3.2.4 CHARACTERISTICS OF THE PROPOSAL

3.2.4.1 Introduction

The proposed development includes for the construction of a secondary wastewater treatment plant, which will form an integral part of the Cork Harbour Main Drainage Scheme. The objective of the scheme is to upgrade the existing drainage network to modern standards and to expand the network in order to cater for the future needs of the area.

Currently, the wastewater from the population centres within the Cork Lower Harbour Area (namely Carrigaline, Ringaskiddy/ Shanbally, Cobh, Monkstown/Passage West and Crosshaven) is not treated and is discharged directly to the Lower Harbour. The proposed site is a greenfield site located approximately 11km south of Cork City and 2.24km west south west of Ringaskiddy in the Shanbally area as shown in Figure 2.

The proposed site consists of portions of two large agricultural fields located on sloping ground and currently used for pasture. The land has been zoned for Utilities and Infrastructure (adopted amendment to the Carrigaline Electoral Area *Local Area Plan 2005).* The site has an area of approximately 7.36 hectares and is located between two overhead high voltage power lines to the north and south of the site.

With the exception of a small Bord Gais substation, which adjoins the south-west corner of the site, the site is bordered on all sides by adjoining agricultural fields. The boundaries of the two fields consist primarily of managed, immature to semi-mature hedgerow. A large ESB substation is situated circa 160 metres west of the site and a sports field is located circa 80 metres to the northeast of the site.

According to the adopted amendment to the Carrigaline Electoral Area *Local Area Plan 2005*, the site has been zoned for Utilities and Infrastructure. It is also noted that there are proposals to construct a branch of the National Primary Route N28 to by-pass the villages of Shanbally and Ringaskiddy on lands immediately north of the site. This new route for the upgraded will provide a buffer between the site and industrial lands to the north.

There is an area zoned for residential development approximately 134m east of the proposed WWTP site boundary for which planning applications have been granted. There are no existing site services.

3.2.4.2 Proposal

The proposed development consists principally of the construction of a large sized urban wastewater treatment plant to serve the population centres of Cork Lower Harbour and its' environs. The proposed wastewater treatment plant is an essential element of the Cork Harbour Main Drainage Scheme. Associated works, which will be carried out as part of the proposed development, include:

- The widening of sections of the minor road to the west of the site
- The upgrading of the site access road
- Marine crossing
- New wastewater pumping stations
- The laying of rising mains, surface water sewers and gravity wastewater sewers to direct the wastewater to the new treatment works
- New wastewater treatment works-

The treated wastewater will be discharged to Cork Lower Harbour through the existing IDA outfall.

The overall area of the two fields on which this proposed wastewater treatment plant will be constructed is approximately 17.5 hectares. However, the fields are traversed by overhead high voltage electrical cables. By providing sufficient clearance from these power lines a

suitable area of approx. 7.36 ha is available between the power lines. This area is considered adequate for the construction of the proposed wastewater treatment plant, including facilities for organic-material removal, nutrient removal (if required), basic sludge treatment and appropriate landscaping measures.

The discharge standards, which shall apply to the proposed Wastewater Treatment Plant, are:

Biochemical Oxygen Demand	- 25 mg/litre
Total Suspended Solids	- 35 mg/litre
COD -	- 125 mg/l

The principal elements of a treatment plant of the type and scale proposed include preliminary, primary and secondary treatment of the wastewater stream with further provision for treatment of surplus sludge arising from the primary and biological stages of the treatment process.

The layout of the proposed development is shown in Figure 1.

3.2.5 ENVIRONMENTAL IMPACTS

Ecological impacts can occur by several different means. As construction works will take place near and within the boundary of the Cork Harbour SPA / Owenboy River NHA / Monkstown Creek NHA, there is potential for direct negative impacts on these internationally and nationally important sites to occur during the construction and operation of the proposed scheme. Other designated areas would not be affected due to their distance from the proposed scheme. Construction impacts could occur as a result of impacts on bird feeding areas due to foreshore construction works or the release of suspended solids contaminated runoff / deleterious substances into nearby areas. Indirect impacts as a result of noise, disturbance etc. could also occur during the construction phase. Contamination incidents (i.e. accidental) from the operation of the WWTP could also occur. However, mitigation measures have been provided to ensure that significant impacts on the designated areas and Cork Harbour in general do not occur during either the construction or operation of the proposed scheme. The provision of a modern WWTP in this region is expected to result in moderate significant benefits for water quality in Cork Harbour compared with the "do nothing scenario". A summary of impacts, mitigation measures and predicted impacts is provided in Table 17.

The results of the baseline survey were evaluated to determine the significance of the features located in the study area on an importance scale ranging from:

- International
- National
- County
- High local
- Local importance
- Local value
- Insignificant

Potential impacts during the construction and operation phase of the proposed scheme are discussed below.

3.2.5.1 Types of Impacts

Direct ecological impacts are those that result in physical loss or degradation of a habitat. Indirect or secondary impacts are those, which contribute to the long-term decline in the quality of the habitat. The means of assessing impact significance is based on the Institute of Ecological and Environmental Management draft guidelines on Ecological Assessment (IEEM, 2002). A full explanation of the methods and terminology used is presented in Appendix 1.

Direct Impacts

The proposed development occurs on artificial man made, semi-natural and natural habitats as described above. The footprint of the development will cause a direct impact though the loss of habitat. In the case of the proposed WWTP this will be a permanent impact but will only affect habitats of low conservation importance. In the case of the foreshore and off-road pipeline this would be a temporary impact provided suitable reinstatement measures are employed.

Secondary Impacts

Secondary or indirect impacts are defined as effects that are "*caused by and result from the activity although they are later in time or further removed in distance, but still reasonably foreseeable*". The proposed development could cause secondary ecological impacts. If these impacts significantly altered the type and/or quality of the habitat, then such changes would be effectively additional habitat losses. In the case of the proposed development, potential secondary/indirect impacts would include habitat fragmentation, disturbance and pollution. In

the present assessment these possible impacts have been taken into consideration. Secondary or indirect impact could include noisy construction phase activities disturbing wildlife utilising habitats close to the works areas. In particular, avifauna of conservation interest feeding along the shoreline could be displaced. Increased human activity associated with construction works could also disturb wildlife in adjacent habitats. Soil exposed during trenching works could be washed into nearby aquatic areas, leading to elevated suspended sediment levels. Spills of construction materials, fuels and lubricants could also be washed from the works area to nearby marine areas. An increase in suspended sediments and other pollutants could impact aquatic communities close to the proposed works area. Uncontrolled dumping or stockpiling of materials could disturb habitats adjacent to the proposed works area. Pollution emanating from an accidental release of untreated/partially treatment effluent during the operational phase could also cause an indirect direct impact on the receiving habitats. However the improvement in water quality due to the operation of the proposed WWTP would be an overall positive and permanent indirect impact.

Cumulative impacts

Cumulative impacts are incremental changes in the environment that result from numerous manmade small-scale alterations. Cumulative impacts can result from individually minor but collectively significant effects taking place over a period of time. Potential cumulative impacts resulting from the current development are related to disturbance, habitat loss and pollution. Such potential effects have been considered in the current assessment. The main cumulative impact of the proposed development is however expected to be positive. Combined with the previous phases of the Cork Main Drainage Scheme, and other pollution control measures being implemented in the Cork Harbour region, the current development would have a cumulative effect of improving water quality within Cork Harbour and its associated internationally and nationally important designated areas.

An interesting possible indirect cumulative impact of the proposal would be that by controlling the man-made organic input (i.e. untreated and poorly treated sewage) into the harbour, the nutrients available for macrofaunal production would decline, possibly reducing the biomass of organisms present. This could result in a depressed food supply for wintering birds compared with the existing situation. However, a similar response to cleaner conditions would be an increase in the numbers of macrofaunal species present and this would be an important positive impact for biodiversity. A reason for this increase in diversity is that algal mats would be less frequent and associated anoxic conditions would be deeper than is currently the case. This would influence the macroinvertebrate population by allowing animals to penetrate deeper into sediments – increasing the available habitats three dimensionally. This would also allow for greater biomass and diversity and would be expected to offset any loss of biomass as a result of reduced nutrient inputs. It is also expected that the littoral areas of Cork Harbour would retain a high level of productivity, as is typical in estuarine waters.

3.2.5.1 Construction phase impacts

Designated areas

Potential impacts on Cork Harbour SPA / Owenboy River NHA / Monkstown Creek NHA designated areas would occur as a result of construction activities when the pipes are laid near the designated shoreline areas. Overall, the potential impacts on designated areas during the construction phase are assessed as being Moderate Negative. There will be moderate positive impacts on these areas due to cleaner water during the operational phase.

A foreshore pipeline is proposed to run along a section of the Owenboy River (within the Owenboy River NHA and Cork Harbour SPA). Installation works associated with this pipe could result in significant habitat loss along the pipeline route and increase the risk for suspended solids laden runoff. It is predicted that there will be a short term increase in the turbidity of the water column during the construction and laying of pipes, as increased suspended solids enter the water column. However, this pipeline would be placed along the upper shore, thereby reducing the level of suspended solids (due to decreased flushing from

high tides). An increase in turbidity could result in increased siltation, smothering of organisms and a reduction of light for phytoplankton over the construction period. High levels of suspended solids settling on the estuary bed could potentially alter habitats resulting in a potential loss of feeding and spawning grounds. Mobile species may move away from unfavourable conditions, however sessile, benthic fauna may be smothered and lost. However, estuarine habitats have very high natural levels of suspended solids so this impact is likely to be negligible with suitable mitigation. Moreover, the benthic faunal community in affected areas such as the Owenboy River is considered to be a very tolerant one.

The effects of elevated suspended sediment in marine environments depend primarily on two factors: the size range of the sediment particles, and the food content of the suspended sediment. If the changes to sediment involve particles above the maximum size used by most suspension feeders (about 2mm diameter) then effects will probably be minimal. If the food content in sediment increases, animals may be able to get more nutrition for time spent feeding. If the food content decreases, animals will have to work harder for their food. The more energy they have to spend to gain the same amount/quality of food, the less energy they have for growth and reproduction. As the energy used on feeding increases, the animal loses condition and, finally, dies. A recent study (NIWA Science, 2007) has found adverse effects of increased suspended sediment concentrations on filter feeders. For example, consistently negative effects were found on the growth and condition of mussels and the growth of cockles. Feeding rates of all species initially increased, but as suspended sediment continued to increase, feeding rates decreased. Some of the research also suggested that the response to increases will depend on the reproductive state of the animal and whether they live in areas with frequent high suspended-sediment concentrations.

Other types of animals may also be affected by increased suspended-sediment concentrations. An increased flux of sediment settling on the bed is likely to affect animals that feed on deposited sediment. Lower water clarity may affect the quantity, type and depth to which bottom-living microscopic algae and seaweeds can grow, thus affecting feeding and distributions of grazers such as limpets. Lower water clarity may also affect feeding abilities of visual fish feeders such as mullet. However, it must be noted that no macroinvertebrate grazers were recorded in the Owenboy Estuary in the current survey and the community identified would be very tolerant to increased suspended solids levels. Mullet were recorded in the Owenboy River at Carrigaline and propably occur throughout the estuary, but their ability to relocate with ease would decrease the chances of a decline in their status. Any suspended solids releases during the construction phase of the current project would also be short-term in nature and this would also reduce the potential for significant effects.

Impacts on the shoreline could also reduce the foraging areas for wintering birds and have an impact on the local macrofauna community in these areas. Construction works near the shore area could deter birds from using the affected areas due to physical intrusion and indirect effects such as noise. However these impacts can generally be avoided with careful site management and appropriate timing of the proposed works. The pipeline will also run along the upper shoreline near the existing road. This area is already disturbed and would not be used extensively by birds. With the mitigation measures proposed the lower shore would not be directly or permanently affected. One of the pipelines associated with the scheme will also run along the road bordering the Monkstown Creek NHA (included in Cork Harbour SPA). Noise, disturbance and runoff from these areas could also have significant impacts in the absence of mitigation. However again, the road corridor is already disturbed and all the significant potential impacts can be mitigated.

Chemical contamination could also occur during the construction phase. Such contamination could result from accidental spillages, such as oil and other chemicals through poor operational management, the non-removal of spillages, poor storage, handling and transfer of oil and chemicals. However, if suitable precautions are taken and best practice for the storage, handling and disposal of such material are followed, impacts will be minimal. To prevent chemical pollution, all fuels or chemicals kept on the construction site will be stored in bunded containers. All refuelling and maintenance will be carried out in ramped containment areas away from sensitive environments (i.e. up-gradient of protected habitats or adjacent watercourses). Prior to any construction taking place, local fishing interests should be notified

and in the event of any spillage or accident occurring below the high water mark of ordinary or medium tides, or above the high water mark which may impact on the foreshore during the carrying out of the works, or during operations following the completion of these works, the Irish Coast Guard will be notified immediately by telephone.

Flora and habitats

The route of the proposed sewer network is mainly restricted to the existing road infrastructure. The impacts associated with the laying of the sewer network in these locations will be negligible. This habitat type is of no ecological interest and is isolated from any semi-natural habitats. Therefore, the general potential impact on flora is rated as imperceptible negative as changes brought about by the proposed development would be limited to the immediate areas for which work is proposed.

Improved agricultural grassland habitats will be lost at the site of the proposed WWTP. This habitat is of low conservation importance and its loss would not be of ecological significance. The access road to the site, which is currently the access road to the Bord Gais substation, will be upgraded in order to cater effectively with traffic associated with the proposed development. Stonewall and Hedgerow habitats will be temporarily disturbed during the construction phase of the development at locations where the pipeline passes and/or runs along field boundaries. Stone walls and hedgerows will be re-instated following the installation of the sewer network. Impacts on these habitats would be minor in significance.

The disturbance of improved agricultural grassland, arable and horticultural land, artificial surfaces and drainage ditches (except where these discharge into a designated area) along the pipeline network is of imperceptible negative impact, as these are all modified habitat types. Discharge into a designated area via drainage ditches could potentially occur on the pipeline route located in agricultural land to the south of the Owenboy Estuary NHA.

Disturbance of hedgerows, particularly with mature trees, in the same areas would be of slight to moderate negative significance, where such disturbance results in either direct habitat loss through hedgerow removal, or indirect effects such as dieback through severance or restriction of tree roots. Habitat loss could also occur through dumping of spoil on hedgerow banks.

The laying of the sewers along shoreline habitats would cause disturbance to a number of estuarine habitats. This would be of minor to moderate significance. However, there is considerable scope to mitigate the impacts on these habitats through careful site management and habitat restoration.

Many of the potential impacts on aquatic habitats have already been discussed in relation to designated habitats in Section 3.1.3 above. Potential impacts on the aquatic areas of Cork Harbour would occur as a result of construction activities when the pipes are laid near or within the shoreline areas. Installation works associated with the foreshore pipeline along the Owenboy River could result in significant habitat loss along the pipeline route and increase the risk for suspended solids laden runoff and accidental releases of other deleterious substances (i.e. oils, fuels etc.).

