

Greater Dublin Drainage

Alternative Sites Assessment and Route Selection Report (Phase 4): Final Preferred Site and Routes

Appendix 12 **Hydrodynamic Modelling**

June 2013

Document control sheet P 04 F8

Client: Fingal County Council
 Project: Greater Dublin Drainage Job No: 32102900
 Document Title: Hydrodynamic Modelling

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Alternate Site Assessment

Numerical Modelling Report

**Comparison of Dilution and Mixing
Characteristics at Representative
Northern and Southern Outfall Locations**

GP201103_doc003_04

Document No: GP201103_doc003_04.pdf
Status: Final



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Introduction

MarCon were commissioned by Jacobs Ireland to undertake a mathematical modelling study of the coastal waters of north County Dublin to examine the relative merits of two marine outfall locations with respect to the mixing capacity of the receiving water body, pursuant to the Greater Dublin Drainage project.

MarCon applied the CORMIX model to predict the near-field dilution characteristics of a proposed outfall discharging to the receiving waters in both the northern and southern study areas to compare the merits of each outfall location. The CORMIX model predicted the plume development, dilution and effluent concentrations within the plume.

This report details the modelling study and appraisal undertaken to determine the dilution and dispersion characteristics from two outfall locations in order to progress the detailed modelling and land based work. The preliminary modelling study has been based on currently available information. The locations of the outfalls considered for this study are presented in Figure 1, and correspond to the locations at which instruments were deployed during the GDD hydrographic survey during July and August 2012.

This modelling study does not account for ambient concentrations of water quality parameters, nor the temporal variation in input loads from other outfalls or rivers. Further, the preliminary modelling study does not account for biogeochemical processes which would impact on the ambient nutrient levels in the coastal waters.

The results from the modelling study predicted and compared the dilution rates and concentrations of the effluent discharged from each outfall and were used to determine the relative merits of each potential outfall location.

The description of the CORMIX model is presented in Section 2. The development of the model, and data requirements for the near field modelling is presented in Section 3. The near field modelling simulations, and results thereof, are presented in Section 4 and Section 5 respectively. Conclusions drawn from the near field modelling study are presented in Section 6.

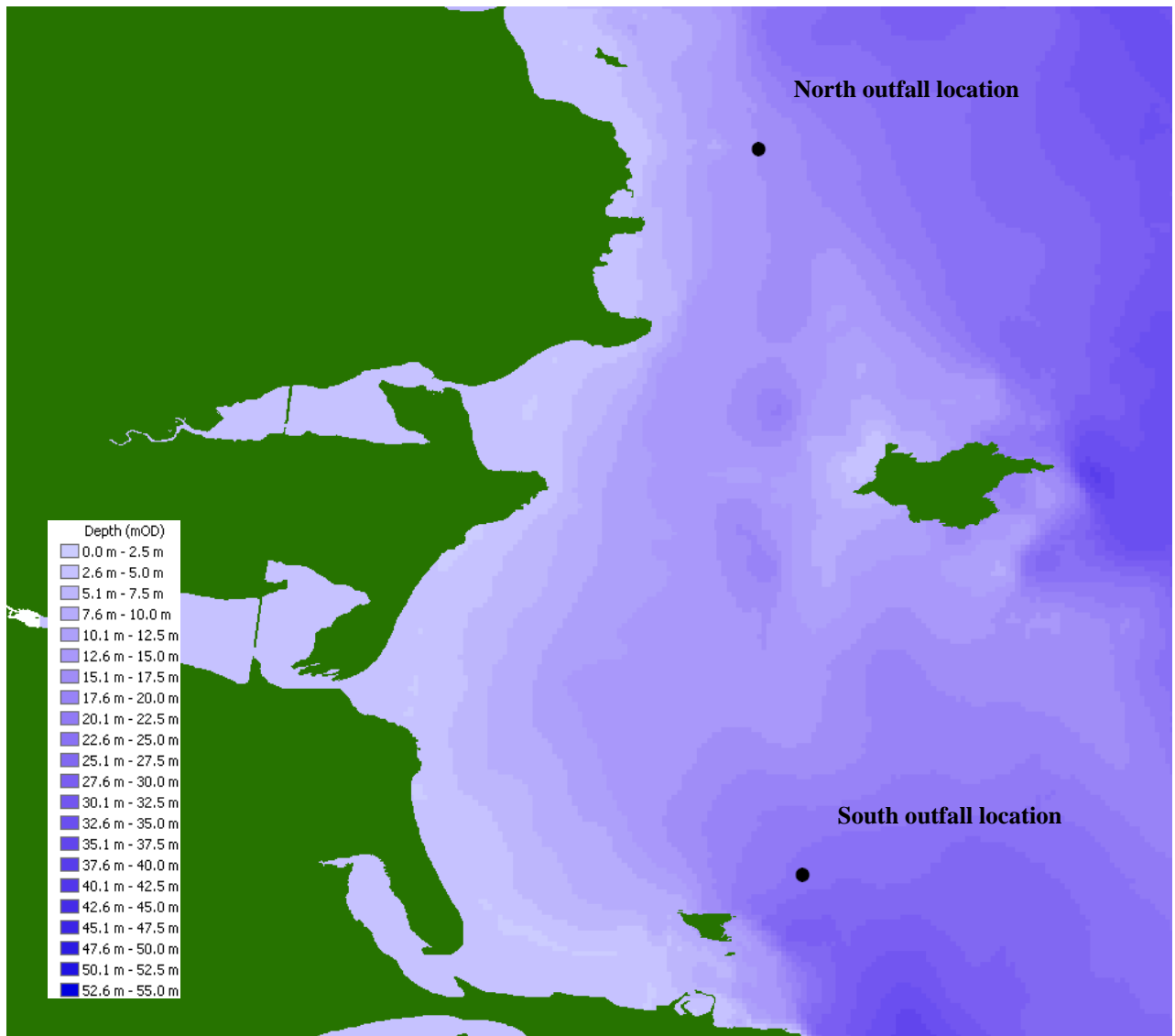


Figure 1: Locations of modelled outfalls



Numerical Model

The Cornell Mixing Zone Expert System (CORMIX) may be described as a software package with a series of modules for the analysis, prediction, and design of aqueous toxic or conventional pollutant discharges into diverse water bodies. It was developed under cooperative funding agreements from the U.S. Environmental Protection Agency, the Maryland Department of Natural Resources Power Plant Research Program, and the Delaware Department of Natural Resources and Environmental Control. The system's major emphasis is on predicting the geometry and dilution characteristics of the initial mixing zone so that compliance with water quality regulatory constraints may be judged. The system also predicts the behaviour of the discharge plume at larger distances.

CORMIX was intended as a first-order, screening/design model. It does not carry out detailed hydrodynamic calculations using the exact geometry of the discharge location, nor does it explicitly handle dynamic ambient currents (i.e., tides). It uses a simplified representation of the physical conditions at the discharge location to approximate the fundamental behaviour of the plume.

CORMIX has been successfully applied by regulators, engineers, environmental scientists, and students worldwide to the design and monitoring of wastewater disposal systems in oceans, rivers, lakes, and estuaries. Because of the ability to simulate details of plume boundary interaction, important for ecological and human health risk assessment, CORMIX is recognized by regulatory authorities in all continents for environmental impact assessment.

CORMIX has previously been applied by the authors to assess the impacts of thermal effluent discharges to the Mulkear River, Co. Limerick and the Boyne River, Co. Meath, assess the impacts of biocide and thermal discharges to Cork Harbour. In the UK, the authors have employed CORMIX for the mixing zone assessment and EQS determination for all IPPC and UWWTD licenced discharges to the Mersey Estuary for the English Environment Agency.



Basic Plume Behaviour

The outflow from a discharge port and the receiving water generally have several different physical characteristics, including velocity, temperature, and density. These characteristics, along with the physical configuration of the receiving waters, determine where, and how rapidly, mixing occurs in the receiving water body.

Near the discharge port, the plume tends to behave as a coherent jet, dominated by its initial momentum and buoyancy. Eventually, these are dissipated by interaction with the surrounding medium, and the plume becomes a diffuse mass carried along by the ambient current.

Mixing initially occurs by turbulent flows at the boundaries of the plume, and later primarily by pure diffusion processes. Depending on the geometry of the port and of the receiving water body, the plume may be freestanding in open water, fill a bounded area bank to bank, or become bank attached, bottom attached, or both.

