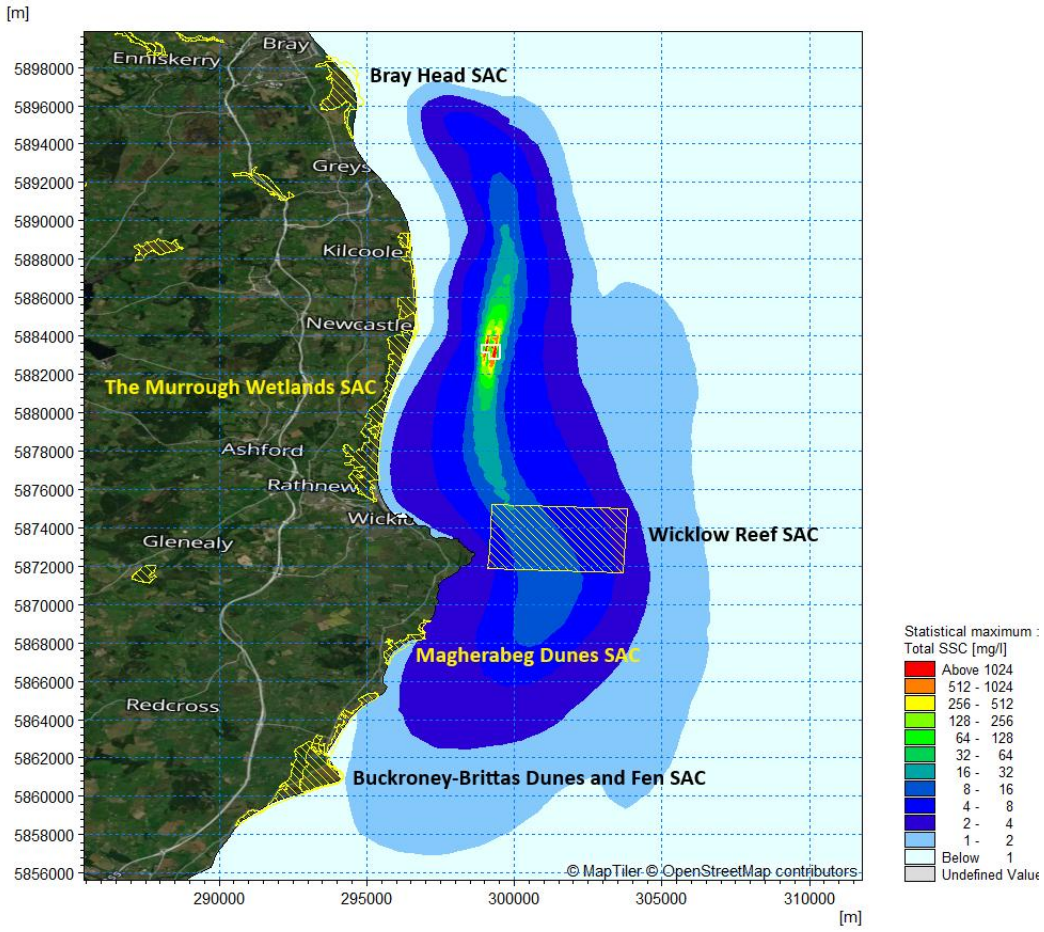


Figure 4.10: Maximum Total SSC along the coast

Figure 4.12 and Figure 4.13 show the time evolution of total SSCs within the vicinity of nearby SACs and at the proposed disposal site respectively, where the disposal events occur between Day 03 and Day 13.

- The northernmost Bray Head SAC experiences a consistently low total SSC of *c.*0.1mg/l.
- The Murrough Wetlands is the closest SAC to the proposed disposal site, yet the highest total SSC reached at the northern monitoring point is 0.65mg/l.
- At the south end of The Murrough Wetlands, the total SSC rises above 1mg/l only towards the end of the disposal period on Day 11 and falls below this value again on Day 15.
- At Wicklow Reef SAC, which is in the direct tidal current path, the total SSC can reach up to 6mg/l during the disposal period.
- The Magherabeg Dunes SAC sees the total SAC rise to just over 2mg/l at the end of the disposal period, reducing quickly again after Day 15.
- A peak total SSC of *c.*1.7mg/l is observed at the Buckroney-Brittas Dunes and Fen SAC.