The road network where the proposed pipelines will be installed is mainly older road, which does not have the pollution control of the modern highway systems currently being built in Ireland under the strict NRA environmental guidelines (NRA, 2005) eg. interception of run-off prior to entering the sewer system. Water and other substances which find their way onto these roads would run untreated into the nearest drain/stream or river. Machinery working on the road during the excavation, laying, backfilling and installation of the pipeline has the potential to produce pollutants both directly (i.e. leaking fuels, oils etc.) and indirectly as a result of the construction work (i.e. suspended solids, leached pollutants etc.). During the construction phase, pollutants and chemicals used could contaminate the area. Potential contamination of sediments and marine flora/fauna from the accidental release of organic polymers or heavy metals associated with cementing and/or grouting materials from the foundations may occur. These materials are toxic to marine organisms in sufficient quantities

and in the event of an accidental release; it could potentially contaminate the estuarine sediments adjacent to the development, inhibiting recolonisation of the area after construction. However, with the mitigation measures proposed where restrictions on refuelling and careful management of trench digging and waste management would be implemented, the impacts would be reduced to imperceptible. No sensitive marine flora communities were identified in the study area during the current assessment.

Fauna

Aquatic fauna: Installation of pipelines in off-road, foreshore and in-channel areas could result in significant impacts on birds, mammals and invertebrates and increase the risk for suspended solids laden runoff and accidental releases of other deleterious substances (i.e. oils, fuels etc.). In particular the internationally important bird communities using the site in winter could be affected. These issues have been dealt with above. Careful timing of the works would ensure that impacts on wintering birds are avoided. Impacts of construction on fauna are deemed to be moderate negative, since work along the foreshores could result in noticeable ecological consequences outside the development boundary. The Owenboy Estuary, in particular could potentially be affected as a foreshore pipeline is proposed for a section of the northern shore. Other foreshore areas could also be affected to the same extent by excavations along roads but with less probability.

Excavation of the foreshore areas would result in the disruption of macrofaunal communities in these areas. As detailed above, pollutants and chemicals used could contaminate the area during the construction phase, potentially contaminating the sediments and associated fauna. However the extent of such areas is relatively limited and the extent of areas disturbed will be reduced as far as possible. Reinstatement of habitats along the pipeline footprint would ensure that such impacts were short-term in nature only.

The machinery and noise associated with construction could have a short-term negative impact upon mammals such as otters and perhaps seals using the shoreline. According to David (2006), underwater construction noise can adversely impact on marine mammals such as dolphins and in some circumstances (i.e. underwater pile driving) the noise can be detectable many kilometres from the source through the medium of water. Construction activity will be responsible for an increase in the noise levels in the water near all areas under construction.The single largest marine construction is the installation of the pipeline across the River Lee west passage. However, this will not involve particularly invasive underwater construction works such as blasting so significant impacts on dolphins, porpoises and other marine mammals are not expected. Moreover, this area is already disturbed as a result of the existing ferry at this location.

Sediment plumes may present a small level of habitat disturbance to seals foraging in the River Lee west channel while installing the marine pipeline but is not considered to be significant in the context of areas nearby which will remain unaffected. It is most likely that any effects of the proposed excavation work at the River Lee west channel, on seals will be minimal. As such, these communities would be acclimated to episodic increases in turbidity levels associated with living in estuarine conditions.

Limpets, a keystone species are not present at the proposed crossing and populations to the south are not expected to be affected. It is envisaged that the pipelines in the west channel will be tunnelled or laid by open cut techniques. The open cut technique is considered to have more potential environmental impacts associated with it. With the open cut technique, the pipelines will be laid below the river bed and backfilled to the original river bed profile. It is likely that the pipes will be encased in concrete for protection in shallower sections. The activities associated with the open cut technique would result in the disruption and removal of parts of the mussel beds in the vicinity. However, the impacts on mussels and other fauna would be more than compensated for by the cleaner conditions brought about by the proposed development.

Benthic excavation activity can result in damage to the biological environment but a relatively small area of the River Lee west channel would be disturbed. Temporary anchors may be

installed in the river bed in order to place the pipeline correctly. The disturbed area would be protected so as to reduce potential bed erosion by tidal movements during construction. Since the substrate will not undergo any major changes, no change in the RPD depth, and therefore no consequences for the infauna outside the construction area are envisaged. In addition, the dominant infauna of the mudflats (ragworms) are versatile creatures and could cope with minor environmental changes. With the placement of anchoring devices, flows could be impeded and oxygen availability to fauna nearby reduced but considering the relative size of the proposed devices and flow rates in the channel this is not expected to be a significant impact.

The overall balance between tidal forces and the forces of wave action greatly influences the sedimentary regime in which soft shore organisms live. Should this balance change, or should there be a change in sediment supply, a shore may erode, accrete, or change in sediment composition. For example, silt and mud particles clump together and do not behave as individual particles like sand particles. The result is that they are hard to erode, and high shore mudflats in particular are relatively stable (Little, 2000). Therefore, increased eddies due to obstacles in the west passage during construction are not deemed to be a threat to the adjacent mudflats/shores. In an estuary, particles are far from stable so that while a particular patch of shore may be here today, it may be gone tomorrow (Little, 2000). Where mussels and substrate stabilising seaweeds are absent for the west channel, slight habitat changes probably already occur periodically. However, it can be concluded that due to the adaptability of the organisms present and the flow regimes in the channel, at most minor negative impacts are envisaged from this part of the scheme.

Should the tunnelling option be used, the impacts on the marine ecology will be significantly reduced as there will be no interface between the tunnelling environment and the marine environment other than minimal vibrations. These would not be considered to have a significant impact on the marine ecology.

Terrestrial fauna: Installation of pipelines along the existing road network could also have impacts on the habitats that fauna use due to contaminated runoff and potential damage to the roots of hedgerows and tree lines. Birds nesting in hedgerows could be disturbed and their young left abandoned. However, with the mitigation measures proposed (i.e. timing of hedgerow removal or destruction outside of the bird nesting season) this would not occur.

The machinery and noise associated with construction could have a short-term negative impact upon terrestrial mammals such as badgers Disturbance to the sett (located within 30m of the WWTP site) during construction would be a short-term significant negative impact for the badger social group involved. However, with appropriate mitigation measures this sett could be fully protected during the construction phase of the proposed development.

Site development and boundary treatments could result in the loss of hedgerows within and on the margins of the affected areas. Some of these hedgerows provide corridors for mammals to move through the grassland. Loss of all of these hedgerows would be of imperceptible negative impact in a local context. No known bat roosts would be affected by the proposed development. However, some trees along the pipeline route may be used to some degree by bats. However, with the mitigation measures proposed (i.e. checking any trees to be felled for bats) no direct negative impact on bats would occur, however there will be a negative impact on bats due to loss of habitat.

Water Quality

Installation of pipelines particularly in off-road, foreshore and in-channel areas could result in significant water quality impacts and increase the risk for suspended solids laden runoff and accidental releases of other deleterious substances (i.e. oils, fuels etc.). The potential impact on water quality is rated as moderate negative.

Excavation of the foreshore areas could result in localised pollution, particularly elevation of suspended solids. However the extent of such areas would be relatively limited and the extent

of areas disturbed will be reduced as far as possible. Reinstatement of habitats along the pipeline footprint would ensure that such water quality impacts were short-term in nature only.

The following sources of pollution are included on the Scottish Environmental Protection Agency (SEPA, 1996) list of the main sources of pollution from construction sites:

- The discharge or entry into waters of contaminated site run-off or pumped contaminated surface/ground waters;
- Loss of oil from machinery or storage areas;
- Cement and cement wash from batching plants, storage areas and other areas where cement grout or concrete is being applied;
- Silty water arising from exposed ground, stockpiles of soil, plant and wheel washing, and site roads.

In the absence of suitable mitigation, all the above impacts could occur during the construction of the proposed scheme.

3.2.5.2 Operational phase impacts

Designated areas

Potential exists through the operation of the proposed WWTP that an accidental pollution episode may affect water quality in the receiving water to which the outfall is discharging. However, the risk of such an event occurring is extremely low in a modern well managed plant as is proposed. The large size of Cork Harbour along with tidal currents would mean that the receiving waters would have a high resilience to such unlikely events. The risk of such an event happening with the proposed WWTP scheme would be much lower than is currently the case. The normal operating quality of the proposed discharge into Cork Harbour will be much improved from existing discharges it would replace. This would result in a moderate beneficial impact for Cork Harbour and its associated designated areas.

The scheme has been designed to ensure that minimum maintenance of the collection system will be required. Any such maintenance works would be preceded by further consultation with NPWS where impacts on habitats or species subject to legal protection are predicted to occur.

Flora and habitats

Potential exists through the operation of the proposed WWTP that an accidental pollution episode may affect water quality in the receiving water to which the outfall is discharging. This may result in a significant eutrophication of the water with the occurrence of harmful algal blooms. These harmful algal blooms can cause fish kills, contaminate seafood with toxins, pose a direct risk to human health, or otherwise alter ecosystems in ways that are perceived as harmful. These harmful algal blooms have the potential to contaminate shellfish with biotoxins, which may be released via the foodchain into the surrounding marine habitat.

The potential impact on the receiving waters from emergency overflows from the Carrigaloe, Monkstown and Raffeen pump stations is likely to be more negative than the current situation. Overflow discharges at these pumping stations will include the wastewater from Cobh, and from Passage West in the case of the pumping stations at Monkstown and Raffeen.

However, the risk of such a large scale eutrophication event occurring is extremely low in a modern well managed plant as is proposed. The large size of Cork Harbour along with tidal currents would mean that the receiving waters would have a high resilience to such unlikely events. Nonetheless, the risk of such an event happening with the proposed WWTP scheme would be much lower than is currently the case. The normal operating quality of the proposed discharge into Cork Harbour will be much improved from existing discharges it would replace. This would result in a moderate beneficial impact for Cork Harbour and its associated flora communities. The reduction in nutrient inputs into the harbour during the operational phase of

the scheme would lead to a decrease in algal mats and *Enteromorpha*, plants which thrive on high nutrient loading. This would be a moderate positive impact.

Fauna

Aquatic fauna: The normal operating quality of the proposed discharge into Cork harbour will be much improved from existing discharges it would replace. This would result in a moderate beneficial impact for fish and other aquatic fauna in Cork Harbour. Potential exists through the operation of the proposed WWTP that an accidental pollution episode may affect water quality in the receiving water to which the outfall is discharging. This could also affect fish and other aquatic life in the area surrounding the outfall. The magnitude of the effect would depend on a variety of factors; the components of such a discharge, the dispersion of these components (related to currents) and the length of time between the operation of the proposed development and a pollution episode (diversity of the aquatic community would be expected to increase with time following operation of the proposed development). However, the risk of such an event happening with the proposed WWTP scheme would be much lower than is currently the case and with the proposed effluent discharge standards. The ecosystem around the outfall would continue to change until a sustainable balance would be eventually reached where organisms suited to the new environmental conditions would thrive. The maintenance of this balance would be dependent on a generally unchanging environment such as the one that the proposed discharge would provide. The diversity of organisms would be expected to increase with distance from the proposed outfall.

Current nutrient inputs by foul water outfalls into the affected aquatic areas would be significantly reduced during the operation of the proposed scheme. Such inputs result in increased in primary production and turbidity, indirectly suppressing filter feeder activity. Phytoplankton blooms are expected to be less frequent with the expected reduction in nutrient loading due to the proposed development and restrictions on the edibility of shellfish would ease considerably due to the reduction in associated biotoxins. Water quality around the shorelines within the harbour and along the Owenboy Estuary is expected to improve, encouraging an increase in diversity of infauna (polychaete worms, bivalves, etc.) and epifauna (crabs, crustaceans, snails, etc.). A reason for this increase in diversity is that algal mats would be less frequent and associated anoxic conditions would be deeper than is currently the case. This would influence the macroinvertebrate population by allowing animals to penetrate deeper into sediments - increasing the available habitats three dimensionally. This would also allow for greater biomass and diversity and would be expected to offset any loss of diversity as a result of reduced nutrient inputs. For example, a reduction in ragworm densities would not be a negative impact for feeding birds on mudflats because ragworms would be replaced by other species such as lugworms and catworms.

Improvements in water quality would also be expected to have positive benefits for fisheries. The value of Cork Harbour as nursery for young fish would increase with improved water quality and the consequences of this would extend beyond the mouth of the harbour, with increased recruitment to the open sea. Adult mullet would not be as concentrated around previously present outfalls. However, this is considered to be a neutral impact. The reduction of nutrients into the affected aquatic areas would improve water quality, habitats and diversity, and consequently add to the conservation status of Cork Harbour.

Should untreated sewage be discharged to Cork Harbour or the Owenboy Estuary via pump stations during the operational phase, water quality and associated fauna could be adversely affected by the resulting pollution. Depending on environmental conditions, the organic loading could cause depletion in oxygen levels through increased BOD and deprive macroinvertebrates and fish of oxygen. Fish could migrate to a location where oxygen levels are sufficient for survival. Depending on flushing rates, an accidental release of untreated sewage would also encourage growth of macroalgae such as *Ulva* and *Enteromorpha* and change the RPD depth (anoxic layer depth) of the substrate, with implications for the infauna such as cockles and *Corophium*. However, with the proposed modern development this is unlikely to occur.

The water velocity, and therefore the supply of oxygen to marine fauna is not expected to change as a result of the proposed crossing since the proposed pipeline crossing is to be finished to the same level as the existing bed.

Terrestrial fauna: There is a possibility that the long-term operation of the WWTP could cause further disturbance to local mammal communities such as badgers due to an increase in human activity. However, disturbance is anticipated to be minimal and mammal species using the areas around the WWTP can be expected to continue to do so during the operational phase. Any significant maintenance works on the scheme (including pipeline network) will be preceded by further consultation with NPWS, where impacts on habitats or species subject to legal protection are predicted to occur.

Water quality

Potential exists through the operation of the proposed WWTP that an accidental pollution episode may affect water quality in the receiving water to which the outfall is discharging. This could affect water quality and consequently fish and other aquatic life. However, the risk of such an event happening with the proposed WWTP scheme would be much lower than is currently the case. The consequences of an accidental release are discussed in the previous section.

The normal operating quality of the proposed discharge into Cork harbour will be much improved from existing discharges it would replace. This would result in a moderate beneficial impact for water quality in Cork Harbour. A study, commissioned by Mott MacDonald Pettit, was undertaken in 2007 by J. O' Kane and K. Barry of University College Cork (O' Kane & Barry, 2007). The study aimed to provide a detailed Environmental Impact Assessment of the likely change in water quality in Cork Harbour as a result of the proposed Cork Harbour Main Drainage Scheme. A computer model was devised; covering an area from the Old Head of Kinsale to the Waterworks weir in Cork City. This model was developed to assess the likely relative change in water quality as a result of this proposed scheme. This model simulated the release, transport and decay of various micro-organisms in Cork Harbour and the surrounding area due to discharges of waste. In order to determine the relative improvement in water quality the model was firstly configured to simulate the release of untreated waste from the towns of Cobh, Passage West, Monkstown, Glenbrook, Ringaskiddy, Crosshaven and Carrigaline. It was then used to simulate the release of treated waste from the proposed WWTP at Carrigaline. This study was based upon the projected human population in the harbour area for 2010.

At present the towns of Cobh, Passage West, Monkstown, Glenbrook, Ringaskiddy, Crosshaven and Carrigaline all discharge untreated sewage into Cork Harbour, each associated with concentrations higher than those proposed at the proposed treated effluent outfall (current IDA outfall). The proposed scheme will collect this waste and treat it to a secondary standard at the new WWTP near Carrigaline. The treated effluent will be discharged through the existing Carrigaline/Crosshaven IDA outfall near the mouth of the harbour at Fort Camden. The discharge standards, which shall apply to the proposed wastewater treatment plant are 25 mg/l for Biochemical Oxygen Demand (BOD), 35 mg/l for total suspended solids and 125 mg/l for chemical oxygen demand (COD). With anticipated populations in the future, the projected inputs of the proposed treatment plant would be 10,371m^3 treated per day while currently an estimated 7,515 m^3 raw sewage enters the harbour. These estimates are based on flow rates from the various outfalls (O' Kane and Barry, 2007).