To make predictions of an effluent discharge's dilution and plume trajectory, CORMIX typically breaks the prediction problem into several stages. In each stage, a solution for the steady-state simplified flow patterns characterising that stage is calculated. These solutions are combined to provide a complete simulation from the outflow point to the distance limit set by the user. CORMIX is not a dynamic model, but it can estimate elapsed time at intervals set by the user.

Adapting CORMIX to Tidal Situations

For a tidal situation, as encountered off the coast of north county Dublin, the dynamic change in ambient velocity further complicates plume behaviour. When predictions are desired in an unsteady ambient flow field, information on the tidal cycle must be supplied. In general, estuaries or coastal waters can exhibit considerable complexity with variations in current velocity magnitude and direction as well as in water depth.

The tidal height varies between mean low water and mean high water. The tidal velocity changes its direction twice during the tidal cycle at times of slack tide. One of these times occurs near, but



is not necessarily coincident with, the time of mean low water and is referred to as Low Water Slack (LWS). The slack period near mean high water is referred to as High Water Slack (HWS).

The rate reversal (time gradient of the tidal velocity) near these slack tides is of considerable importance for the concentration build-up in the transient discharge plume, as tidal reversals will reduce the effective dilution of a discharge by re-entraining the discharge plume remaining from the previous tidal cycle. Hence, CORMIX needs some information on the ambient design conditions relative to any of the two slack tides.

A CORMIX design case consists of an instantaneous ambient condition, before or after one of the two slack tides. In general, tidal simulations should be repeated for several time intervals (usually hourly or two-hourly will suffice) before and after slack time to determine plume characteristics in unsteady ambient conditions.

Therefore, for the purpose of this assessment, simulations were carried out at hourly time intervals relative to high and low water. These simulations were carried out under both spring and neap tidal conditions giving a total of 28 simulations for each modelled outfall location.

Diffuser Representation within CORMIX

Subsystems within CORMIX cater for the simulation of various discharge conditions. CORMIX1 predicts the geometry and dilution characteristics of the effluent flow resulting from a submerged single port discharge and is, therefore, a point source model.

CORMIX2 applies to submerged multiport discharges and uses the 'equivalent slot diffuser' concept to model the multiport discharges. Therefore, it neglects the details of the individual jets issuing from each diffuser port and their merging process and instead assumes the flow arises from a long slot discharge with equivalent dynamic characteristics. It is, therefore, a line source model.

The proposed diffuser arrangement for the GDD outfall is a multiport diffuser, similar to that presented in Figure 2. This diffuser arrangement, though consisting of multiple ports, still represents a point source discharge and, therefore, necessitated the use of CORMIX1.

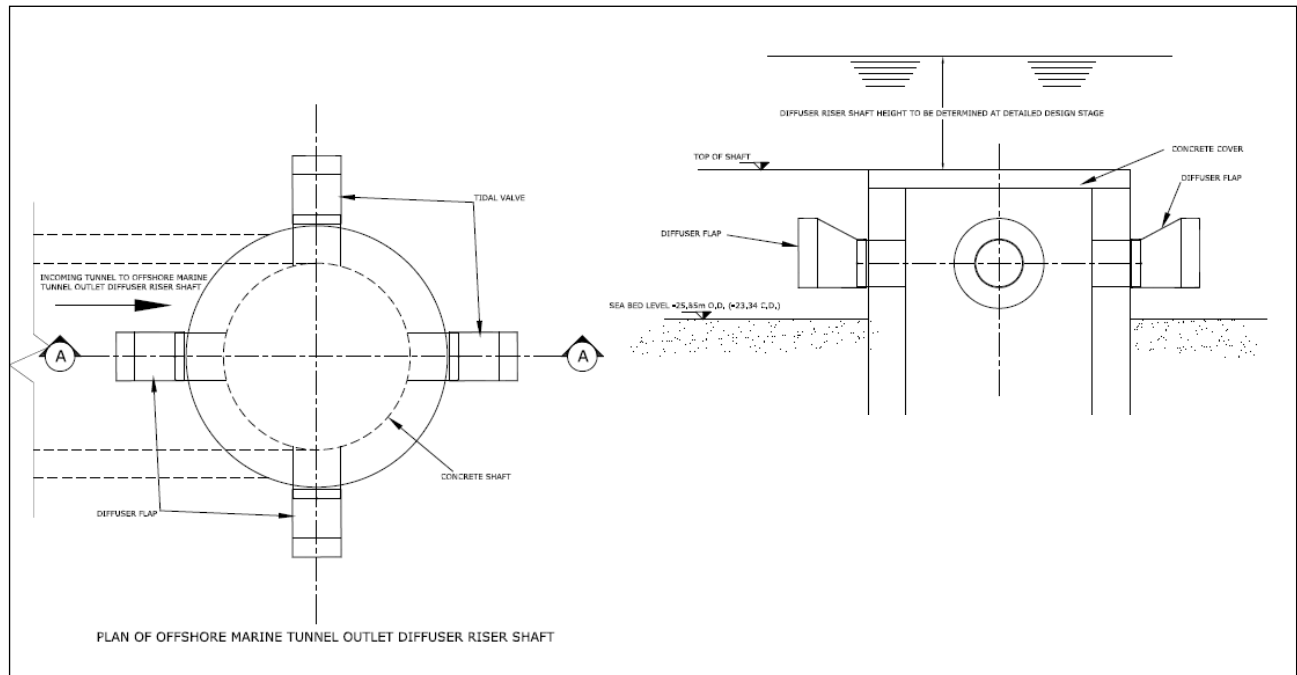


Figure 2: Typical multiport diffuser schematic

The classical modelling solution as recommended by CORMIX software managers would require the simulation to be carried out in two distinct stages; one to assess the mixing around the diffuser and the other to assess mixing in the water column at distance from the diffuser, at each time interval.

As detailed designs had not been undertaken for the diffuser at this stage of the GDD project, it was not possible to provide realistic diffuser configuration specifics to the CORMIX model.

Therefore, the modelling study considered the multiport diffuser as a virtual, single port of similar discharge characteristics in order to ascertain dilution characteristics in the receiving waters at distance from the outfall and hence the mixing extents.

The virtual single port represented a ‘worst-case scenario’ as initial dilution for the multiport will be greater than that for the virtual, single port. Modelling the single port configuration at both outfall locations as the worst case scenario allowed for conservative estimates of the initial dilutions and mixing zones that would be achieved using the proposed GDD multiport diffuser.



Comparison of dilution characteristics and mixing extents from the same multiport diffuser located in the north or the south of the study allowed for the assessment of the relative merits of both locations.

Inherent CORMIX Limitations

In addition to the items mentioned above, the user must overcome several inherent limitations to applying CORMIX in tidal simulations. These include the following:

- The use of an idealised rectangular cross-section to represent the geometry of the receiving waterbody and a steady and uniform ambient flow normal to the cross-section plane, both of which are unrealistic.
- Problems simulating effluent plumes during slack (i.e., low ambient current) conditions. These occur partly because steady-state solutions take much longer to realize than the typical duration of the low current conditions. There is no way to modify the CORMIX input to account for the developing high-concentration pool near the discharge point.

Fortunately, conditions at either of the outfall sites considered in this study do not fall within either of the above criteria because:

- In the case of the present study, the relatively flat sloping bed off the north Dublin coastline at the proposed outfall locations facilitate idealised rectangular cross section schematisation, and there is no land mass forming a boundary within the modelled region of assessment (500m)
- The depth of water into which both outfalls discharge does not allow for the development of high concentration pools of effluent around the discharge point even at slack water(s). In addition, the density difference between the effluent and the receiving sea water facilitate the vertical mixing of the effluent plume even at low ambient water current speeds.



CORMIX is a steady-state model, whereas tidal environments are inherently unsteady. Because most mixing zone analyses requires "worst case" dilution analysis, conditions at slack tide (often zero ambient velocity) are considered as representative of the "worst case". However, minimum initial dilution generally will not occur at slack tide, but shortly after slack tide when the plume re-entrains material remaining from the previous tidal cycle.

In tidal mode, CORMIX considers the reduction in initial dilution due re-entrainment of material remaining from the previous cycle. It does not consider unsteady build-up of material over several tidal cycles. It assumes a complete flushing of the historic plume in the near-field, will occur within a tidal cycle. Assessment of the unsteady build up of material over several tidal cycles will be examined during the detailed modelling as part of the EIS stage of the project.