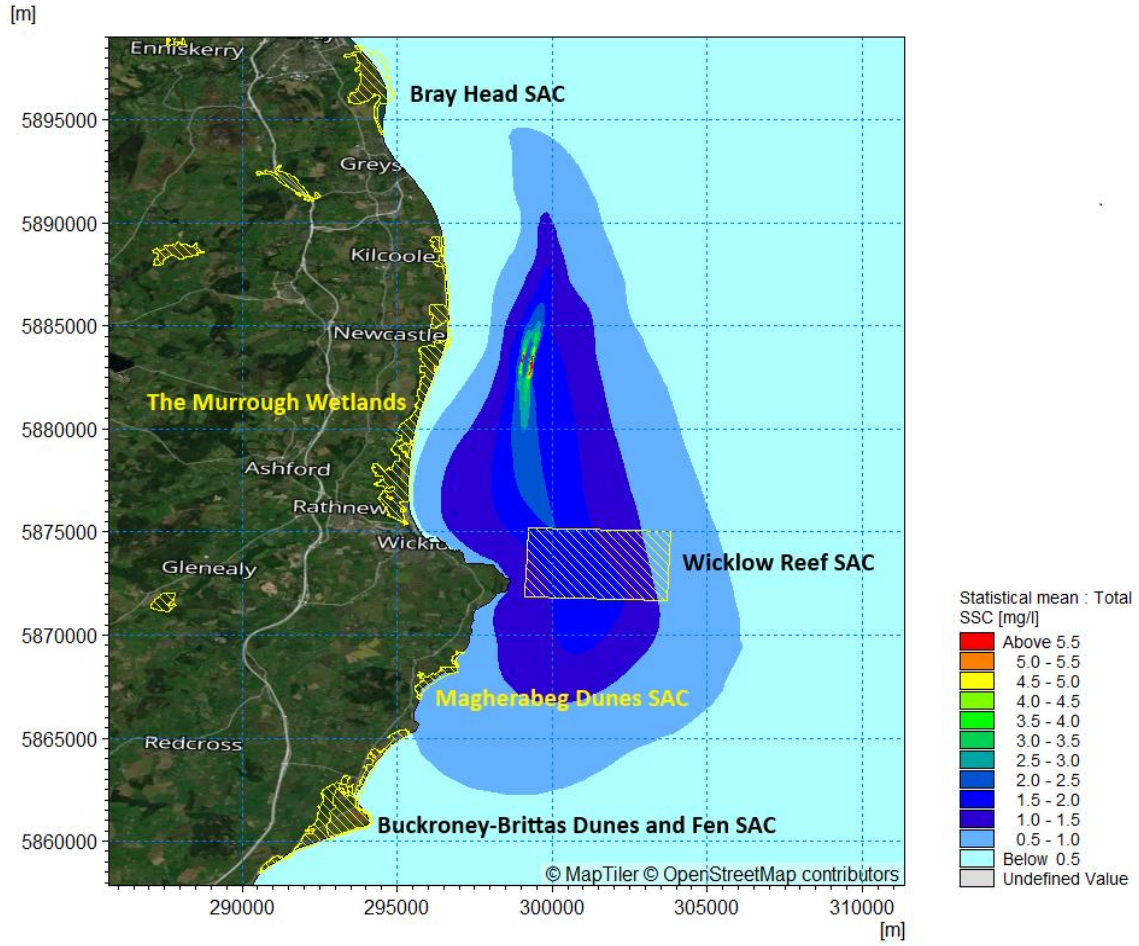


Figure 4.11: Mean Total SSC along the coast

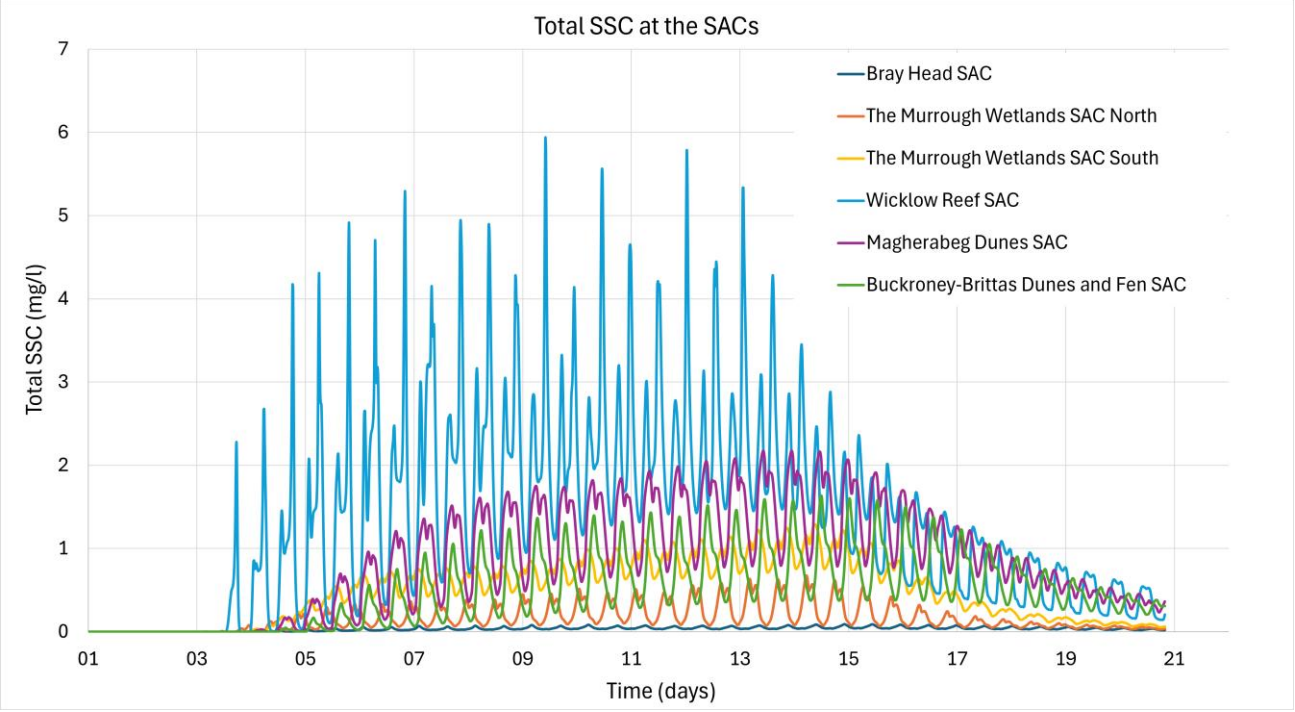


Figure 4.12: Evolution of Total SSC at nearbySACs

Total SSCs were also extracted from five points across the disposal site, one at the centre and four from around the perimeter. The simulated total SSCs at these locations are illustrated in Figure 4.13. During the disposal operations, the largest variations of total SSC were found to occur at the centre and at the southern boundary of the site. The smallest concentrations were found to occur to the east and west of the site. The total SSC at all locations across the disposal site gradually reduces to *c.*1mg/l by Day 18.

It can be seen from Figure 4.14 that at the end of the dumping operations, there is very little change in bed level. Within the disposal site, the maximum total bed thickness change is approximately 0.25m at the three dump locations while elsewhere within the proposed site, bed thickness changes do not exceed *c.*0.1m.

Beyond the vicinity of the disposal site, there was no discernible increase to bed level change as a result of the proposed dumping at sea operations.