In the O' Kane report, three separate water quality issues which are likely to be affected by the proposed scheme were considered; faecal coliform bacteria, *Norovirus* and simple nitrogen cascade.

- *Faecal coliforms:* Faecal coliforms are bacteria found in the intestinal tracts of humans and most other mammals and are used as an indicator of faecal pollution in water. Elevated levels of faecal coliforms in water can indicate a higher risk of pathogens being present in the water. The number of faecal coliforms per 100ml of

water is a recognised standard in water quality. The mandatory and guide values for faecal coliforms in the Bathing Water Directive are 2000 and 100 counts per 100ml of water respectively. The guideline values for the Shellfish Hygiene Directive are, for faecal coliforms, less than 300 counts per 100ml in the shellfish flesh and inter-valvular liquid. During the operational phase it is estimated that the concentration of faecal coliforms in the Lower Harbour Area (contributed by the WWTP) will be significantly less than the current scenario (untreated dishcarges). The model predicts an 80-95% reduction in the contribution of faecal coliform concentrations to the Lower Harbour Area.

- *Norovirus:* The *Norovirus* or "Winter Vomiting bug" is the primary pathogen in outbreaks of gastroenteritis following consumption of raw oysters. The *Norovirus* was included as part of the study in order to determine the impact of the proposed treatment plant on the oyster farms and water-contact recreational areas in Cork Harbour.

- *Nitrogen Cascade:* The study examined the impact of the proposed scheme on the ecological and biological status of Cork Harbour by using a model containing three species of nitrogen; organic nitrogen, ammonia and nitrate. Changes in the distribution of nitrogen can have an impact on the ecological and biological status of a harbour by the increase or decrease of primary production by phytoplankton and macrophytes. O 'Kane & Barry (2007) quantifies the relative effect of the scheme on the concentration of these three species throughout the harbour and adjacent coast and the relative effect is measured against an unaltered background concentration of each species of nitrogen.

In spite of an increasing human population in the Cork Harbour area, the O'Kane & Barry (2007) study predicted a marked relative improvement in water quality due to the reduction in pollutant load as a result of the proposed treatment plant, and the increased dilution available when the treated effluent is discharged just inside the mouth of the harbour.

The study found that a 95% relative reduction in the maximum number of faecal coliforms may be expected for Lough Mahon, the Inner Harbour, the East and West Passages and the area around the Ringaskiddy ferry terminal, and predicted an 80% relative reduction in the maximum number of faecal coliforms for the outer harbour when the treatment plant is operational. O'Kane & Barry (2007) also showed that the contribution of faecal coliforms from the proposed treatment plant into Cork Harbour would be several orders of magnitude less than the requirements for faecal coliforms under the Shellfish Hygiene and Bathing Water Directives.

The O' Kane & Barry (2007) study also found that the proposed treatment would significantly reduce the number of *Norovirus* in the harbour and the waters outside Roche's Point leading to a relative improvement in water quality. The model showed a 90 – 95% relative reduction in the maximum number of *Norovirus* at the oyster farm in the North Channel after the construction of the proposed treatment plant and a 90% relative reduction for Lough Mahon, the Inner Harbour, the East and West Passages as well as the area around Ringaskiddy while for the rest of the harbour and the area outside Roche's Point an 80% relative reduction may be expected. It is important to state that these percentages are relative to the improvement to be expected from the proposed treatment plant with respect to an unaltered background In the O' Kane report discharges of treated effluent from Carrigrennan, Midleton or Cloyne or the untreated discharges from the outfalls serving the towns on the eastern side of the harbour were not considered Neither was the impact of stormwater overflows considered. The results are therefore not representative of absolute water quality. They simply show the relative improvements in water quality.

Additionally, the study showed that the proposed scheme may reduce considerably the forcing on primary production in Lough Mahon and in the North Channel behind Great Island as a result of decreased levels of organic nitrogen, nitrate and ammonia. The study also predicted a relative decrease in primary production in the outer harbour, with the possible

exception of the immediate vicinity of the diffuser, to be located inside the mouth of the harbour.

3.2.5.3 Do nothing impact

The 'do nothing' impact would result in continued discharging of untreated effluent into Cork Lower Harbour. The provision of a modern WWTP in this region is expected to result in moderate significant benefits for water quality in Cork Harbour compared with the "do nothing scenario".

3.2.5.4 Worst Case Scenario Impact

In the worst-case scenario (i.e. a failure of the mitigation measures proposed) habitat loss, pollution and disturbance of avifauna in NHA/SPA areas could occur. However, such worst-case scenario impacts are considered unlikely and would at worst only a small area of these sites would be affected. During the operational phase a worst case impact would be an accidental release of untreated effluent from the WWTP. This would affect water quality in the receiving water to which the outfall is discharging. However, the risk of such an event occurring is extremely low in a modern well managed plant as is proposed. The large size of Cork Harbour along with tidal currents would mean that the receiving waters would have a high resilience to such unlikely events. It should be noted that the risk of such an event happening with the proposed WWTP scheme would be much lower than is currently the case. Indeed, at present untreated raw sewage is being released into the harbour.

3.2.6 MITIGATION MEASURES

3.2.6.1 Construction Phase Mitigation

Designated Areas

The appointed sub-contractor will prepare detailed method statements prior to initiating construction works. These method statements will outline how the impacts of the proposed works in and near designated areas will be minimised. The method statement will be developed in consultation with NPWS.

The main conservation interest of the affected designated areas (Cork Harbour SPA, Monkstown Creek NHA and Owenboy River NHA) is wintering birds and the habitats which they use. The mitigation response required will include the following:

1. Excavation works and associated machinery on and near the foreshore will take place during August and September only, unless otherwise agreed with the NPWS, DCENR and SWRFB.
2. Minimise habitat disturbance in foreshore areas where possible.
3. Avoid the release of pollutants and sediment into adjoining areas.

The main mitigation measure required to protect the designated areas will therefore be the careful timing of works, the minimising of habitat disturbance and the protection of water quality. These measures are in accordance with the recommendations of the SWRFB (South Western Regional Fisheries Board). Excavation works on and near the foreshore should take place during August and September only. Approval from NPWS, DCENR and SWRFB would be required for work outside this period. Indeed, Birdwatch Ireland recommends that efforts be made to ensure that there is no deterioration in waterbird habitat quality which might be caused by pollution and dredging of the mudflats, and that little disturbance is caused to wintering waterbirds during any construction. Timing of works to this window would ensure that both breeding and wintering birds would be protected thus maintaining the conservation objectives of the designated areas. If works are limited to the line of the pipelines only and the top layer of sediment / substrate is used in the reinstatement works, the foreshore macro fauna community in the disturbed areas would be expected to recover quickly.

To minimise marine habitat, species loss and disturbance, efforts will be made to keep the area of shore disturbed by the pipeline trenches to a minimum. In order to minimise the amount of suspended solids released into the water column during construction, the area of shore disturbed will be minimised. Contractors installing pipelines will use chemicals that have been approved for use in the marine environment and employ methods that reduce the release of polluting materials into the water column. More detailed mitigation measures for suspended solids are given in the fauna section below.

In the event that particularly invasive techniques will be used during construction of the marine crossing the methods and programme of construction activities will be developed in consultation with appropriately qualified and experienced marine ecologists, the NPWS, DCENR and SWRFB. The purpose of this consultation will be to determine specific constraints for specific activities in relation to water quality and marine ecology.

Flora and habitats

As for the designated areas, the area of estuarine habitats disturbed by excavation will be kept as small as possible and employ methods conducive to maintaining good water quality. Prior to construction, the amount of hedgerow that will be required to be removed will be determined so that only the amount of hedgerows which is absolutely necessary to be removed will be impacted upon. Under the Wildlife (Amendment) Act 2000 restrictions are placed on the removal of scrub (on previously uncultivated land), hedges and ditch clearance, with such works prohibited between 1st March and 31st August. The construction schedule will

pay due cognisance to such restrictions, unless authorisation is received from the NPWS for works within this period.

Proposed landscaping works will use native species of local provenance which are commercially available. The details of species to be used in landscaping works will be developed in consultation with an appropriately qualified ecologist.

Fauna

The remedial and reductive measures outlined for designated areas and habitats and flora respectively will also protect fauna in the receiving environment.

The main mitigation measure required to protect fauna will be the careful timing of works, the minimising of habitat disturbance and the protection of water quality. Ideally excavation works on and near the foreshore should take place during August and September only. Approval from NPWS, DCENR and SWRFB would be required for work outside this period. Timing of works to this window would ensure that both breeding and wintering birds would be protected. Works involving the removal of scrub (on previously uncultivated land), hedges and ditch clearance are prohibited between 1st March and 31st August for the protection of nesting birds, unless authorisation is received from the NPWS for works within this period.

The badger sett located near the proposed WWTP will be fenced off and monitored during the construction phase of the project. An appropriately qualified ecologist will be engaged at the pre-construction phase of the project to advice on how to protect this sett. NPWS will be consulted regarding the existence of this sett and mitigation measures proposed. Monitoring of the sett will be in accordance with criteria developed in consultation with the NPWS.

If works are limited to the line of the pipelines only and the top layer of sediment / substrate is used in the reinstatement works, the foreshore macro fauna community in the disturbed areas would be expected to recover quickly.

Should open cut techniques be used for the River Lee west passage marine crossing a construction environmental management plan and monitoring programme will be developed in consultation with an appropriately qualified ecologist, the NPWS, DCENR and SWRFB to monitor water quality.

All stockpiles of soil or fill will be kept 30m from the waters edge and protected by fencing comprised of material known as terram (also known as silt fencing). This fencing will trap any sediment/silt mobilised during periods of high rainfall.

To reduce the impact of pollution and waste from maintenance and boat traffic it is necessary to minimise the likelihood of any spillage or contamination. Potential contaminants will be stored in suitable storage facilities, such as bunded containers. Waste and litter generated during construction will be collected for authorised disposal at suitable facilities. Care and vigilance will be followed to prevent accidental contamination of the site and surrounding environment during construction.

Water quality

The mitigation measures provided above for designated areas, flora and fauna will be employed to mitigate for water quality.

3.2.6.2 Operational Phase Mitigation

Any newly planted hedgerows, lawns and treelines will be monitored and maintained by a horticulturalist or other suitably qualified contractor. This will include plants around the WWTP and those planted in various other areas around adjacent to pipelines. No fertilisers will be used in any habitat pertaining to the proposed development. Litter, grass cuttings and other wastes will be removed from the WWTP site by a suitable contractor.

Monitoring of the badger sett to the east of the WWTP will be in accordance with monitoring guidelines stipulated by the NPWS.

Provision of continuous monitoring and sampling of wastewater flow entering and leaving the site will be provided. This will also include monitoring and measuring of the storm water content. This wastewater monitoring is critical not only in terms of controlling plant operation but also in terms of complying with the Urban Waste Water Regulations 2001 & 2004 amendments.

To comply with the Waste Water Discharge (Authorisation) Regulations of 2007, a Waste Water Discharge licence will be required from the Environmental Protection Agency EPA for the Cork Harbour WWTP. The purpose of the licence is to make provision for the protection of human, animal and plant life from harm and nuisance caused by the discharge of Dangerous Substances to the aquatic environment as well as to ensure compliance with National law.

In order to minimise the risk of untreated effluent discharging from pump stations an automated control operating system should be put in place to ensure that if a downstream pumping station fails to operate, the upstream pumping station will cease pumping.

It is not anticipated that the WWTP will be staffed 24 hrs/day, automatic control of the plant will be undertaken by a computerised control system, with key information and alarms relayed to the relevant Cork County Council office. When the site is unmanned, any critical alarms of the plant will activate an automatic call-out system. It is recommended that the WWTP have a standby generator to ensure operation of the WWTP during any electrical power failure. In such a modern facility, and adhering to the discharge standards proposed, no further mitigation is required.

3.2.7 RESIDUAL IMPACTS

Residual impacts following the implementation of mitigation measures will include the permanent loss of habitat at the WWTP site which is not considered a significant impact. Improvements in water quality will result in long-term moderate positive impacts for marine flora, estuarine birds, marine invertebrates, mammals and fish species. With moderate benefits for biodiversity following the improvement in water quality, the value of the designated areas would be expected to increase in Cork Lower Harbour.

Table 17 Summary of Impacts and mitigation measures for the Cork Harbour Main Drainage Scheme.

	Potential impacts	Mitigation Measures	Predicted impacts
Designated areas	Moderate Negative (C). Moderate Positive (O).	Careful timing of the works (considering birds, fish, rainfall), avoiding releases of pollutants, minimal interference with designated areas and vigilant site management(C) With the modern WWTP and discharge standards proposed, no mitigation further mitigation (O).	Minor Negative (C). Moderate Positive (O).
Flora and habitats	Moderate Negative (C). Moderate Positive (O)	Minimise disturbance, removal of hedgerows restricted to pipeline path and certain times of the year. New plants to be grown will be from a list provided by an ecologist (C). Monitoring of reinstated areas and Owenboy estuarine shore, no use of fertilisers (O).	Minor Negative (C). Imperceptible Negative (O).
Fauna	Moderate Negative (C). Moderate Positive (O).	Careful timing of the works, avoiding releases of pollutants, careful site management, consultation (C). Monitor the badger sett near the proposed WWTP (O).	Minor Negative (C). Moderate Positive (O).
Water quality	Moderate Negative (C). Moderate Positive (O).	Careful timing of the works, avoiding releases of pollutants, careful site management, consultation (C). Provide 2 holding tanks for stormwater, regular servicing of pump stations (O).	Imperceptible Negative (C). Moderate Positive Impact (O).

(c) Construction Phase, (O) Operational Phase.

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Plates A – Terrestrial Areas

Plate A1 Improved agricultural grassland located on the site of the proposed wastewater treatment plant.

Plate A2 Hedgerow habitats located on the north-eastern boundary of the proposed wastewater treatment plant.

Plate A3 Artificial surfaces - the roadway leading into the proposed wastewater treatment plant site.

Plate A4 The R610 regional road linking Monkstown to Passage West. This is an area that would be affected by the proposed on-road pipeline network.

Plate A5 Woodland and shore habitats to the east of Cobh. The proposed pipeline runs along the foreshore in this area.

Plate A6 An area of farmland with arable crops located to the east of the Carrigaline. This area would be affected by a section of off-road pipeline.

Plates B – Littoral and inshore areas

Plate B1 Grab sampling from a boat near the existing IDA outfall pipeline.

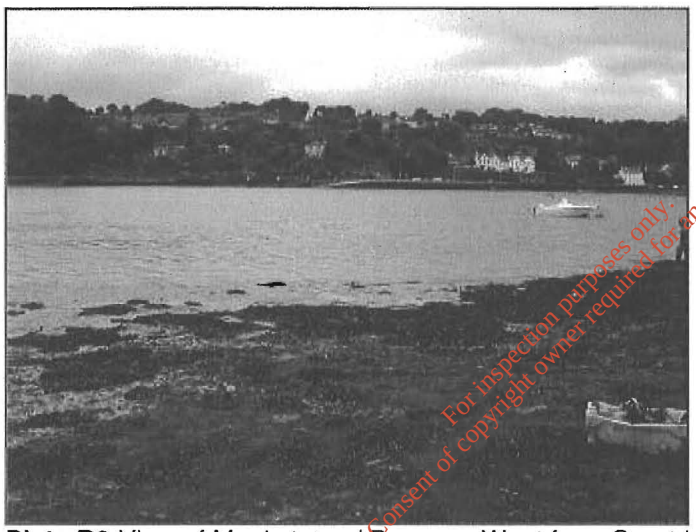

Plate B2 View of Monkstown / Passage-West from Great Island. 'Mixed substrata shore LR4' was the dominant littoral habitat in this area.