CORMIX results are best utilised when options assessment is undertaken to examine the relative merits of one situation over another, as was the case for this present study.

Model Development

The data required to define each simulation to CORMIX was extensive and when necessary values could not be accurately defined, assumptions or estimates had to be made in relation to these.

The density of any effluent discharge will depend on the constituent compounds in the wastewater stream and cannot be calculated definitively a priori to sample analyses. From experience, waste water discharge densities range between those of fresh water and saline seawater.

Details of the proposed GDD outfall diffuser, where known, were provided by the project team, but complete schematisation of the GDD outfall in CORMIX had to be estimated, as finalised designs have not been undertaken to date. The schematisation of the GDD outfall was based on similar multiport outfalls in Ireland.

Irrespective of the final outfall design specifications, the relative impact on the receiving water will remain valid. The purpose of the present study is to examine and compare the relative merits of the north and south outfall *locations* with respect to mixing zones and dilution capacity.



Details of the bathymetry, the hydrodynamic regime and the properties of the receiving waters were obtained from the hydrographic surveys undertaken earlier in the project. The input data required by the model is described in detail in the following sections.

Hydrodynamics and Water Depths

The hydrodynamic data used to force the CORMIX model was obtained from the Acoustic Doppler Current Profilers (ADCPs) and the tide gauges deployed during the course of the hydrographic survey in July – August 2012.

To provide representative conditions at each outfall location both spring and neap current velocities and water depths were extracted from the survey data. The spring tide data was from the 4th August 2012, and the neap tide data was from the 12th August.

Recorded current velocities at mid water level on the spring tide of 4th August 2012 at each modelled outfall location are presented in Figure 3. Recorded current velocities at mid water level on the neap tide of 12th August 2012 at each modelled outfall location are presented in Figure 4.

Recorded water depths on the spring tide of 4th August 2012 at each modelled outfall location are presented in Figure 5. Recorded water depths on the neap tide of 12th August 2012 at each modelled outfall location are presented in Figure 6.

The points on each of the figures represent the hourly data defined to the CORMIX model for both current speeds and water depths, and are presented in Table 1 for neap tide simulations, and in Table 2 for spring tide simulations.

Seawater Density

The difference in density between the receiving water and the discharge has an impact on the rate of initial mixing. The density of the receiving water was specified to the CORMIX model based on the water temperatures and water salinity recorded at each outfall location during the course of the hydrographic survey.



At both the north and south locations, the seawater was well mixed with no density gradients observed. The density of the receiving waters at both the north and south locations was calculated to be 1023 kg/m³.

Discharge Characteristics

The characteristics of the effluent discharge were provided by the project team. It should be noted that these values are proposed design levels, and not actual sampled data:

Total Nitrogen:	50 mg/l
Total Phosphorus:	10 mg/l
Intestinal enterococci:	2,000 cfu/100ml
Escherichia coliforms:	10,000 cfu/100ml
Faecal coliforms:	2,000 cfu/100ml
BOD:	25 mg/l

Other relevant discharge characteristics required by CORMIX were:

Flow rate:	4.635 m ³ /s	(GDD design peak flow in 2040)
Effluent density:	1,010 kg/m ³	(estimated)

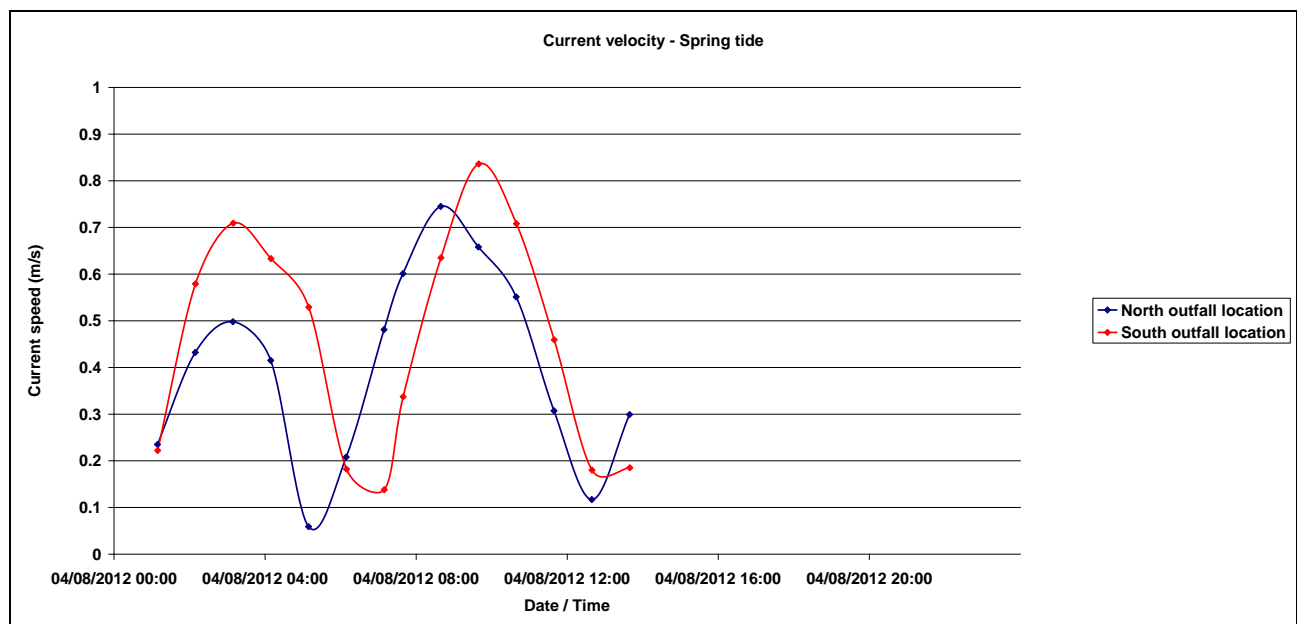


Figure 3: Mid water column recorded current velocities on spring tide of 4th August 2012

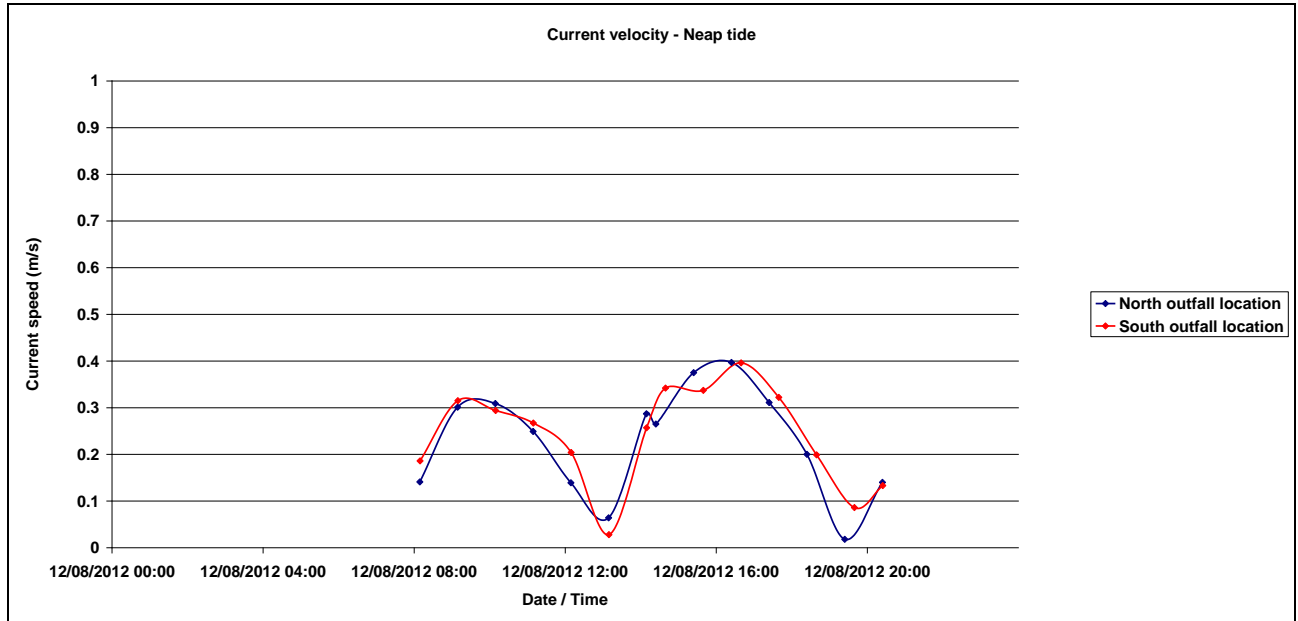


Figure 4: Mid water column recorded current velocities on neap tide of 12th August 2012