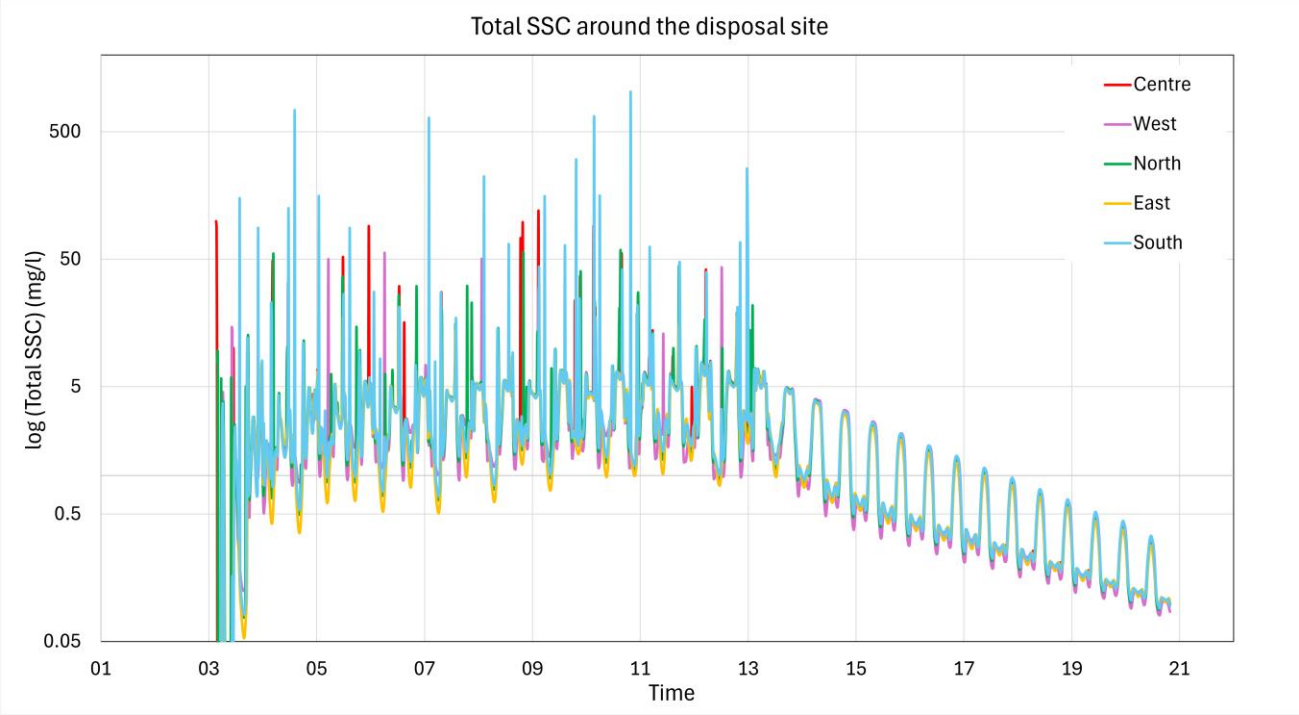


Figure 4.13: Evolution of Total SSC at the proposed disposal site

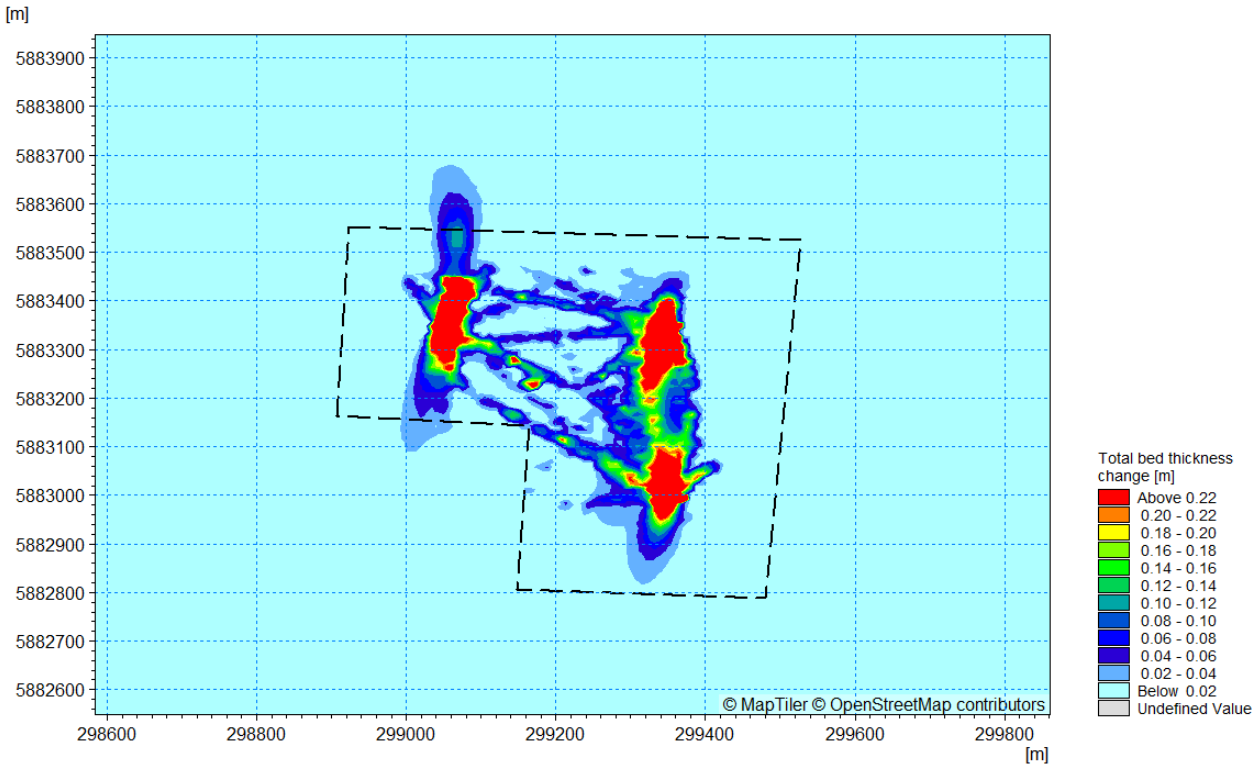


Figure 4.14: Total bed thickness change after three week simulation

5 Conclusion

A modelling study was undertaken to evaluate the disposal phase of the proposed maintenance dredging operations within Wicklow Harbour. This included tide and sediment dispersion modelling. The computational modelling was undertaken by development of a Tetra Tech in house model utilising the suite of MIKE coastal process modelling software by the Danish Hydraulic Institute.

The maximum total SSC plume envelope observed during the disposal operations did not generally exceed 2mg/l directly along the Wicklow coastline and near to the Special Areas of Conservation. The higher maximum total SSC observed inside and near the disposal site, are related to times when the vessel was active and therefore represented the sediment source before any dispersion had occurred.

The average total SSC within 3km north and south of the proposed disposal site does not generally exceed 4.5mg/l while the greater plume envelope has an average total SSC of less than 1 mg/l.

An assessment of the dumping operations found that the average total suspended sediment concentration beyond the immediate vicinity of the disposal site did not generally exceed 3mg/l. The average suspended sediment concentration quickly dispersed to less than 0.5mg/l approximately 10km to the north of the disposal site, and within 22km to the south. Five days after the final disposal event, the sediment plumes have fully dispersed into the background concentrations.