Plate B3 Owenboy estuary with the biotope '*Hediste diversicolor* in littoral mud'.

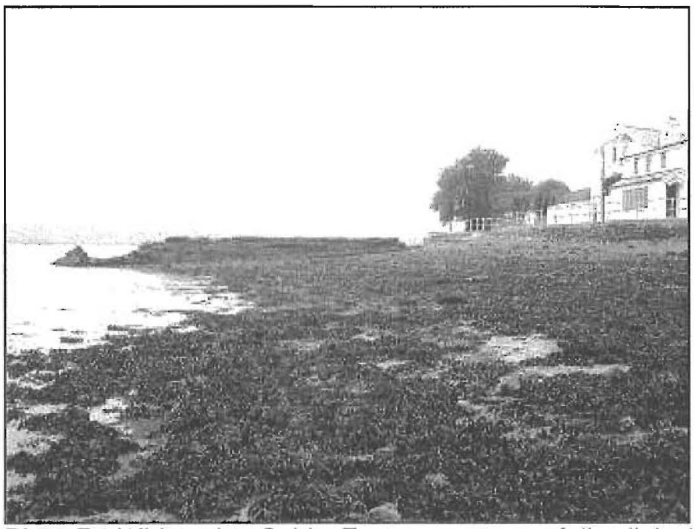

Plate B4 Whitepoint, Cobh. *Fucus serratus* on full salinity lower eulittoral mixed substrata.

Plate B5 View of Cobh and Cork Harbour. The habitat type 'Shingle and gravel shores LS1' was present here.

Plate B6 Shoreline near the existing IDA outfall. This habitat comprises mainly of the habitat type 'Muddy sand shores LS3'.

Appendix 1 Assessment of Impacts and Impact Significance

Criteria for assessing impact type and magnitude are presented in Tables A2.1 and A1.2, respectively.

In assessing the magnitude and significance of impacts it is important to consider the value of the affected feature, this is taken into account in Table A1.2.

Table A1.1. Criteria for assessing impact type

Impact type	Criteria
Positive impact:	A change is likely to improve the ecological feature in terms of its ecological value.
Neutral	No effect.
Negative impact:	The change is likely to adversely affect the ecological value of the feature.

Table A1.2 Criteria for assessing impact magnitude

Impact magnitude	Definition
No change:	No discernible change in the ecology of the affected feature.
Imperceptible Impact:	A change in the ecology of the affected site, the consequences of which are strictly limited to within the development boundaries.
Minor Impact:	A change in the ecology of the affected site which has noticeable ecological consequences outside the development boundary, but these consequences are not considered to significantly affect the distribution or abundance of species or habitats of conservation importance.
Moderate Impact:	A change in the ecology of the affected site which has noticeable ecological consequences outside the development boundary. These consequences are considered to significantly affect the distribution and/or abundance of species or habitats of conservation importance.
Substantial Impact:	A change in the ecology of the affected site which has noticeable ecological consequences outside the development boundary. These consequences are considered to significantly affect species or habitats of high conservation importance and to potentially affect the overall viability of those species or habitats in the wider area.
Major Impact:	A change in the ecology of the affected site which has noticeable ecological consequences outside the development boundary. These consequences are considered to be such that the overall viability of species or habitats of high conservation importance in the wider area[2] is under a very high degree of threat (negative impact) or is likely to increase markedly (positive impact).

Appendix 2 NPWS Site Synopses.

SITE NAME: Great Island Channel
SITE CODE: 001058

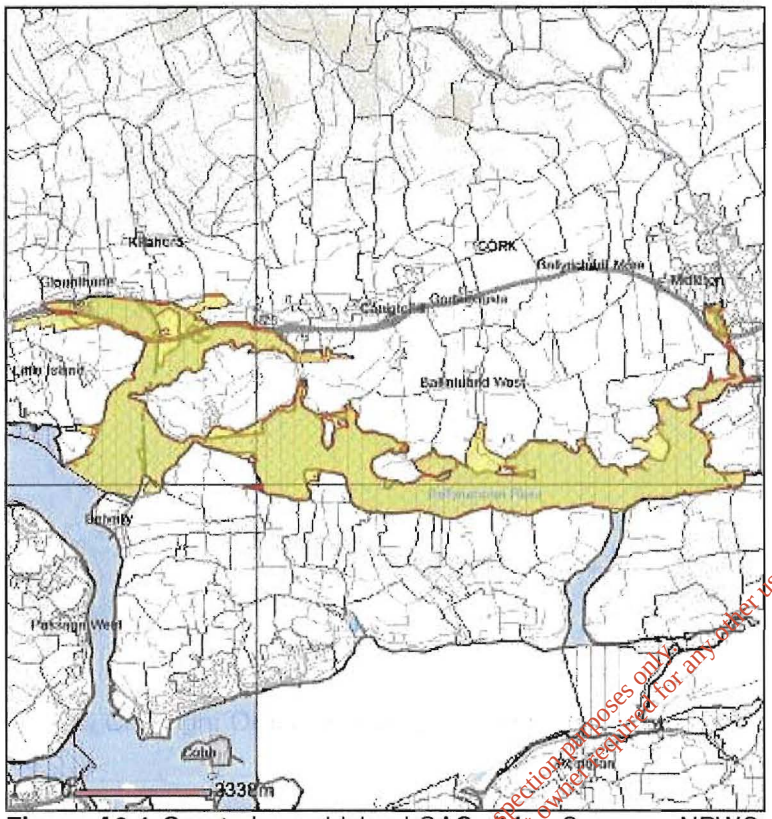

Figure A2.1 Great channel island SAC. (Map Source – NPWS. © Ordnance Survey Ireland. All rights reserved. Licence number Cork County Council CCMA 2004/07).

The Great Island Channel stretches from Little Island to Midleton, with its southern boundary being formed by Great Island. It is an integral part of Cork Harbour which contains several other sites of conservation interest. Geologically, Cork Harbour consists of two large areas of open water in a limestone basin, separated from each other and the open sea by ridges of Old Red Sandstone. Within this system, Great Island Channel forms the eastern stretch of the river basin and, compared to the rest of Cork Harbour, is relatively undisturbed. Within the site is the estuary of the Owennacurra and Dungourney Rivers. These rivers, which flow through Midleton, provide the main source of freshwater to the North Channel. The main habitats of conservation interest are the sheltered tidal sand and mudflats and Atlantic salt meadows, both habitats listed on Annex I of the EU Habitats Directive. Owing to the sheltered conditions, the intertidal flats are composed mainly of soft muds. These muds support a range of macro-invertebrates, notably *Macoma balthica, Scrobicularia plana, Hydrobia ulvae, Nepthys hombergi, Nereis diversicolor* and *Corophium volutator*. Green algal species occur on the flats, especially *Ulva lactua* and *Enteromorpha* spp. Cordgrass (*Spartina* spp.) has colonised the intertidal flats in places, especially at Rossleague and Belvelly. The salt marshes are scattered through the site and are all of the estuarine type on mud substrate. Species present include Sea Purslane (*Halimione portulacoides*), Sea Aster (*Aster tripolium*), Thrift (*Armeria maritima*), Common Saltmarsh-grass (*Puccinellia maritima*), Sea Plantain (*Plantago maritima*), Greater Sea-spurry (*Spergularia media*), Sea Lavender (*Limonium humile*), Sea Arrowgrass (*Triglochin maritimum*), Mayweed (*Matricaria maritima*) and Red Fescue (*Festuca rubra*).

The site is extremely important for wintering waterfowl and is considered to contain three of the top five areas within Cork Harbour, namely North Channel, Harper's Island and Belvelly-Marino Point. Shelduck are the most frequent duck species with 800-1000 birds centred on

the Fota/Marino Point area. There are also large flocks of Teal and Wigeon, especially at the eastern end. Waders occur in the greatest density north of Rosslare, with Dunlin, Godwit, Curlew and Golden Plover the commonest species. A population of about 80 Grey Plover is a notable feature of the area. All the mudflats support feeding birds; the main roost sites are at Weir Island and Brown Island and to the north of Fota at Killacloyne and Harper's Island. Ahanesk supports a roost also but is subject to disturbance. The numbers of Grey Plover and Shelduck, as given above, are of national importance. The site is an integral part of Cork Harbour which is a wetland of international importance for the birds it supports.

Overall, Cork Harbour regularly holds over 20,000 waterfowl and contains internationally important numbers of Black-tailed Godwit (1,181) and Redshank (1,896) along with nationally important numbers of nineteen other species. Furthermore, it contains the large Dunlin (12,019) and Lapwing (12,528) flocks. All counts are average peaks, 1994/95 – 1996/97. Much of the site forms part of Cork Harbour Special Protection Area, an important bird area designated under the EU Birds Directive. While the main land use within the site is aquaculture (Oyster farming), the greatest threats to its conservation significance come from road works, infilling, sewage outflows and possible marina developments. The site is of major importance for the two habitats listed on the EU Habitats Directive that it contains, as well as for its important numbers of wintering waders and wildfowl. It also supports a good invertebrate fauna.

SITE NAME: Cork Harbour SPA
SITE CODE: 004030

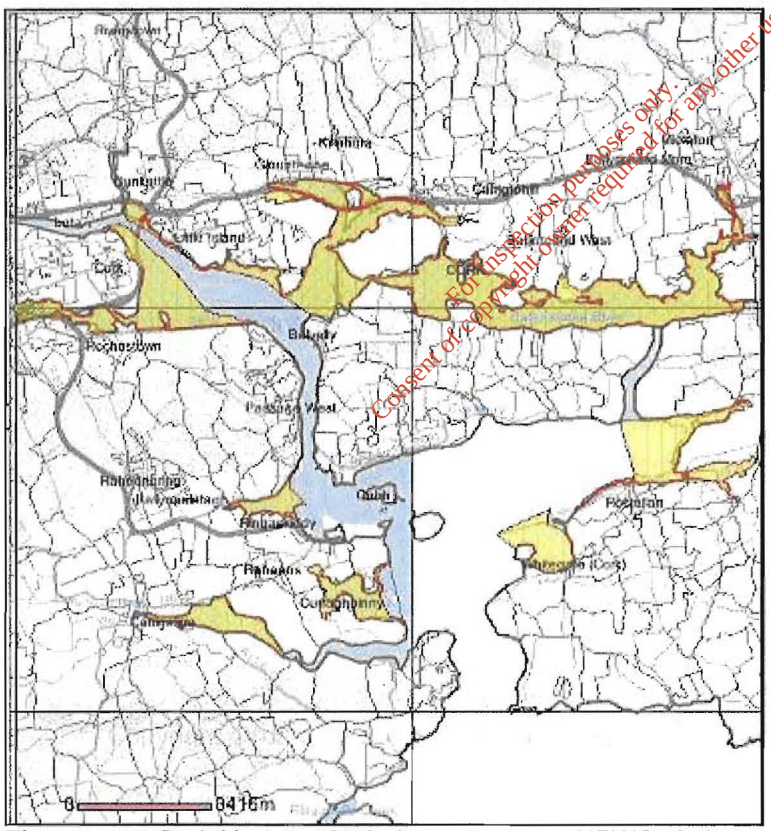

Figure A2.2 Cork Harbour SPA. (Map Source – NPWS. © Ordnance Survey Ireland. All rights reserved. Licence number Cork County Council CCMA 2004/07).

Cork Harbour is a large, sheltered bay system, with several river estuaries – principally those of the Rivers Lee, Douglas and Owenacurra. The SPA site comprises most of the main intertidal areas of Cork Harbour, including all of the North Channel, the Douglas Estuary, inner Lough Mahon, Lough Beg, Whitegate Bay and the Rostellan inlet. Owing to the sheltered conditions, the intertidal flats are often muddy in character. These muds support a range of macro-invertebrates, notably *Macoma balthica*, *Scrobicularia plana*, *Hydrobia ulvae*, *Nepthys hombergi, Nereis diversicolor* and *Corophium volutator.* Green algae species occur

on the flats, especially *Ulva lactua* and *Enteromorpha* spp. Cordgrass (*Spartina* spp.) has colonised the intertidal flats in places, especially where good shelter exists, such as at Rossleague and Belvelly in the North Channel. Salt marshes are scattered through the site and these provide high tide roosts for the birds. Salt marsh species present include Sea Purslane (*Halimione portulacoides*), Sea Aster (*Aster tripolium*), Thrift (*Armeria maritima*), Common Saltmarsh-grass (*Puccinellia maritima*), Sea Plantain (*Plantago maritima*), Laxflowered Sea-lavender (*Limonium humile*) and Sea Arrowgrass (*Triglochin maritima*). Some shallow bay water is included in the site. Cork Harbour is adjacent to a major urban centre and a major industrial centre. Rostellan lake is a small brackish lake that is used by swans throughout the winter. The site also includes some marginal wet grassland areas used by feeding and roosting birds. Cork Harbour is an internationally important wetland site, regularly supporting in excess of 20,000 wintering waterfowl, for which it is amongst the top five sites in the country. The five-year average annual core count for the entire harbour complex was 34,661 for the period 1996/97-2000/01. Of particular note is that the site supports an internationally important population of Redshank (1,614) – all figures given are average winter means for the 5 winters 1995/96-1999/00. A further 15 species have populations of national importance, as follows: Great Crested Grebe (218), Cormorant (620), Shelduck (1,426), Wigeon (1,750), Gadwall (15), Teal (807), Pintail (84), Shoveler (135), Red-breasted Merganser (90), Oystercatcher (791), Lapwing (3,614), Dunlin (4,936), Black-tailed Godwit (412), Curlew (1,345) and Greenshank (36). The Shelduck population is the largest in the country (9.6% of national total), while those of Shoveler (4.5% of total) and Pintail (4.2% of total) are also very substantial.

The site has regionally or locally important populations of a range of other species, including Whooper Swan (10), Pochard (145), Golden Plover (805), Grey Plover (66) and Turnstone (99). Other species using the site include Bat-tailed Godwit (45), Mallard (456), Tufted Duck (97), Goldeneye (15), Coot (77), Mute Swan (39), Ringed Plover (51), Knot (31), Little Grebe (68) and Grey Heron (47). Cork Harbour is an important site for gulls in winter and autumn, especially Common Gull (2,630) and Lesser Black-backed Gull (261); Black-headed Gull (948) also occurs. A range of passage waders occur regularly in autumn, including Ruff (5-10), Spotted Redshank (1-5) and Green Sandpiper (1-5). Numbers vary between years and usually a few of each of these species over-winter. The wintering birds in Cork Harbour have been monitored since the 1970s and are counted annually as part of the I-WeBS scheme.

Cork Harbour has a nationally important breeding colony of Common Tern (3-year mean of 69 pairs for the period 1998-2000, with a maximum of 102 pairs in 1995). The birds have nested in Cork Harbour since about 1970, and since 1983 on various artificial structures, notably derelict steel barges and the roof of a Martello Tower. The birds are monitored annually and the chicks are ringed. Extensive areas of estuarine habitat have been reclaimed since about the 1950s for industrial, port-related and road projects, and further reclamation remains a threat.