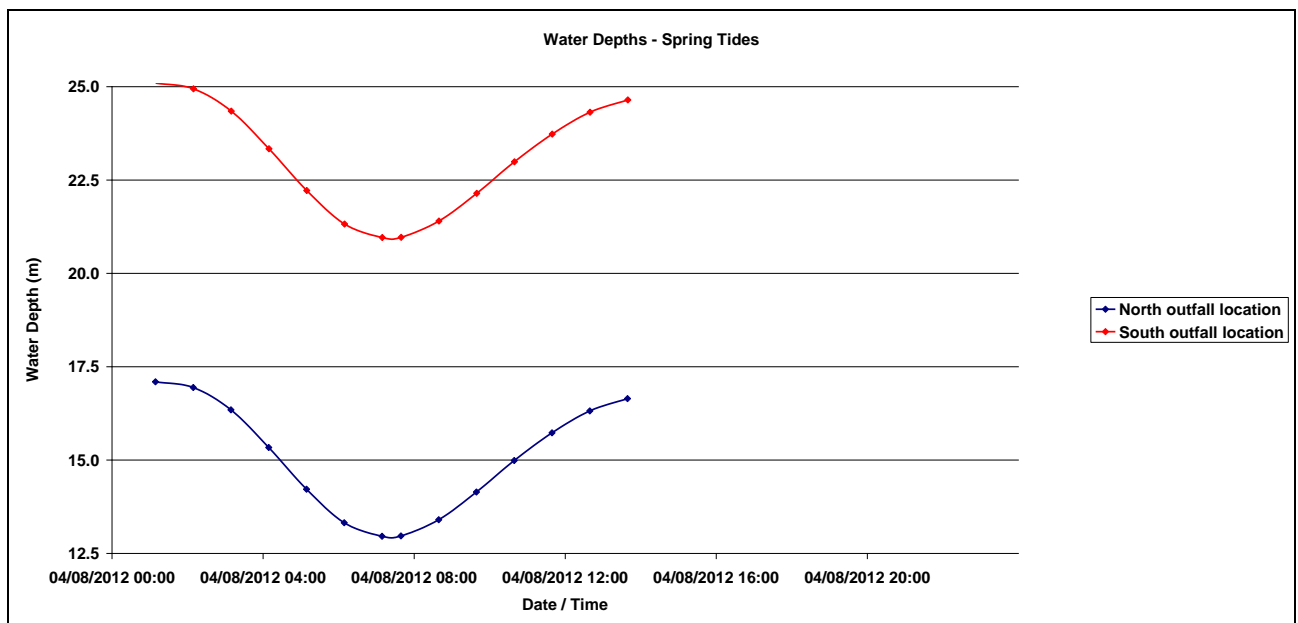


Figure 5: Recorded water depths on spring tide of 4th August 2012

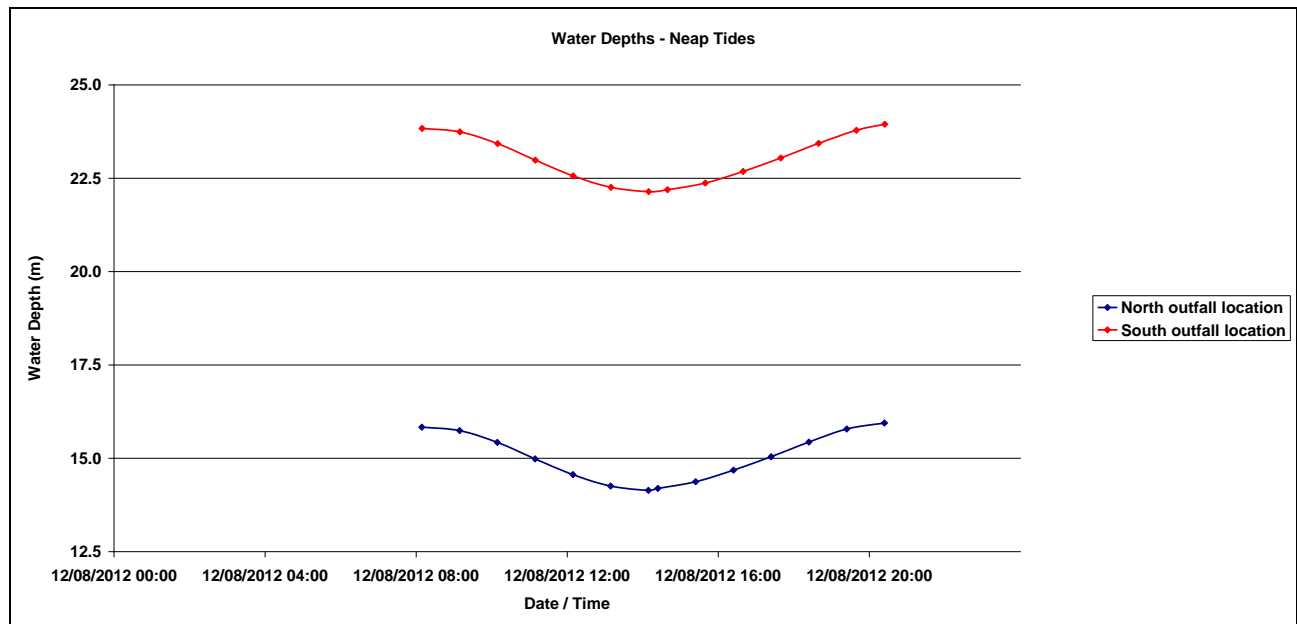


Figure 6: Recorded water depths on neap tide of 12th August 2012

Diffuser Representation

The proposed outfall and diffuser arrangement comprises a single 2.0m diameter riser pipe with four assumed 400mm diameter ports located at 2.0m above the sea bed, giving a combined port area of 0.502m². The ports are to be positioned concentrically around the main pipe, perpendicular to the bed. A three-dimensional CORMIX representation of the diffuser is shown in Figure 7.

As explained previously, it was necessary to model the diffuser using CORMIX1 which is only applicable for submerged single port discharges. This required modelling each of the multiports combined into a virtual, single port of similar discharge characteristics to the multiport diffuser to investigate the dilution and mixing extents. The mixing extents predicted for the virtual, single port represent a 'worst-case scenario' as initial dilution levels in the near-field should be much greater for the multiport.

A schematization of the single port diffuser used in the modelling scenarios is shown in Figure 8. The properties of this single port were varied to replicate the combined area of the individual multiport diameters and orientations. The virtual port used a diameter of 0.4m, (giving an identical



port area of 0.502m^2 as the combined area of the 4 multiports), and the same port height and flow rate specified above.