This is unsurprising given that this proposed site is almost completely dispersive for fine material with slow fall velocities such as the silt material being disposed of from Wicklow Harbour. Instead, most of the silt material disposed of at this site disperses to the point that it becomes indistinguishable from background levels.

A change to bed thickness, which does not exceed 25cm, is observed only within the disposal site area. Outside the disposal site, little to no change is observed in the bed thickness.

It should be emphasised that the modelling undertaken in this study represents the highest possible volume of material to be disposed of during the eight year Wicklow Harbour dredging project. Actual material volumes, and spill rates, may be lower and would therefore have a reduced plume envelope and concentrations along the Wicklow coast, than those presented in this report.

References

[1] **Gavin & Doherty Geosolutions**, *Assessment and Report on Dispersion Modelling due to Water Injection Dredging at Wicklow Harbour*, 23009-REP-005-02, 2024.

[2] **Gavin & Doherty Geosolutions**, *Assessment and Report on Dispersion Modelling at the Arklow Disposal Site*, 23145-REP-001-03, 2024.

[3] **Hydro Environmental Ltd,** *Hydrodynamic Modelling Assessment of the Wicklow Harbour Dredge Disposal Site*, HEL095101 v1.1, 2012.

[4] **RPS**, *Seabank to Kilmichael Point Coastal Erosion Risk Management Study (CERM)*, IBE2290, 2025.