As Cork Harbour is adjacent to a major urban centre and a major industrial centre, water quality is variable, with the estuary of the River Lee and parts of the Inner Harbour being somewhat eutrophic. However, the polluted conditions may not be having significant impacts on the bird populations. Oil pollution from shipping in Cork Harbour is a general threat. Recreational activities are high in some areas of the harbour, including jet skiing which causes disturbance to roosting birds.

Cork Harbour is of major ornithological significance, being of international importance both for the total numbers of wintering birds (i.e. > 20,000) and also for its population of Redshank. In addition, there are at least 15 wintering species that have populations of national importance, as well as a nationally important breeding colony of Common Tern. Several of the species which occur regularly are listed on Annex I of the E.U. Birds Directive, i.e. Whooper Swan, Golden Plover, Bar-tailed Godwit, Ruff and Common Tern. The site provides both feeding and roosting sites for the various bird species that use it.

SITE NAME: Monkstown creek NHA
SITE CODE: 001979

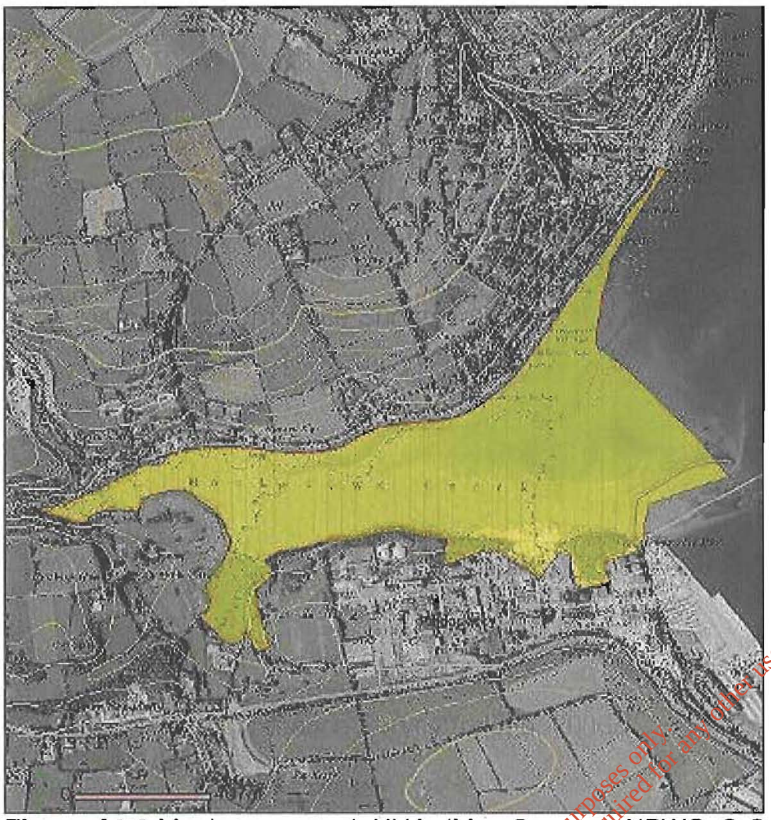

Figure A2.3 Monkstown creek NHA. (Map Source – NPWS. © Ordnance Survey Ireland. All rights reserved. Licence number Cork County Council CCMA 2004/07).

Monkstown Creek is situated between Monkstown and the major seaport of Ringaskiddy on the western shores of Cork Harbour. Geologically, Cork Harbour consists of two large areas of open water in a limestone basin, separated from each other and the sea by ridges of old red sandstone. Within this system, Monkstown Creek is a tidal inlet composed of mudflats, with limestone along the southern shore. A brackish lake also occurs, separated from the sea by a sluice gate.

The mudflats and tidal creeks are fringed by a small amount of saltmarsh vegetation while, above the limestone on the southern shore, two areas of semi-natural woodland occur. The latter contain Spindle (*Euonymus europaeus*) and a thick carpet of Bluebell (*Hyacintnoides non-scripta*) and Ramsons (*Allium ursinum*).

The marsh interest of the site is ornithological, with the mudflats acting as winter refuge to at least locally important numbers of waterfowl, including Shelduck, Teal, Redshank and Dunlin. However, Cormorant may reach nationally important numbers with the jetty supporting a Cormorant roost of over 100 birds, in addition to a second roost in the woods (NHA survey, 1994).

The predominant land use is as a safe mooring for small craft; however major industry and a golf course adjoin the site. The main potential threat is water pollution.

The area is of value beacuse its mudflats provide an important feeding area for waterfowl and it is a natural part of Cork Harbour which, as a complete unit, is of international importance for waterfowl.

SITE NAME: Owenboy River NHA
SITE CODE: 001990

Cork Harbour consists of a central basin with a number of narrow estuaries running E-W in line with the ridge structure of this part of Ireland. The Owenboy River is the most southerly of these bays on the western side and runs from Carrigaline to Crosshaven. It consists of two expanded sections with extensive mudflats at low tide, separated by a much narrower channel. Only the upper part is included in the NHA because it is here that the great majority of birds congregate in winter.

The wildfowl and waders of the whole harbour are usually taken as a single population as they move from site to site depending on tidal and feeding conditions. Many species occur in numbers of international importance within the overall total of 42,000 waterfowl. Some species frequent the Owenboy more than others and Dunlin, Redshank and Curlew are the most numerous birds. A roost of up to 2,000 of these waders uses fields near Rabbit Point at high tide.

There are few other habitats of interest around the estuary. The southern shore is taken up by the Crosshaven road, backed by planted woodland while on the opposite side there are fields of pasture and sections of artificial shore created by dumping. A small section of saltmarsh however occurs east of Morgan's Quay and contains a series of brackish and freshwater communities in microcosm.

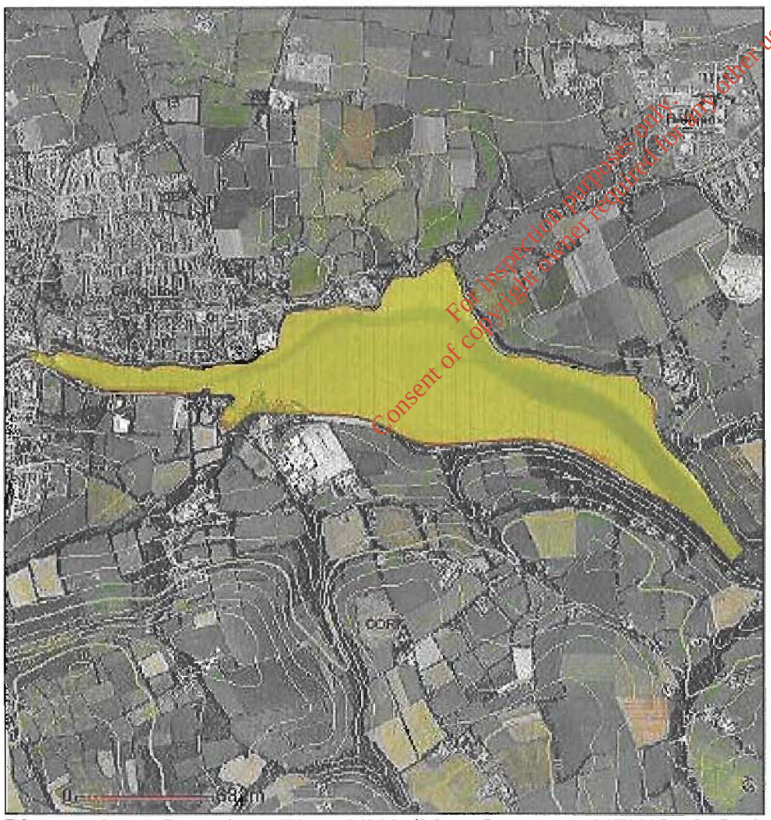

Figure A2.4 Owenboy River NHA (Map Source – NPWS. © Ordnance Survey Ireland. All rights reserved. Licence number Cork County Council CCMA 2004/07).

Appendix 3 Plant species list of different habitats.

Common name	Scientific Name	GA1	WD1	WL1	BL3	GS2	CC1	LS1	BL1	BC1	WL2	GS4)	WS3
Alder	*Alnus glutinosa*		✓	✓							✓		
Annual meadow-grass	*Poa annua*	✓		✓		✓						✓	
Ash	*Fraxinus excelsior*		✓	✓							✓		
Ash seedlings	*Fraxinus excelsior*		✓			✓							
Barley	*Hordeum vulgare*									✓			
Bent	Agrostis spp	✓	✓	✓									
Bird's foot trefoil	*Lotus corniculatus*			✓		✓							
Black knapweed	*Centaurea nigra*			✓		✓							
Blackthorn	*Prunus spinosa*		✓	✓									
Bladder wrack	*Fucus vesiculosus*							✓					
Bluebell	*Hyacinthoides non-scripta*		✓										
Bramble	*Rubus fruiticosus agg.*	✓	✓	✓		✓							
Broad-leaved dock	*Rumex obtusifolius*	✓											
Broad-leaved willowherb	*Epilobium montanum*												
Brookweed	*Samolus valerandi*											✓	
Bugle	*Ajuga reptans*		✓										
Bulrush	*Typha latifolia*												
Bush vetch	*Viccia cracca*	✓	✓	✓									
Butterfly bush	*Buddleja davidii*												✓
Celandine	*Ranunculus ficaria*		✓			✓							
Chickweed	*Stellaria media*									✓			
Cleavers	*Galium aparine*	✓	✓	✓		✓							
Cock's-foot	*Dactylis glomerata*	✓		✓		✓						✓	
Coltsfoot	*Tussilago farfara*												
Common field Speedwell	*Veronica persica*	✓	✓	✓		✓							
Common mouse-ear	*Cerastium fontanum*	✓				✓						✓	
Common Ragwort	*Senecio jacobaea*	✓		✓	✓	✓							
Common reed	*Phragmites australis*												
Creeping Bent	Agrostis stolonifera	✓		✓		✓						✓	
Creeping Buttercup	*Ranunculus repens*	✓		✓		✓							
Creeping thistle	*Cirsium arvense*	✓		✓		✓						✓	
Curled dock	*Rumex crispus*	✓				✓						✓	
Daisy	*Bellis perennis*	✓	✓	✓	✓	✓							
Dandelion	*Taraxacum officinale*	✓		✓	✓	✓							
Distant sedge	*Carex distans*												
Dock	*Rumex* spp.	✓	✓			✓							
Downy birch	*Betula pubescens*		✓	✓									

Common name	Scientific Name	GA1	WD1	WL1	BL3	GS2	CC1	LS1	BL1	BC1	WL2	GS4)	WS3
Eared willow	*Salix aurita*			✓									
Enchanter's nightshade	*Circaea lutetiana*		✓										
Escalonia	*Escalonia spp*												✓
False fox sedge	*Carex otrubae*											✓	
False oat-grass	*Arrhenatherum elatius*	✓											
Ferns	*Asplenium spp*		✓	✓		✓							
Field horsetail	*Equisetum arvense*					✓							
Foxglove	*Digitalis purpurea*					✓							
Fuschia	*Fuschia magellanica*			✓									✓
Glaucous sedge	*Carex flacca*											✓	
Goat willow	*Salix caprea*			✓									
Gorse	*Ulex europaeus*			✓									
Great willowherb	*Epilobium hirsutum*			✓		✓			✓				
Great wood-rush	*Luzula sylvatica*		✓										
Greater plantain	*Plantago major*	✓				✓							
Grey willow	*Salix cinerea*			✓									
Griselinia	*Griselinia* spp												✓
Ground ivy	*Glechoma hederacea*		✓										
Hairy bittercress	*Cardamine hirsuta*	✓	✓										
Hairy brome	*Bromopsis ramosa*			✓		✓							
Hard rush	*Juncus inflexus*		✓										
Hawkweed	*Hieracium* agg.					✓							
Hawthorn	*Cratageous monogyna*					✓							
Hazel	*Corylus avellanna*		✓	✓							✓		
Hedge bindweed	*Calystegia sepium*		✓	✓					✓				
Hedge woundwort	*Stachys sylvatica*			✓		✓							
Herb robert Geranium robertanium	*Geranium robertanium*	✓	✓	✓		✓			✓				
Hogweed	*Heracleum sphondylium*	✓		✓									
Holly	*Ilex aquifolium*		✓	✓									
Honeysuckle	*Lonicera periclymenum*		✓	✓									
Horse chestnut	*Aesculus hippocastanum*		✓								✓		
Ivy	*Hedera helix*		✓	✓		✓							
Juniper	*Juniperus communis*												✓
Knotgrass	*Polygonum aviculare*			✓									
Knotted wrack	*Ascophyllum nodosum*							✓					
Lawson's cypress	*Chamaecyparis lawsoniana.*												✓
Lesser spearwort	*Ranunculus flammula*											✓	
Meadowsweet	*Filipendula ulmaria*											✓	
Navelwort	*Umbilicus rupestris*								✓				

Common name	Scientific Name	GA1	WD1	WL1	BL3	GS2	CC1	LS1	BL1	BC1	WL2	GS4)	WS3
Nettle	*Urtica dioica*	✓	✓	✓	✓	✓						✓	
Oats	*Avena Sativa*									✓			
Parsley water dropwort	*Oenanthe lachenalii*												
Perennial Rye-grass	*Lolium perenne*	✓				✓							
Perennial sow-thistle	*Sonchus arvensis*												
Plicate sweet-grass	*Glyceria notata*												
Polypody fern	*Polypodium* sp.						✓		✓				
Poplar	*Populus spp*										✓		
Portugal laurel	*Prunus lusitanica*												✓
Potatoe	*Solanum tuberosum*									✓			
Prickly sow-thistle	*Sonchus asper*												
Primrose	*Primula vulgaris*		✓			✓							
Purple loosestrife	*Lythrum salicaria*			✓									
Red clover	*Trifloium pratense*	✓			✓	✓							
Red fescue	*Festuca rubra*	✓				✓			✓			✓	
Redshank	*Persicaria maculosa*												
Red valerian	*Centranthus ruber*								✓				
Remote sedge	*Carex remota*											✓	
Rhubarb	*Rheum rhabarbarum*												
Ribwort Plantain	*Plantago lanceolata*	✓	✓			✓							
Scarlet pimpernel	*Anagallis arvensis*												
Scots pine	*Pinus sylvestris*		✓								✓		
Self-heal	*Prunella vulgaris*		✓	✓		✓							
Sessile oak	*Quercus petraea*		✓										
Sharp-flowered rush	*Juncus acutiflorus*												
Sheep's fescue	*Festuca ovina*	✓											
Silverweed	*Potentilla anserina*	✓		✓		✓						✓	
Sitka spruce	*Picea sitchensis*		✓										
Snowberry	*Symphoricarpos albus*												✓
Soft rush	*Juncus effussus*											✓	
Soft shield-fern	*Polystichum setiferum*		✓										
Spear thistle	*Cirsium vulgare*	✓				✓							
Square-stalkedSt. John's wort	*Hypericum tetrapterum*												
Sycamore	*Acer pseudoplatanus*		✓	✓							✓		
Tufted vetch	*Vicia cracca*	✓	✓			✓							
Velvet bent	*Agrostis canina*	✓				✓							
Water mint	*Mentha aquatica*											✓	
Wheat	*Triticum sativum*									✓			
White clover	*Trifolium repens*					✓						✓	
Wild strawberry	*Fragaria vesca*		✓										
Wood dock	*Rumex sanguineus*		✓										

Common name	Scientific Name	GA1	WD1	WL1	BL3	GS2	CC1	LS1	BL1	BC1	WL2	GS4)	WS3
Wood sedge	*Carex sylvatica*		✓										
Wood sorrel	*Oxalis acetosella*		✓										
Yellow pimpernel	*Lysimachia nemorum*			✓		✓							
Yorkshire fog	*Holchus lanatus*	✓				✓							

Improved Agricultural Grassland GA1
Mixed broadleaved Woodland WD1
Hedgerows WL1
Buildings and artificial surfaces BL3
Grassy verges GS2
Sea walls, piers and jetties CC1
Shingle and gravel shores LS1
Stones walls BL1
Arable crops BC1
Treelines WL2
Wet grassland GS4
Ornamental/ non native shrub WS3

Appendix 4 Bird counts from Cork Harbour

Table A4.1 Total numbers of waterfowl recorded at Cork Habour during the IWeBS surveys of 1999-2000, 2000-2001, 2001-2002, 2002-2003, 2003-2004 and 2004-2005 (Boland & Crowe, 2006).