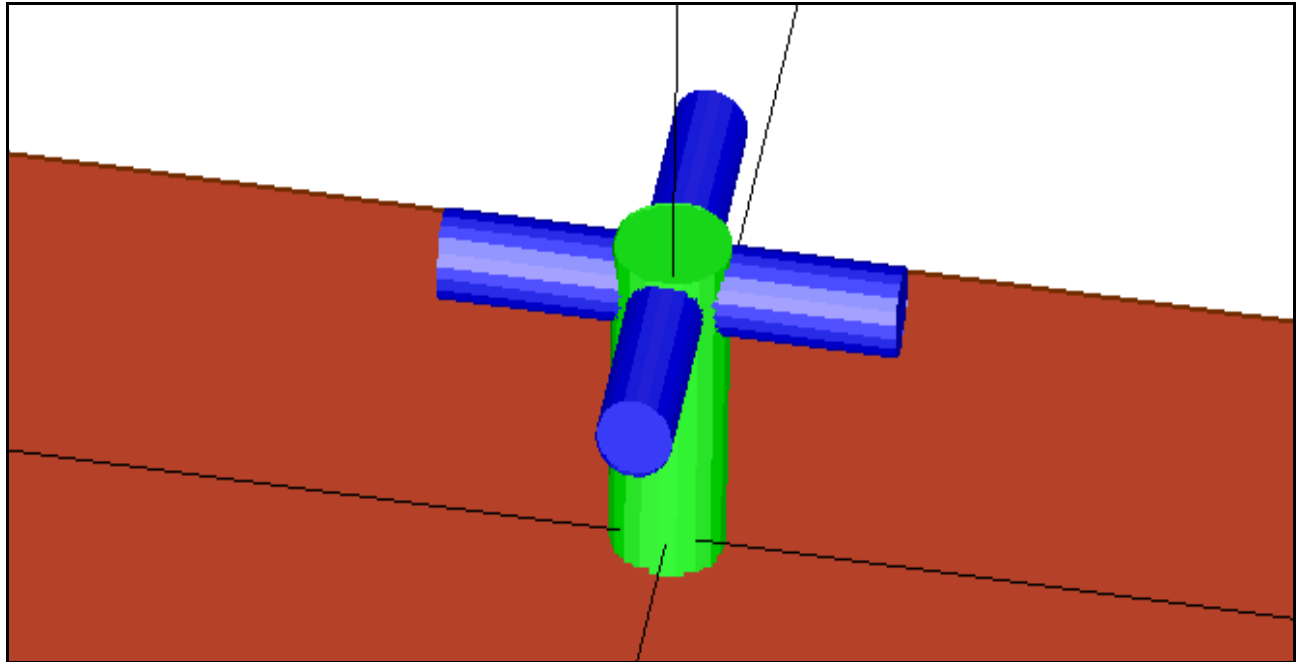


Figure 7: CORMIX visualisation of proposed multi-port diffuser.

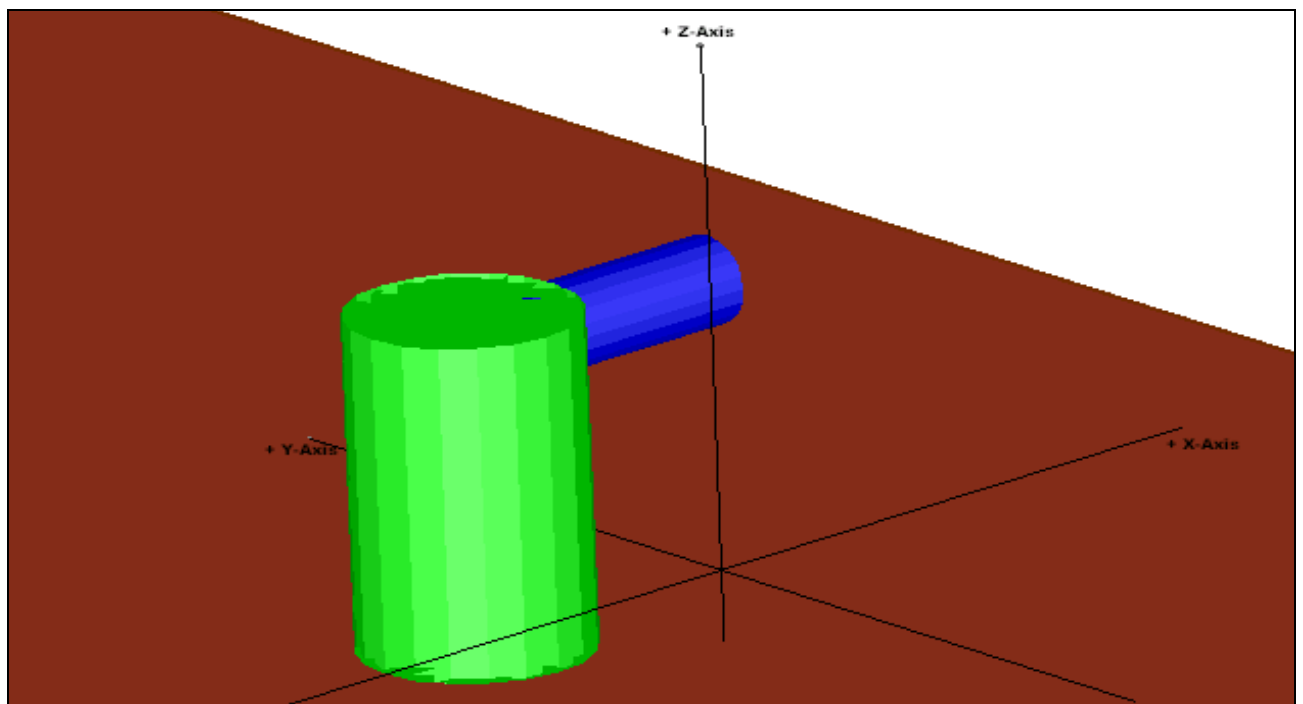


Figure 8: CORMIX visualisation of single port diffuser used in study.



Model Simulations

Details of all CORMIX simulations carried out as part of the preliminary assessment study are described below. Results are presented for both the near-field and far-field mixing regions.

North Outfall Location

In order to identify dilution characteristics and mixing zone extents for the proposed GDD outfall in the northern study area, the CORMIX model was run at 14 different tidal stages for Total Nitrogen on both neap and spring tides, a total of 28 model simulations. The tidal stages simulated and the associated model inputs are listed in Table 1.

Tide	Tide Stage	Discharge			Ambient Water			Outfall	
		Concentration (mg/l)	Flow (m ³ /s)	Density (kg/m ³)	Depth (m)	Speed (m/s)	Density (m ³ /s)	Area (m ²)	Height (m)
Neap	HW	50	4.635	1010	15.832	0.141	1023	0.50	2.00
	HW+1	50	4.635	1010	15.740	0.301	1023	0.50	2.00
	HW+2	50	4.635	1010	15.425	0.309	1023	0.50	2.00
	HW+3	50	4.635	1010	14.984	0.249	1023	0.50	2.00
	HW+4	50	4.635	1010	14.561	0.139	1023	0.50	2.00
	HW+5	50	4.635	1010	14.257	0.064	1023	0.50	2.00
	HW+6	50	4.635	1010	14.140	0.287	1023	0.50	2.00
	LW	50	4.635	1010	14.192	0.265	1023	0.50	2.00
	LW+1	50	4.635	1010	14.371	0.375	1023	0.50	2.00
	LW+2	50	4.635	1010	14.681	0.397	1023	0.50	2.00
	LW+3	50	4.635	1010	15.041	0.311	1023	0.50	2.00
	LW+4	50	4.635	1010	15.435	0.200	1023	0.50	2.00
	LW+5	50	4.635	1010	15.783	0.018	1023	0.50	2.00
	LW+6	50	4.635	1010	15.947	0.140	1023	0.50	2.00
Spring	HW	50	4.635	1010	17.096	0.235	1023	0.50	2.00
	HW+1	50	4.635	1010	16.942	0.432	1023	0.50	2.00
	HW+2	50	4.635	1010	16.345	0.498	1023	0.50	2.00
	HW+3	50	4.635	1010	15.337	0.415	1023	0.50	2.00
	HW+4	50	4.635	1010	14.220	0.059	1023	0.50	2.00
	HW+5	50	4.635	1010	13.320	0.208	1023	0.50	2.00
	HW+6	50	4.635	1010	12.959	0.481	1023	0.50	2.00
	LW	50	4.635	1010	12.966	0.601	1023	0.50	2.00
	LW+1	50	4.635	1010	13.400	0.745	1023	0.50	2.00
	LW+2	50	4.635	1010	14.144	0.658	1023	0.50	2.00
	LW+3	50	4.635	1010	14.988	0.551	1023	0.50	2.00
	LW+4	50	4.635	1010	15.728	0.307	1023	0.50	2.00
	LW+5	50	4.635	1010	16.316	0.117	1023	0.50	2.00
	LW+6	50	4.635	1010	16.644	0.299	1023	0.50	2.00

Table 1: Simulated tidal stages and associated model inputs for north outfall location.



South Outfall Location

In order to identify dilution characteristics and mixing zone extents for the proposed GDD outfall in the southern study area, the CORMIX model was run at 14 different tidal stages for Total Nitrogen on both neap and spring tides, a total of 28 model simulations. The tidal stages simulated and the associated ambient conditions are listed in Table 2.