Year	Numbers
1999 to 2000	30,339
2000 to 2001	28,686
2001 to 2002	26,476
2002 to 2003	29,551
2003 to 2004	30,368
2004 to 2005	31,198
Mean	**29,398**

Table A4.2 Five year mean counts (1998-99 to 2002-03, extracted from Gittings, 2006) and maximum counts for species which are recorded in Cork Harbour. Internationally important species are shown in bold. Nationally important species are shown in italics.

Species	Mean	Max
Dunlin	*6160*	*8847*
Lapwing	*4615*	*7267*
Golden Plover	*4318*	*6888*
Black-tailed Godwit	**2232**	**3162**
Curlew	*1919*	*2927*
Redshank	**1765**	**2269**
Wigeon	*1561*	*1931*
Shelduck	*1496*	*1903*
Oystercatcher	*1467*	*1698*
Teal	*1184*	*1492*
Mallard	*505*	*671*
Cormorant	*360*	*556*
Bar-tailed Godwit	*263*	*477*
Great Crested Grebe	*216*	*287*
Turnstone	*123*	*166*
Knot	100	306
Shoveler	*95*	*148*
Red-breasted Merganser	*95*	*128*
Grey Heron	80	114
Little Grebe	*57*	*60*
Ringed plover	57	78
Pintail	*51*	*74*
Grey Plover	*47*	*108*
Greenshank	*45*	*61*
Coot	39	96
Mute swan	34	46
Little Egret	*33*	*61*
Tufted duck	33	46
Pochard	23	38
Moorhen	23	28
Goldeneye	18	28
Great Northern Diver	3	8

Appendix 5 Protected mammal species

Table A.5.1 Protected mammal species recorded from the 40km square within which the proposed development site is located, comprising OS W66, W67, W76, W77, W86, W87, W96, W97. Based on Hayden and Harrington (2000).

Species	Indication of population	Level of Protection
Badger	Found throughout Ireland	Wildlife Act, though exceptions are written into the Act for road building. Appendix III Bern Convention
Daubenton's bat	Distributed widely through Ireland	Irish Red Data Book 'Internationally important', Annex IV of the EU Habitats Directive and Appendix II of the Bern Convention.
Common pipistrelle	Found throughout Ireland	Irish Red Data Book 'Internationally important', Annex IV of the EU Habitats Directive and Appendix II if the Bern Convention.
Soprano pipistrelle	Found throughout Ireland	Irish Red Data Book 'Internationally important', Annex IV of the EU Habitats Directive and Appendix II if the Bern Convention.
Whiskered Bat	Distributed widely through Ireland	Annex IV of the EU Habitats Directive and Appendix II of the Bern Convention.
Natterer's Bat	Distributed widely through Ireland	Annex IV of the EU Habitats Directive and Appendix II of the Bern Convention.
Leisler's Bat	Distributed widely through Ireland	Annex IV of the EU Habitats Directive and Appendix II of the Bern Convention.
Brown Long Eared Bat	Distributed widely through Ireland	Annex IV of the EU Habitats Directive and Appendix II of the Bern Convention.
Hedgehog	Found throughout Ireland	Appendix III of the Bern Convention.
Irish stoat	Found throughout Ireland	Appendix III of the Bern Convention.
Pygmy shrew	Found throughout Ireland	Appendix III of the Bern Convention.
Otter	Found throughout Ireland	Annexe II and IV of Habitats Directive Appendix III of the Bern Convention.
Irish (mountain) hare	Found throughout Ireland	Irish Red Data Book 'Internationally important'. Annex V of the Habitats Directive. Appendix III Bern Convention.
Red squirrel	Distributed widely through Ireland	Protected under the Wildlife Act; classified as near threatened in a global context in the 2000 IUCN Red List of Threatened Species.
Fallow deer	Distributed widely through Ireland	Wildlife Act, 1976.
Common dolphin	Distributed widely around Ireland, particularly around the south and west coasts.	Annex IV of the EU Habitats Directive. Whale Fisheries Act, 1937.

Species	Indication of population	Level of Protection
Common porpoise	Widespread in Irish sea. Typically inshore animals. Populations of major significance found off the W. Coast.	Annex II of the EU Habitats Directive. Whale Fisheries Act, 1937.
Long finned pilot whale	Main concentrations seen off west coast. Occasionally seen in Irish sea.	Annex IV of the EU Habitats Directive. Whale Fisheries Act, 1937.

Appendix 6 Marine habitat and macrofauna assessment

Table A6.1 Habitats and biotopes recorded at the quadrate stations surveyed.

Code	Location	Fossitt Habitat Type	Biotope
Q1	Crosshaven. North of town centre on the southern shore.	Mixed sediment shore (LS5). Sheltered shore, poorly sorted mix of sediments. Supports some fucoids.	*Littoral mixed sediments.*
Q2	Crosshaven. Just east of the town centre on the southern shore.	Mixed substrata shore (LR4). Mix of rock and sediment. Sheltered location.	"*Fucus serratus* on full salinity lower eulittoral mixed substrata".
Q3	Ringaskiddy. East-facing beach.	Moderately exposed rocky shore (LR2). Shore of boulders and stable cobbles. Incomplete cover of fucoids(Sampled). The shore also contains a large area of sand shore (LS2).	*Moderately exposed littoral rock.*
Q4	Ringaskiddy. East-facing beach.	Moderately exposed rocky shore (LR2). Shore of bedrock, boulders and stable cobbles. Incomplete cover of fucoids.	"*Mytilus edulis* and *Fucus vesiculosis* on moderately exposed mid-eulittoral rock".
Q5	Ringaskiddy. North-facing shore. Opposite Whitepoint, Cobh.	Mixed substrata shore (LR4). Mix of rock and sediment. Sheltered location.	"*Fucus vesiculosis* on mid-eulittoral mixed substrata".
Q6	Monkstown. Northern end of town on the western shore. North of pier.	Mixed substrata shore (LR4). Close to sea wall and pier (CC1). Sheltered location.	"*Mytilus edulis* beds on littoral mixed substrata".
Q7	Monkstown. Just south of River Ferry.	Mixed substrata shore (LR4). Mix of rock and sediment. Sheltered location.	"*Mytilus edulis* beds on littoral mixed substrata".
Q8	Monkstown / Passage West. North of River Ferry.	Mixed substrata shore (LR4). Mix of rock and sediment. Sheltered location.	"*Fucus serratus* and large *Mytilus edulis* on variable salinity lower eulittoral rock".
Q9	Passage West. Near slipway at bottom of public green.	Sheltered rocky shore (LR3). Boulders and cobbles with dense growth of fucoids.	"*Fucus serratus* and large *Mytilus edulis* on variable salinity lower eulittoral rock".
Q10	Great Island. Just north of River Ferry on east of R. Lee.	Mixed substrata shore (LR4). Mix of rock and sediment. Sheltered location.	"Mytilus edulis beds on littoral mixed substrata".
Q11	Great Island. South of River Ferry on east of R. Lee.	Mixed substrata shore (LR4). Mix of rock and sediment. Sheltered location.	"*Fucus serratus* and large *Mytilus edulis* on variable salinity lower eulittoral rock".
Q12	Whitepoint, Cobh.	Mixed substrata shore (LR4). Mix of rock and sediment. Sheltered location. Dense growth of fucoids.	-
Q13	East Beach, Cobh. Bottom of the steps to the east of Lynch's Quay.	Shingle and gravel shore (LS1). Moderately exposed shore with accumulations of mobile rocky material. Near sea walls (CC1).	"Barren littoral shingle".
Q14	Cobh. East of red chimney stack.	Moderately exposed rocky shore (LR2). Shore of boulders and stable cobbles. No fucoids present.	"*Mytilus edulis* beds on littoral mixed substrata".
Q15	Cobh. Just east of fishing quay.	Moderately exposed rocky shore (LR2). Shore of bedrock, boulders and stable cobbles.	*Moderately exposed littoral rock.*

Table A6.2 Habitats and biotopes recorded at the core stations surveyed.

Code	Location	Fossitt Habitat Type	JNCC Biotope Type
C1	Carrigaline. Downstream of bridge. On the north side of the channel.	Mud shore (LS4). Sheltered area of variable salinity.	"*Hediste diversicolor* and *Copophium volutar* in littoral mud".
C2	Carrigaline. Downstream of bridge. On the north side of the channel.	Mud shore (LS4). Sheltered area of variable salinity.	"*Hediste diversicolor* in littoral mud".
C3	Carrigaline. Further Downstream of bridge. On the north of the channel.	Mud shore (LS4). Sheltered area of variable salinity.	"*Hediste diversicolor* in littoral mud".
C4	Crosshaven. East of town centre on the southern shore.	Mud shore (LS4). Sheltered area of variable salinity.	"*Hediste diversicolor* in littoral mud".
C5	Glenbrook, Passage West.	Mud shore (LS4). Sheltered area of variable salinity.	"*Hediste diversicolor* in littoral mud".
C6	Great Island. South of River Ferry on east of R. Lee.	Mud shore (LS4). Sheltered area of variable salinity.	"*Hediste diversicolor* in littoral mud".
C7	Rushbrook, Great Island.	Mud shore (LS4). Sheltered area of variable salinity.	"Polychete dominated mid-estuarine mud shores".
C8	Cobh. South facing mudflat at Whitepoint.	Mud shore (LS4). Sheltered area of variable salinity.	"Polychete dominated mid-estuarine mud shores".

Table A6.3 Habitats and biotopes recorded at the grab stations surveyed.

Code	Location	Fossitt Habitat Type	JNCC Biotope Type
G1	IDA outfall pipe, to the west of Carlisle fort.	Infralittoral mixed sediments (SS4). Sea inlets and Bays (MW2)	Sublittoral mixed sediment in variable salinity.
G2	IDA outfall pipe, to the west of Carlisle fort.	Infralittoral muddy sands (SS2). Sea inlets and Bays (MW2)	Sublittoral mixed sediment in variable salinity.
G3	Proposed pipeline crossing at West Passage. North side.	Infralittoral muds (SS3). Estuary (MW4).	Sublittoral mixed sediment in variable salinity.
G4	Proposed pipeline crossing at West Passage. South side.	Infralittoral muds (SS3). Estuary (MW4).	Sublittoral mixed sediment in variable salinity.

Table A6.4 Selected characteristics of the 8 sites assessed using core sampling during June 2007.

Site No.	Mounds / casts	Burrows / holes	Tubes	Algal mat	Waves / dunes (>10cm high)	Ripples (<10cm high)	Drainage channels / creeks	Standing water	Subsurf. clay / mud	Subsurf. silt / flocculent	Firmness (Firm - Soft)	Stabilty (Stable - Mobile)	Sorting (Well - Poor)	Anoxic layer
C1							Present	Present		Present	4	4	1	3
C2					Present			Present		Present	4	4	2	1
C3						Present	Present		Present	Present	4	4	2	3
C4								Present	Present		4	4	2	1
C5	Present	Present						Present	Present		4	4	2	2
C6		Present	Present			Present		Present			4	4	2	4
C7		Present		Present		Present		Present	Present		4	4	1	3
C8	Present				Present			Present	Present		4	4	2	4

For the anoxic layer depth: 1=not visible, 2= >20cm, 3= 5-20cm, 4= 1-5cm, 5=<1cm.

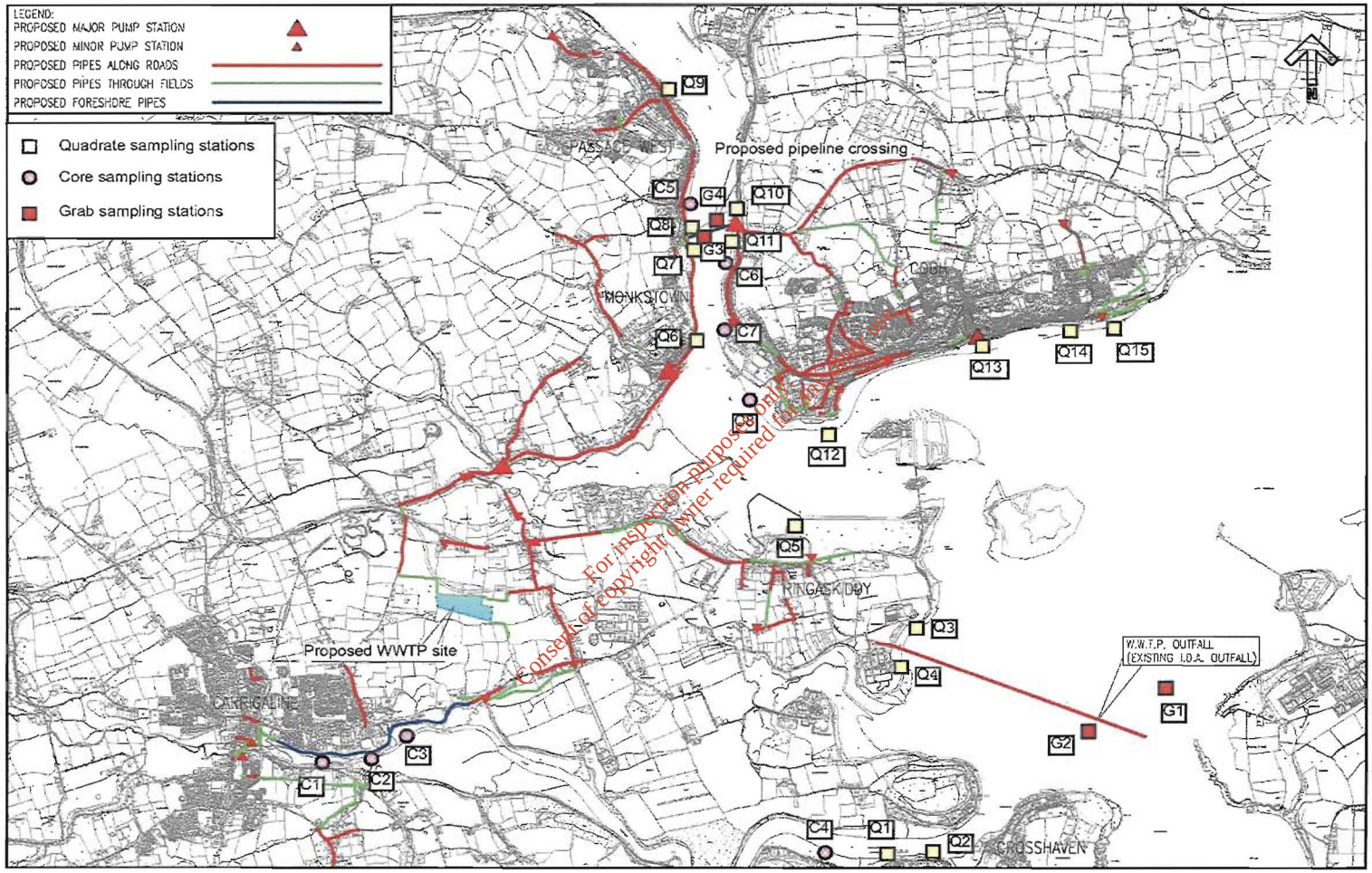

Figure A6.1 Location of marine / estuarine sampling sites.

Table A6.5 Numbers of macrofauna recorded at the 8 sites investigated using core sampling during June 2007.

	C1	C2	C3	C4	C5	C6	C7	C8
SEGMENTED WORMS (Annelida, Polychaeta)								
Family Naididae	1							
Ragworm (Family Nereidae)								
Hediste diversicolor	7	43	57	12	21	3		
Catworm (Family Nephytidae)							7	
Nephtys sp.				2				4
Family Arenicolidae								
Lugworm *Arenicola marina*						1		
CRUSTACEANS (Amphipoda)								
Family Corophidae								
Corophium volutator	16							1
CRABS (Crustacea, Decapoda)								
Family Portunidae								
Carcinus maenas			1					
BIVALVES (Mollusca, Bivalva)								
Cerastoderma edule								1
Family Mactridae								
Spisula elliptica		1	1					
SEA ANENOMES (Cnidaria, Actinaria)								
Family Actiniidae						1		
Number of species	**3**	**2**	**3**	**2**	**1**	**3**	**1**	**3**
Total (n)	**24**	**44**	**59**	**14**	**21**	**5**	**7**	**6**

Table A6.6 Weights of macrofauna recorded at the 8 sites investigated using core sampling during June 2007.

	C1	C2	C3	C4	C5	C6	C7	C8
SEGMENTED WORMS (Annelida, Polychaeta)								
Family Naididae	0.09							
Ragworm (Family Nereidae)								
Hediste diversicolor	1.33	21.7	27.2	15.2	17.9	0.11		
Catworm (Family Nephytidae)								
Nephtys sp.				3.63			7.54	0.28
Family Arenicolidae								
Lugworm *Arenicola marina*						6.04		
CRUSTACEANS (Amphipoda)								
Family Corophidae								
Corophium volutator	0.39							0.08
CRABS (Crustacea, Decapoda)								
Family Portunidae								
Carcinus maenas			23.7					
BIVALVES (Mollusca, Bivalva)								
Cerastoderma edule								0.8
Family Mactridae								
Spisula elliptica		0.58	0.97					
SEA ANENOMES (Cnidaria, Actinaria)								
Family Actiniidae						1		
Number of species	**3**	**2**	**3**	**2**	**1**	**3**	**1**	**3**
Total (g)	**1.81**	**22.3**	**51.9**	**18.8**	**17.9**	**7.15**	**7.54**	**1.16**

Table A6.7 Numbers of macrofauna recorded at the 4 sites investigated using grab sampling during June 2007.

	C1	C2	C3	C4
SEGMENTED WORMS (Annelida, Polychaeta)				
Ragworm (Family Nereidae)				
Hediste diversicolor	0	0	0	1
Total (n)	**0**	**0**	**0**	**1**

Table A6.8 Numbers of macrofauna recorded at the 15 sites investigated using quadrate sampling during June 2007.

Species/group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
CRUSTACEANS (Amphipoda)															
Family Gammaridae															
Chaetogammarus marinus	1														
Gammarus deubeni			1		4				14					100	
Family Corophiidae															
Mud shrimp *Corophium volutator*											20				
BARNACLES (Crustacea, Family Balanidae)															
Elminius modestus		100+	100+			100+	100+		100+	100+	100+	100+		100+	100+
Semibalanus balanoides				5+		100+									
Balanus crenatus			20+				100+				100+				
CRABS (Crustacea, Decapoda)															
Family Portunidae															
Green shore crab *Carcinus maenas*	2	2	7	2	3	15	38	1	28	16	8	2		24	28
SNAILS (Mollusca, Gastropoda)															
Topshells (Family Trochidae)															
Purple/Flat topshell *Gibbula umbilicalis*			3		1										12
Grey topshell *Gibbula cineraria*		5	7									2		4	
Family Patellidae															
Common limpet *Patella vulgata*		1	2	4	6	2						1			36
Winkles (Family Littorinidae)															
Edible periwinkle *Littorina littorea*		50	29	3	59	29	104		1	36	8			122	328
Flat periwinkle *Littorina obtusata*	3		5		4				3		4				
Flat periwinkle *Littorina mariae*		2	1		5				5						
Littorina rudis					5					8				681	228
CHITONS (Mollusca, Family Ischnochitonidae)															
Lepidochitona cinereus		2			1										
Lepidochitona asellus						1									
ISOPODS (Crustacea, Ostracoda)															
Family Sphaeromatidae															
Lekanespharea rugicauda														8	
BIVALVES (Mollusca, Bivalva)															

Table A6.8 (Continued) Numbers of macrofauna recorded at the 15 sites investigated using quadrate sampling during June 2007.

Species/group	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**
Family Mytilidae															
Common mussel *Mytilus edulis*		1	2	4	4	5	360	21	19	476	52			152	220
Family Cardiidae															
Common cockle Cerastoderma edule								1		4		1			
STARFISH (Echinodermata, Asteroidea)															
Family Asteridae															
Common starfish *Asterina rubens*						1			1		4				
SEA ANENOMES (Cnidaria, Actinaria)															
Snakelocks anemone *Anemonia viridis*		2	1	1	1					8					
Family Actiniidae															
Beadlet anemone *Actinia equina*							2		8	12	8			16	3
SEGMENTED WORMS (Annelida, Polychaeta)															
Family Serpulidae															
Keel worm *Pomatoceros lamarcki*		100+							20+			20+			32
Ragworm (Family Nereidae)															
Hediste diversicolor						1									
Family Cirratulidae															
Cirratulus cirratus									5		4	3			
Family Terebellidae															
Sand mason *Lanice conchilega*		1	1					27				3			
No of species	**3**	**11**	**13**	**6**	**11**	**9**	**6**	**4**	**11**	**8**	**11**	**8**	**0**	**9**	**9**

Table A6.9 Weights (g) of macrofauna recorded at the 15 sites investigated using quadrate sampling during June 2007.

Species/group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
CRUSTACEANS (Amphipoda)															
Family Gammaridae															
Chaetogammarus marinus	0.09														
Gammarus deubeni			0.08		0.45				0.6					100	
Family Corophiidae															
Mud shrimp *Corophium volutator*											0.52				
BARNACLES (Crustacea, Family Balanidae)															
Elminius modestus		-	-			-	n/a		n/a	n/a	n/a	n/a		n/a	n/a
Semibalanus balanoides				-		-									
Balanus crenatus			-				n/a				100+				
CRABS (Crustacea, Decapoda)															
Family Portunidae															
Green shore crab *Carcinus maenas*	1.72	1.19	13.5	22.9	22.7	8.67	44.9	82.4	22.3	112	10.4	48.4		29.5	18.9
SNAILS (Mollusca, Gastropoda)															
Topshells (Family Trochidae)															
Purple/Flat topshell *Gibbula umbilicalis*			6.91		0.44										1.96
Grey topshell *Gibbula cineraria*		8.66	41.4									4.94		4.02	
Family Patellidae															
Common limpet *Patella vulgata*		0.1	21.3	69.5	92.1	40.4						8.21			80.4
Winkles (Family Littorinidae)															
Edible periwinkle *Littorina littorea*		229	104	10.4	140	63.2	567		6.74	217	37.5			113	387
Flat periwinkle *Littorina obtusata*	4.85		9.9		5.43				2.4		4				
Flat periwinkle *Littorina mariae*		0.39	0.72		4.63				0.8						
Littorina rudis					2.54					6.42				118	45.2
CHITONS (Mollusca, Family Ischnochitonidae)															
Lepidochitona cinereus		0.49			0.41										
Lepidochitona asellus						0.39									
ISOPODS (Crustacea, Ostracoda)															
Family Sphaeromatidae															
Lekanespharea rugicauda														1.2	

Table A6.9 (Continued) Weights (g) of macrofauna recorded at the 15 sites investigated using quadrate sampling during June 2007.

Species/group	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
BIVALVES (Mollusca, Bivalva)															
Family Mytilidae															
Common mussel *Mytilus edulis*		0.73	0.1	24.9	23.8	73.2	5000	642	107	5520	1679			1300	1210
Family Cardiidae															
Common cockle Cerastoderma edule								21.8		80.4		25			
STARFISH (Echinodermata, Asteroidea)															
Family Asteridae															
Common starfish *Asterina rubens*						65			0.98		6.16				
SEA ANENOMES (Cnidaria, Actinaria)															
Snakelocks anemone *Anemonia viridis*			2.61	1.11	0.51					3.64					
Family Actiniidae															
Beadlet anemone *Actinia equina*							1.22		1.52	6.4	6.84			10.8	1.44
SEGMENTED WORMS (Annelida, Polychaeta)															
Family Serpulidae															
Keel worm *Pomatoceros lamarcki*		-							n/a			n/a			n/a
Ragworm (Family Nereidae)															
Hediste diversicolor						0.46									
Family Cirratulidae															
Cirratulus cirratus									1.28		1.02	0.39			
Family Terebellidae															
Sand mason *Lanice conchilega*		0.92	0.88					43.3				1.29			
No of species	**3**	**11**	**13**	**6**	**11**	**9**	**6**	**4**	**11**	**8**	**11**	**8**	**0**	**9**	**9**

Appendix 7 Angling and bait collection marks in Cork Harbour

Table A7.1 The principle shore angling marks in Cork Harbour and the main angling species present (adapted from Dunlop & Green, 1992).

Location	**Main species** **Specimens recorded.*
Seawall, Monkstown	Codling, conger, ray, dabs, and dogfish
Deepwater Quay	Conger, ray, codling, whiting*, dabs*, flounder*, coalfish, three bearded rockling*.
Brown's Island	Thornback ray, plaice, flounder, and dogfish.
Lower Agda Pier	Flounder, dabs, dogfish and conger.
Carlisle Pier	Pollack, mackerel, bass, flatfish, codling, thornback ray and homelyn ray.
White Bay	Plaice*, Bass, flatfish, dogfish, and rays.
Roches Point	Bass*, pollack, mackerel, conger, three bearded rockling, and ballan wrasse*.
Inch	Bass*, flatfish, conger, and flounder*.
Ballybranagan	Bass*, turbot, and flatfish.

Table A7.2 The main fishing bait collection areas in Cork Harbour and the main bait species present (adapted from Dunlop & Green, 1992). Distance from proposed storm sewage outfall point is also indicated.

Location	**Main bait species**
Glenbrook	Crab
Saleen to East Ferry	Lugworm and peeler crab.
Rostellan to Lower Aghda Pier	Lugworm
Whitegate Bay	Lugworm

Appendix 3A

Hydrodynamic and Modelling Report

Mott MacDonald

Cork Harbour Main Drainage Scheme –

EIA Modelling Study

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Non-Technical Executive Summary

The lead author of this report was commissioned by Mott MacDonald Pettit (MMP) to undertake a detailed Environmental Impact Assessment of the improvement in water quality as a result of the proposed Lower Harbour Main Drainage Scheme. At present the towns of Cobh, Passage West, Monkstown, Glenbrook, Ringaskiddy, Crosshaven and Carrigaline all discharge untreated sewage into Cork Harbour. The proposed scheme will collect this waste and treat it to a secondary standard at a new wastewater treatment plant near Carrigaline. The treated effluent will be discharged through the existing Carrigaline/Crosshaven outfall near Dognose Bank. In spite of increasing population a marked improvement in quality is to be expected for two reasons: (a) the reduction in pollutant load due to the treatment plant, and (b) the increased dilution available downriver when the treated effluent is discharged just inside the mouth of the Outer Harbour. This study quantifies the improvement.

A computer model, called the 'OH_2' model covering an area from the Old Head of Kinsale to the Waterworks weir in Cork City was developed. This model simulates the release, transport and decay of various micro-organisms in Cork Harbour and the surrounding area due to discharges of untreated and treated waste. In order to determine the improvement in water quality the OH_2 model was configured in two different ways. Firstly it was configured to simulate the release of untreated waste from the towns of Cobh, Passage West, Monkstown, Glenbrook, Ringaskiddy, Crosshaven and Carrigaline. It was then configured to simulate the release of treated waste from the proposed wastewater treatment plant at Carrigaline.

By comparing the results of these two cases the improvement in water quality can be estimated. A proper comparison requires the same population is used in both cases. In this study we have used the projected population loadings for 2010.

In this Environmental Impact Study three separate micro-organisms have been considered:

1. **Faecal coliform bacteria -** The number of faecal coliforms per 100ml is a recognised standard in the relevant EU Directives. The I (mandatory) and G (guide) values for the Bathing Water Directive are, for faecal coliforms, 2000 counts per 100ml and 100 counts per 100ml respectively. The G (guideline) values for the Shellfish Waters Directive are, for faecal coliforms, less than 300 counts per 100ml in the *shellfish flesh and intervalvular liquid*. We have used the results of the faecal coliform model to predict the concentrations of intestinal enterococci and *Escherichia coli* at the main points of interest in the study.
2. **Norovirus -** The *Norovirus* or "Winter Vomiting bug" is the primary pathogen in outbreaks of gastroenteritis following consumption of raw oysters. There is no standard for seawater at present due to the difficulty of measuring its concentration.
3. **Simple Nitrogen Cascade -** The forcing exerted on the Harbour ecosystem by organic nitrogen, nitrate and ammonia is examined using a simplified nitrogen cascade model.

In this report we have not considered discharges of treated effluent from Carrigrennan, Midleton or Cloyne or the untreated discharges from the outfalls serving the towns on the eastern side of the harbour. Neither have we considered the impact of stormwater overflows. Our results are therefore not representative of absolute water quality. They simply show the improvement to be expected from the proposed treatment plant. As the models in this report are linear, the relative concentrations are with respect to an unspecified background.

We have examined the measurements of background concentrations of coliforms and nitrogen from the harbour. There are no measurements of *Norovirus* in water anywhere in the world. The sampling error and the spatio-temporal variability of coliforms and nitrogen throughout the harbour make any estimate of the background concentrations very uncertain. Consequently, in our

view, it is sufficient to model the improvement in concentrations due to the proposed treatment plant and outfall.

It is possible to model the background concentrations but this would require substantially more resources and time than were available for this comparative study.

The results of the study may be summarised as follows.

Faecal Coliform Results

Our results show that the proposed treatment plant will reduce the number of faecal coliforms in Cork Harbour and the waters outside Roches Point. We have found that a 95% relative reduction in the maximum number of faecal coliforms may be expected for Lough Mahon, the Inner Harbour, the East and West Passages and the area around the Ringaskiddy ferry terminal. For the Outer Harbour we have found that an 80% relative reduction in the maximum number of faecal coliforms may be expected.