Tide	Tide Stage	Discharge			Ambient Water			Outfall	
		Concentration (mg/l)	Flow (m ³ /s)	Density (kg/m ³)	Depth (m)	Speed (m/s)	Density (m ³ /s)	Area (m ²)	Height (m)
Neap	HW	50	4.635	1010	23.832	0.186	1023	0.50	2.00
	HW+1	50	4.635	1010	23.740	0.315	1023	0.50	2.00
	HW+2	50	4.635	1010	23.425	0.294	1023	0.50	2.00
	HW+3	50	4.635	1010	22.984	0.267	1023	0.50	2.00
	HW+4	50	4.635	1010	22.561	0.204	1023	0.50	2.00
	HW+5	50	4.635	1010	22.257	0.028	1023	0.50	2.00
	HW+6	50	4.635	1010	22.140	0.257	1023	0.50	2.00
	LW	50	4.635	1010	22.192	0.342	1023	0.50	2.00
	LW+1	50	4.635	1010	22.371	0.337	1023	0.50	2.00
	LW+2	50	4.635	1010	22.681	0.396	1023	0.50	2.00
	LW+3	50	4.635	1010	23.041	0.322	1023	0.50	2.00
	LW+4	50	4.635	1010	23.435	0.199	1023	0.50	2.00
	LW+5	50	4.635	1010	23.783	0.086	1023	0.50	2.00
	LW+6	50	4.635	1010	23.947	0.133	1023	0.50	2.00
Spring	HW	50	4.635	1010	25.096	0.222	1023	0.50	2.00
	HW+1	50	4.635	1010	24.942	0.579	1023	0.50	2.00
	HW+2	50	4.635	1010	24.345	0.709	1023	0.50	2.00
	HW+3	50	4.635	1010	23.337	0.633	1023	0.50	2.00
	HW+4	50	4.635	1010	22.220	0.529	1023	0.50	2.00
	HW+5	50	4.635	1010	21.320	0.182	1023	0.50	2.00
	HW+6	50	4.635	1010	20.959	0.138	1023	0.50	2.00
	LW	50	4.635	1010	20.966	0.337	1023	0.50	2.00
	LW+1	50	4.635	1010	21.400	0.635	1023	0.50	2.00
	LW+2	50	4.635	1010	22.144	0.836	1023	0.50	2.00
	LW+3	50	4.635	1010	22.988	0.708	1023	0.50	2.00
	LW+4	50	4.635	1010	23.728	0.459	1023	0.50	2.00
	LW+5	50	4.635	1010	24.316	0.180	1023	0.50	2.00
	LW+6	50	4.635	1010	24.644	0.185	1023	0.50	2.00

Table 2: Simulated tidal stages and associated model inputs for south outfall location.



Model Results

The CORMIX simulations at each modelled outfall location, at each stage of the tide, produced graphical output of the extent of the discharge plume, the dilution and the concentrations within the plume.

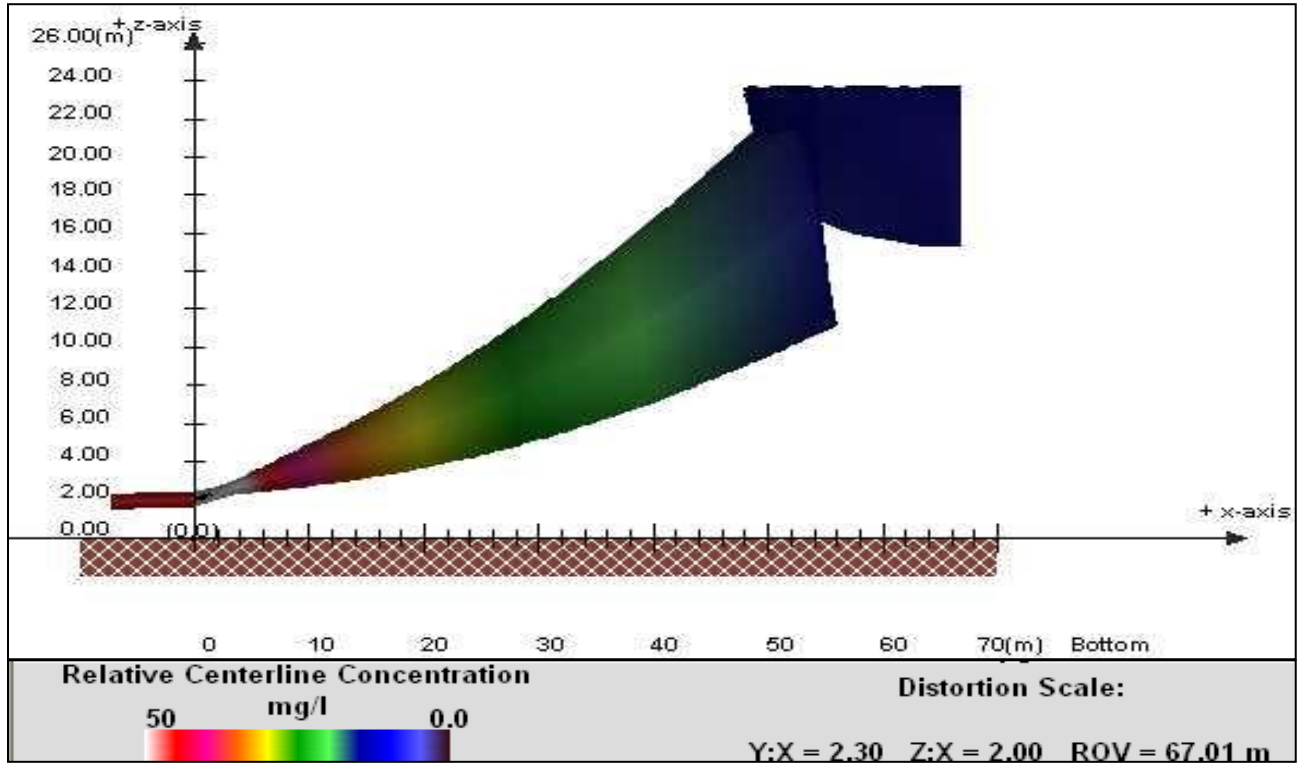
The near-field results indicate initial plume formation and dilution levels within the near-field region. The far-field results allow identification of the mixing zone extents, and predicted the change in parameter concentrations as the effluent is advected from the outfall location.

The near-field is considered as the region of the receiving water where the initial jet characteristic of momentum flux, buoyancy flux and outfall geometry influence the jet trajectory and mixing of an effluent discharge and used in CORMIX for describing the zone of strong initial mixing where outfall design conditions are most likely to have an impact on concentrations.

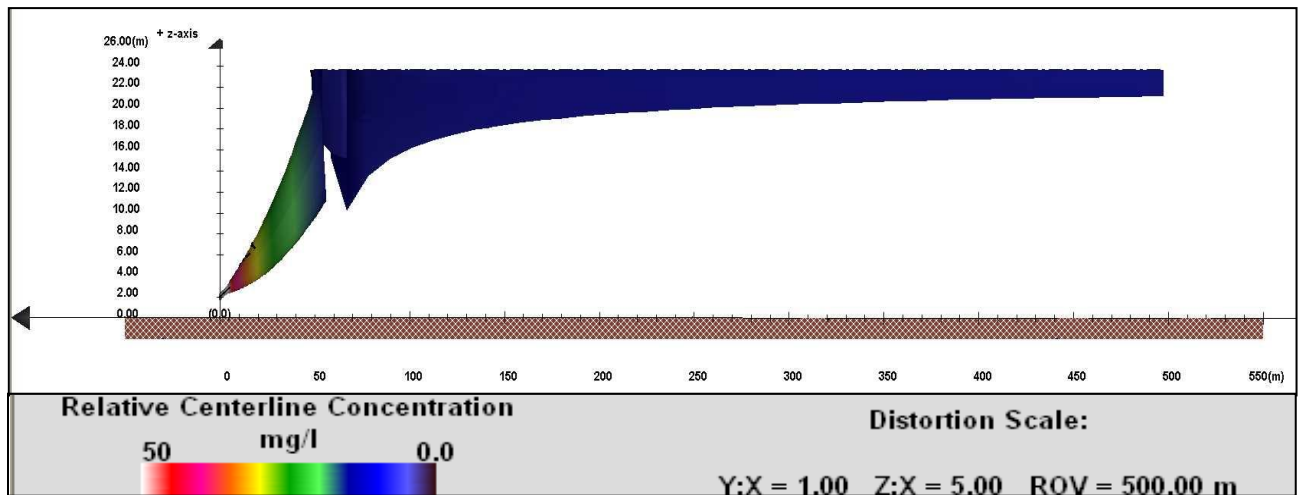
The far-field is considered to be the region of the receiving water where buoyant spreading motions and passive diffusion control the trajectory and dilution of the effluent discharge plume. The physical mixing mechanisms in this region are dominated by the ambient receiving water conditions, particularly ambient current velocity and density differences between the mixed flow and the ambient receiving water.

For this study, the density of effluent discharge was estimated at $1,010 \text{ kg/m}^3$ while that of the receiving seawater was calculated as $1,023 \text{ kg/m}^3$. The discharge was therefore positively buoyant and rose to the sea surface.

This effect is presented graphically in the figures below, by way of explanation. The buoyant nature of the plume is apparent in the effluent plume side elevation in the immediate (near-field) region of the outfall as presented in Figure 9 for HW+1 hour on spring tides at the south outfall location. The ultimate fate of the effluent plume (far-field) over a distance of 500m from the outfall is presented in Figure 10 for the same simulation, showing the effluent dilution over distance within the surface layer(s) of the water column. In both figures, effluent concentrations are presented as 'above ambient'.



**Figure 9: Side elevation of effluent plume in near-field region
HW+1hr on spring tides at south outfall location**



**Figure 10: Side elevation of effluent plume over region of simulation
HW+1hr on spring tides at south outfall location**

On investigation of the presented plume it can be seen that initially both the discharge’s momentum and density is the predominant factor in plume development, with initial jet trajectory remaining horizontal but developing into an upwards trajectory within 10m of the outfall.. As the



jet's momentum begins to dissipate, after approximately 50m, the discharge buoyancy becomes the predominant controlling mechanism and the plume starts to rise to the surface.

The most important predicted results are the dilution levels, and the distances from the outfall at which they were achieved. Comparison of the dilution characteristics allowed quantitative assessment of the north and south outfall locations.

In order to compare the relative merits of the dilution and assimilation capacity of the receiving waters, a metric had to be adopted to quantifiably evaluate both discharge locations. An arbitrary dilution level of 20 dilutions was therefore chosen to evaluate the receiving water's ability to assimilate the proposed effluent discharge. A figure of 20 dilutions represents the reduction in effluent concentration from 50mg/l to 2.5 mg/l.

Figure 11 presents the results of the CORMIX analysis at hourly intervals on neap tides for both the north and south outfall locations. The results are expressed as the predicted extent of the plume to achieve 20 dilutions.

Figure 12 presents the results of the CORMIX analysis on spring tides as the predicted distance to 20 dilutions for both the north and south outfall locations. The results are expressed as the predicted extent of the plume to achieve 20 dilutions.

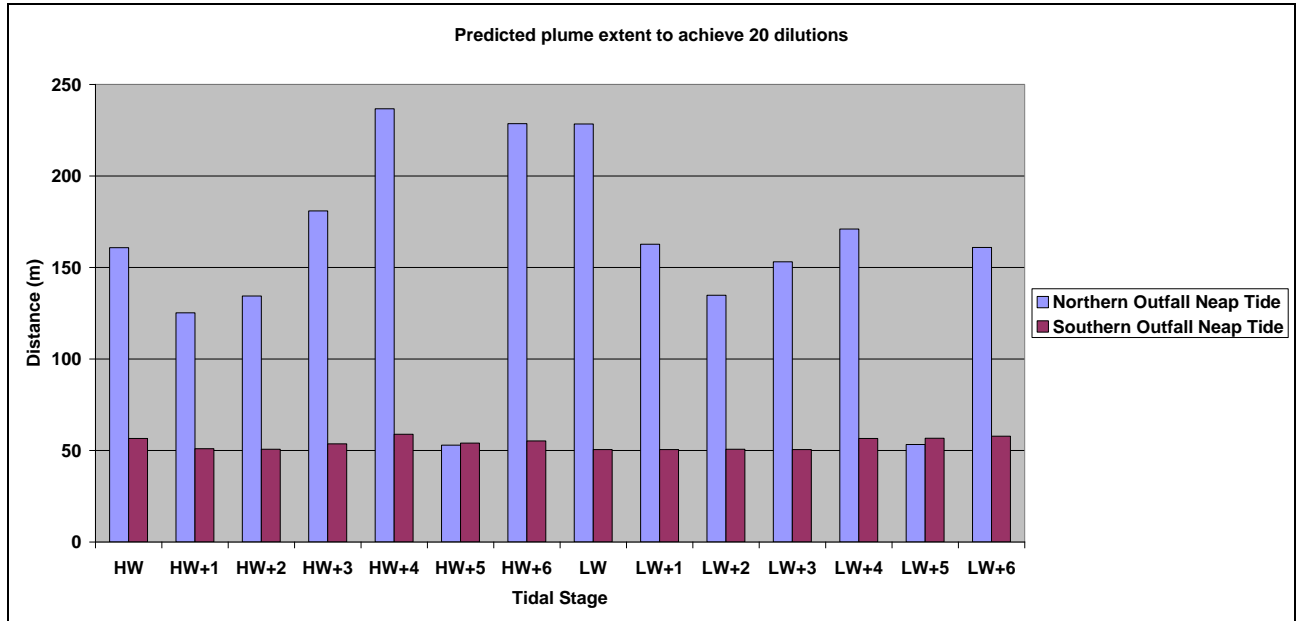


Figure 11: Plume extent to 20 dilutions on neap tide

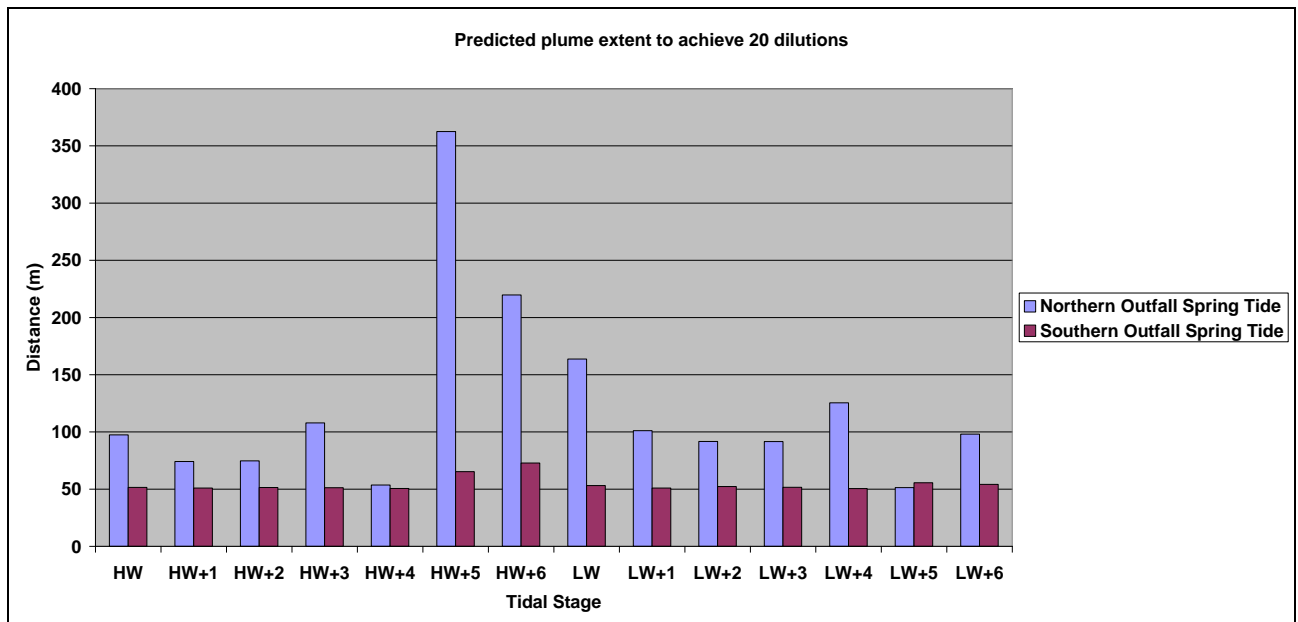


Figure 12: Plume extent to 20 dilutions on spring tide



Both Figure 11 and Figure 12 show that effluent released through the diffuser at the southern outfall location achieves 20 dilutions in a much shorter distance (generally ~50m) than effluent discharged through the same diffuser at the northern outfall location (50m – 350m+).

Additional analysis of the CORMIX model predictions has been completed to determine the effluent concentrations at an arbitrary distance of 500m from both the southern and northern outfall locations.

Figure 12 presents the results of the CORMIX analysis at hourly intervals for neap tides for both the north and south outfall locations. The results are expressed as effluent concentration at a distance of 500m from the outfall.

Figure 14 presents the results of the CORMIX analysis on spring tides as the predicted distance to 20 dilutions for both the north and south outfall locations. The results are expressed as effluent concentration at a distance of 500m from the outfall.

Both Figure 13 and Figure 14 show that the predicted effluent concentrations at 500m from the outfall are much less at the southern outfall location than at the northern outfall location.

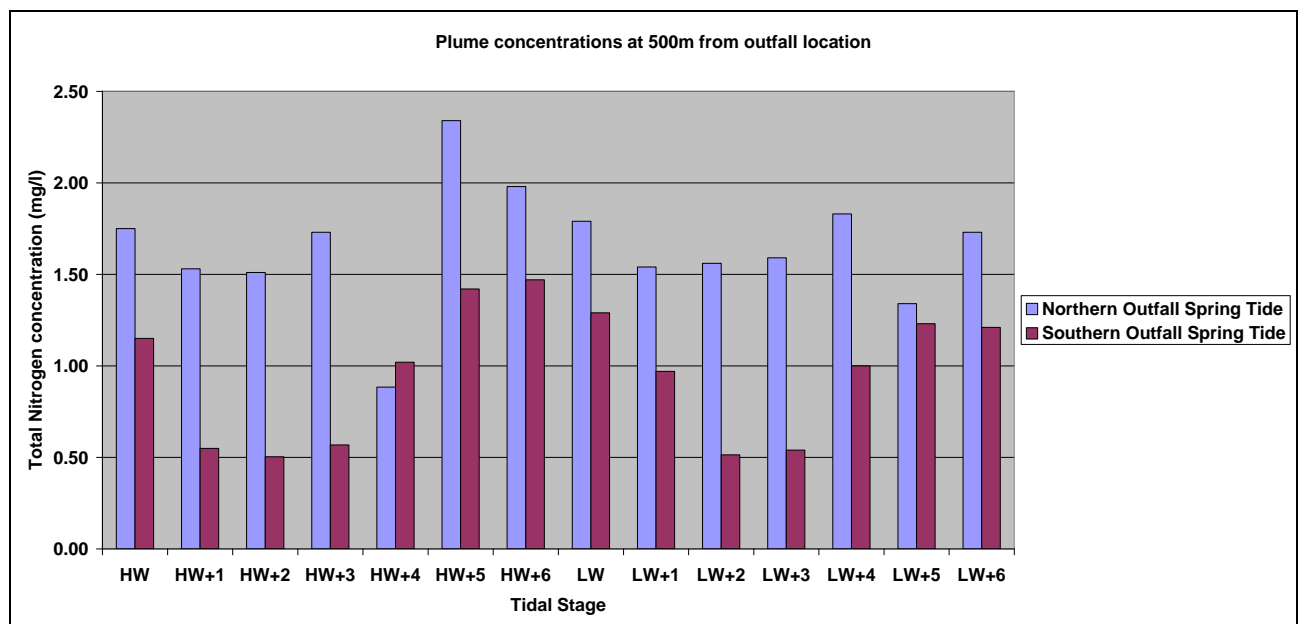


Figure 13: Plume concentrations 500m from outfalls on neap tides

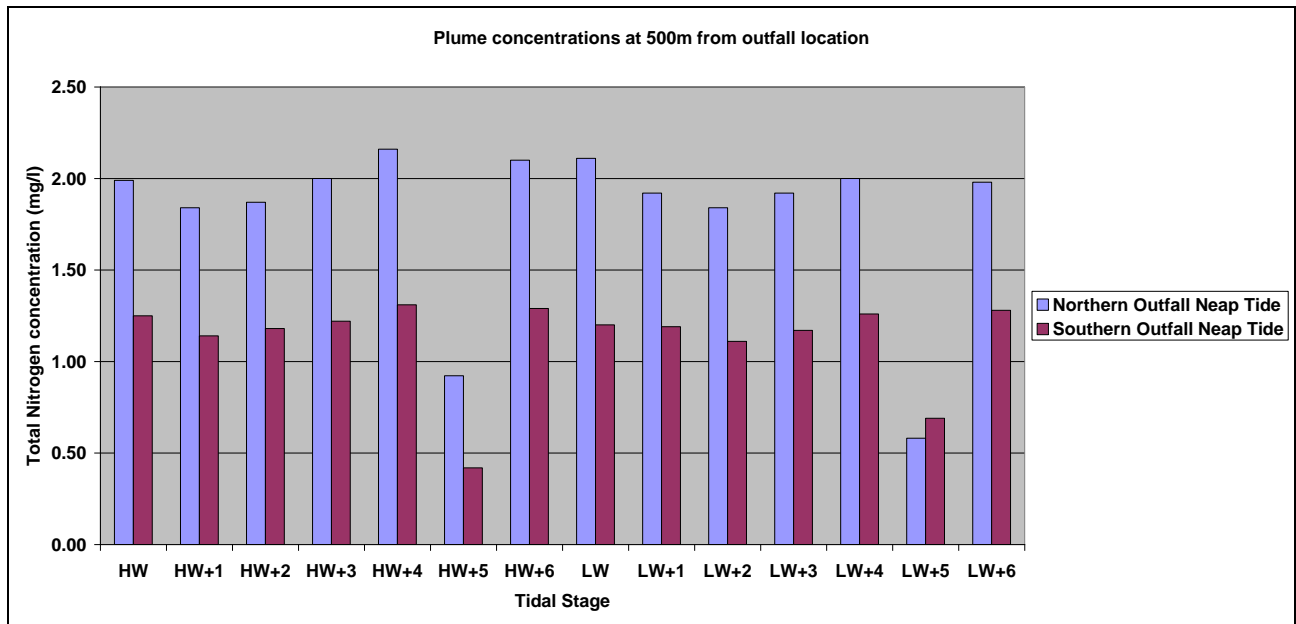


Figure 14: Plume concentrations 500m from outfalls on spring tides

Conclusions

A near-field modelling study has been undertaken to predict and compare the dilution capacity of the receiving water body at two outfall locations off north County Dublin using the CORMIX modelling system.

The modelling study was used to compare the relative merits between two locations off the coast of north County Dublin for a proposed new treated effluent outfall. The metrics used to determine the relative merit of each outfall location were the initial mixing lengths and dilution characteristics.

By adopting a single equal area diffuser port, rather than 4No. orthogonal diffuser ports, the modelling study detailed above considered the worst case scenario.

By adopting the 2040 design peak discharge flow conditions of 4.635 m³/s in combination with an discharge effluent concentrations of 50mg/l Total Nitrogen, the modelling study considered the worst case scenario and results presented herein can be considered as conservative.



The recorded current speeds in the mid water column, extracted from the hydrographic survey undertaken during July and August 2012, used in the model simulations, (presented in Figure 3 and Figure 4) do not show significant differences between the northern and southern modelled outfall locations on neap tides.

The recorded current speeds in the mid water column show that the southern outfall location experiences slightly higher current speeds during spring tides than current speeds recorded at the northern outfall location.

The primary influencing factor in relation to the dilution capacity of the northern and southern outfall locations is the depth from which the outfalls discharge.

The southern outfall location discharges into a mean water depth of 23m, whereas the northern outfall location discharges into a mean water depth of only 15m.

The southern outfall location has a greater depth (and hence volume) of water to facilitate greater initial dilution of effluent discharges than the northern outfall location.

The CORMIX model predictions of plume dilutions and effluent concentrations from this modelling study found that the southern outfall location exhibited better relative initial dilution and mixing characteristics for the effluent plume than the northern outfall location.

This study did not examine the impacts of the proposed discharges on the receiving environment, nor did the modelling study did not account for the ambient water quality of the coastal waters, nor any material entering the coastal waters from other outfalls or rivers discharging to the study area.

The modelling study did not examine the transport and fate of microbial parameters, nor the complex interaction of the various nutrients in the effluent discharging through the outfall.

A full water quality dispersion modelling study will be undertaken in the next phase of the project to quantify the magnitude of impacts on the various sensitive receptors for a range of determinands of concern as part of the GDD Environmental Impact Assessment.