For the case of untreated waste being discharged from the relevant towns we found that the maximum concentrations of faecal coliforms ranged across the harbour from 2 to 1500 counts per 100ml. The areas immediately adjacent to the outfalls have the highest concentrations; areas further away have reduced concentrations due to the mixing and decay of the bacteria.

The equivalent range with the proposed treatment plant in operation is from 2 to 400 faecal coliforms per 100ml representing a significant improvement in water quality.

Adverse wind conditions, or longer-lived bacteria, may increase the maximum concentrations from the proposed treatment plant in certain areas of the outer harbour by as much as 60 – 80 faecal coliforms per 100ml.

We have used conservative estimates for the number of faecal coliforms present in treated sewage. When less conservative values were assumed, we found that there may be a 99% relative reduction in the maximum concentrations of faecal coliforms for Lough Mahon, the Inner harbour, the East and West Passages and

Ringaskiddy with a corresponding 96% relative reduction for the rest of the harbour.

We have found that the concentrations of intestinal enterococci with the proposed treatment plant in operation are very small with the exception of the area immediately surrounding the outfall. The concentrations of *Escherichia coli* are the same as for the Faecal Coliforms as the inputs to both models are identical.

The main conclusion to be reached from the results of the OH_2 model is that the proposed treatment plant will significantly reduce the number of indicator organisms in the upper harbour area. It will also reduce the number of indicator organisms in the outer harbour and waters beyond Roches Point but to a slightly lesser degree.

The I (mandatory) and G (guide) values for the Bathing Water Directive are, for faecal coliforms, 2000 counts per 100ml and 100 counts per 100ml respectively. From the results presented in Chapter 4 we may conclude that the contribution from the proposed treatment plant is several orders of magnitude less than these requirements far the bathing areas.

The G (guideline) values for the Shellfish Waters Directive are, for faecal coliforms, less than 300 counts per 100ml in the shellfish flesh and intervalvular liquid.

Oyster bio-accumulate bacteria and viruses form the surrounding waters. Our models do not account for this complex biological process. We therefore cannot predict the concentrations of bacteria within the flesh; only in the surrounding waters.

We can see from the results presented in Chapter 4 that the contribution from the proposed treatment plant is several orders of magnitude less than these requirements.

Norovirus Results

The *Norovirus* was included as part of this study in order to determine the impact of the proposed treatment plant on the oyster farms[1] and water-contact recreational areas in Cork Harbour. It was found that the proposed treatment will significantly reduce the number of *Norovirus* in Cork Harbour and the waters outside Roches Point leading to an improvement in water quality. There is 90 – 95% relative reduction in the maximum number of *Norovirus* at the oyster farm in the North Channel after the construction of the proposed treatment plant.

For Lough Mahon, the Inner harbour, the East and West Passages as well as the area around Ringaskiddy our results show that a 90% relative reduction in the maximum concentrations of *Norovirus* may be expected with the introduction of the treatment plant. For the rest of the harbour and the area outside Roches Point an 80% relative reduction may be expected.

Nitrogen Results

Nitrogen in different forms is an important nutrient in the coastal zone. Changes in the distribution of nitrogen can have an impact on the ecological and biological status of an estuary or harbour.

We have examined the impact of the proposed scheme on the ecological and biological status of Cork Harbour by using a simplified model containing three species of nitrogen: organic nitrogen, ammonia and nitrate.

The model quantifies the relative effect of the scheme on the concentration of these three species throughout the harbour and adjacent coast over a test period of ten days. The relative effect is with respect to an unaltered background concentration of each species of nitrogen.

The results reported in this report are estimates of the change in forcing, expressed as changes in the concentrations of the three species of nitrogen, due

[1] There are no designated shellfish production areas in Cork Harbour at present although oysters have been produced at two farms in the past. These are the oyster farms referred to in this report.

to the proposed scheme. They are estimates of relative changes. All the models are linear so the concentrations are with respect to an unspecified background. We leave the judgement of the wider consequences of these relative changes in nutrient forcing to the marine ecologists advising the project.

The time series presented in chapter 6 show an improvement in water quality with a marked reduction in concentrations of organic nitrogen, ammonia and nitrate in all of the fifteen points of special interest to the project compared to the unspecified background following the introduction of treatment. In other words the desired improvement has been demonstrated and quantified in the model under the specified conditions of tide, river flow and wind.

The spatially varying maps of concentration showed that the proposed scheme may reduce considerably the forcing on primary production in the inner harbour (Lough Mahon) and in the North Channel behind Great Island. There is also an improvement throughout the Outer Harbour.

When a more conservative treatment plant removal efficiency is assumed we find that the concentrations of all three species of Nitrogen increase.

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Chapter 1 Introduction

1.1 The background

The lead author of this report was commissioned by Mott MacDonald Pettit (MMP) to undertake a detailed Environmental Impact Assessment of the improvement in water quality as a result of the proposed Lower Harbour Main Drainage Scheme. At present the towns of Cobh, Passage West, Monkstown, Glenbrook, Ringaskiddy, Crosshaven and Carrigaline all discharge untreated sewage into Cork Harbour. The proposed scheme aims to collect all of this waste and treat it to a secondary standard at a waste water treatment plant to be located near Carrigaline. The treated effluent is to be discharged through the existing Carrigaline/Crosshaven outfall near Dognose Bank.

As part of the study a computer model which covers an area from the Old Head of Kinsale to the Waterworks weir in Cork City has been developed (Fig. 1.1). This model simulates the discharge, transport and decay of bacteria, viruses and three species of nitrogen from all the relevant outfalls. By simulating the discharge of untreated waste and comparing it with the discharge of treated waste an informed assessment of the improvement in water quality can be made. The boundary conditions for this model are provided by data from the Proudman Oceanographic Laboratory (POL), UK as described in section 2.2.3.

The hydrodynamic parameters of this model are based on a calibration and validation of a model covering a smaller area which reaches from Roches Point to the Waterworks weir (Fig. 1.2). The boundary conditions for this model are provided by recorded water levels from Roches Point in section 2.2.2.

The larger model has been labelled the 'Old Head_2' model (OH_2) in this report while the smaller model is referred to as the 'Roches Point_2' model (RP_2).

The OH_2 model has been validated against measurements of water level taken at Cobh and Tivoli. The error is within 20cm which is a satisfactory agreement between the modelled and measured data.

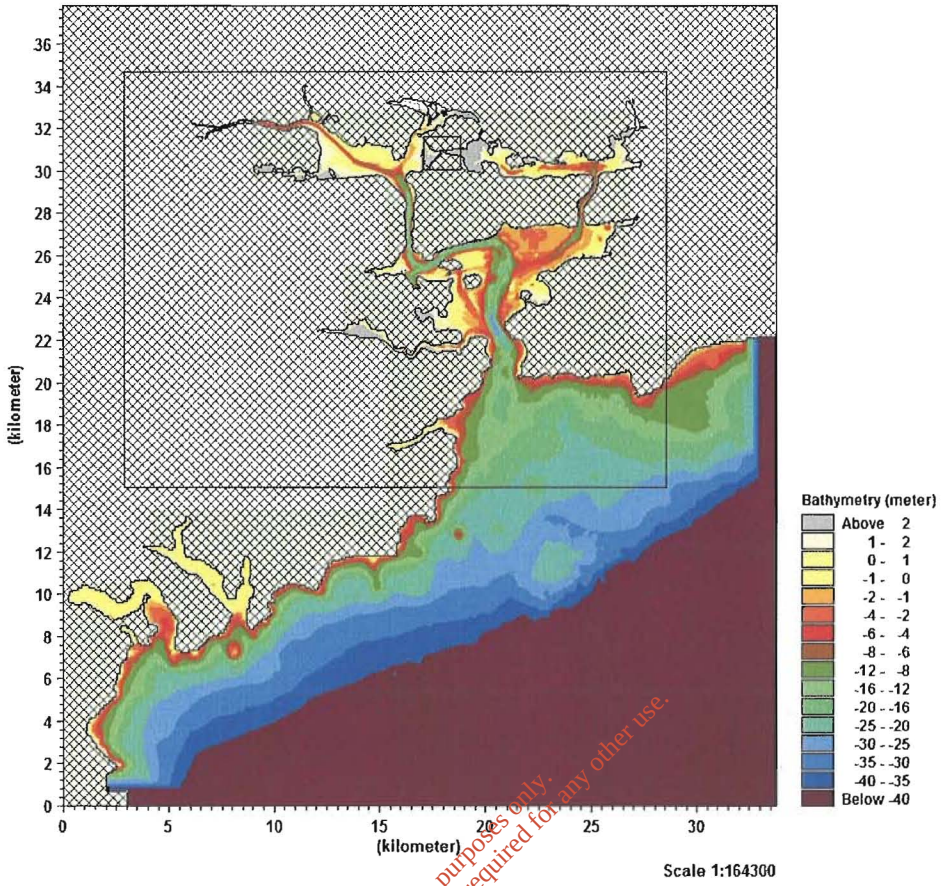

Fig. 1.1 Layout of the OH_2 model. The resolution of the 3 nested grids are 90m, 30m and 10m

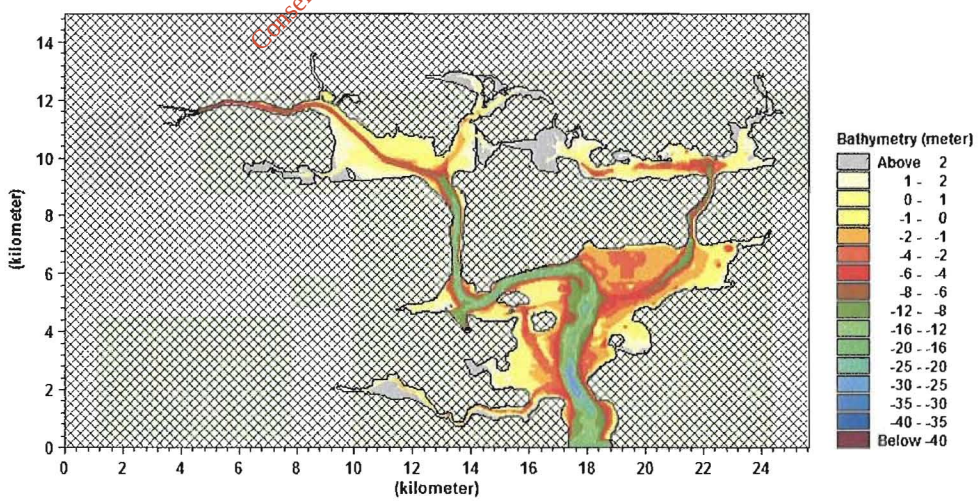

Fig. 1.2 Layout of the RP_2 model. The resolution of the 2 nested grids are 30m and 10m

The OH_2 model consists of two parts: the hydrodynamic model and the advection-dispersion model. The hydrodynamic model is based on the concepts and scientific principles of geometry and classical physics[2], and on relevant data[3]. It predicts the numerical variation in water level and the speed and direction of currents throughout Cork Harbour. We have achieved satisfactory agreement with measurements of these quantities. Pilots and sailors have also identified and confirmed the location of transient tidal eddies predicted by the model. We can predict with confidence, many, but not all, aspects of the motion of the waters of Cork Harbour under different conditions of tide, wind and river inflow.

The second part is the advection-dispersion model. This model simulates the release, transport and decay of particles discharged at any location in the harbour. We have considered faecal coliforms, intestinal enterococci, *Escherichia coli*, nitrogen and *Norovirus* for this study.

1. **Faecal Coliforms**
    - The number of Faecal Coliforms per 100ml is a recognised standard by which water quality is assessed in the relevant EU Directives.
2. **Intestinal enterococci**
    - The number of Intestinal enterococci per 100ml is a recognised standard by which water quality is assessed in the relevant EU Directives.

[2] These are represented as partial differential equations, expressing conservation of mass and linear momentum, with attendant boundary and initial conditions, and environmental forcing functions.

[3] Bathymetry of the Harbour from the Waterworks Weir to the Old Head of Kinsale; wind speed and direction; river flow and the tide at the mouth.

3. *Escherichia Coli*

- The number of *E. coli* per 100ml is a recognised standard by which water quality is assessed in the relevant EU Directives.

4. Simple Nitrogen Cascade

- The forcing exerted on the Harbour ecosystem by organic nitrogen, nitrate and ammonia is examined using a simplified nitrogen cascade model. Nitrogen has been included in this Environmental Impact Statement because the Water Framework Directive aims for good ecological status of all waters. High concentrations of nitrogen, when limiting, may lead to the over-fertilisation, or eutrophication, of aquatic ecosystems resulting in excessive growth of algae.

5. *Norovirus*

- The *Norovirus* or "Winter Vomiting bug" is the primary pathogen in outbreaks of gastroenteritis following consumption of raw oysters. The *Norovirus* is endemic in many countries. Outbreaks of "winter vomiting" may occur all year round and are often made public in Ireland by the closure of hospitals to visitors.

The models predict the changing concentration of the bacteria, three species of nitrogen, and *Norovirus*, under various physical forcing by the tide, wind and river flows. The variation in concentration at any site within the harbour may then be examined. From this it may be determined if the concentrations of the micro-organisms from the proposed scheme satisfy the water quality standards as stipulated in the relevant EU Directives:

- Bathing Water Directive (2006/7/EEC)
- Shellfish Waters Directive (79/923/EEC)

We understand there are no designated bathing water areas within Cork Harbour. The nearest one is at Fountainstown 5.25 km outside the harbour mouth. At present there are also no designated shellfish production areas within

Cork Harbour although oyster production has occurred in the past in the North Channel and Outer Harbour.

For this study we have not considered the discharges of treated effluent from Carrigrennan, Midleton or Cloyne. Neither have we considered the untreated discharges from the outfalls serving the towns on the eastern side of the harbour such as Rostellan, Farsid, Aghada and Whitegate. Stormwater overflows have not been included. The results presented in the report are therefore not representative of the absolute water quality in the harbour and surrounding waters. They present the contribution from the outfalls considered in the simulation runs.

We have examined the measurements of background concentrations of coliforms and nitrogen from the harbour. There are no measurements of *Norovirus* in water anywhere in the world. The sampling error and the spatio-temporal variability of coliforms and nitrogen throughout the harbour make any estimate of the background concentrations very uncertain. Consequently, in our view, it is sufficient to model the improvement in concentrations due to the proposed treatment plant and outfall.

It is possible to model the background concentrations but this would require substantially more resources and time than were available for this comparative study.

In order to illustrate the overall benefit of the proposed scheme four separate cases have been considered in the study and are listed in the following table.

	Year	Treatment	Total Flow Rate
Case 1 – no treatment 2001	2001	None	7,516 m^3/d
Case 2 – no treatment 2010	2010	None	10,371 m^3/d
Case 3 – With treatment 2010	2010	Secondary – 90% removal of organic matter	10,371 m^3/d
Case 4 – With treatment 2030	2030	Secondary – 90% removal of organic matter	14,873 m^3/d

Table 1-1 The four cases considered in the study

The loading on each outfall was determined by Mott MacDonald Pettit as part of a detailed and comprehensive preliminary study into the proposed scheme[4]. The loadings for the future years were calculated based on the predicted growth in population and industry for the relevant towns[5]. We have used the values from this report in our numerical model. Table 1-1 lists the values used for the 2001 situation, case 1 in the table above.

For case 2 we have assumed that the combined flow of 10,371m^3/d is divided between the outfalls as in the 2001 situation. Cases 2 and 3 have been simulated with the model. Because the model is linear, cases 1 and 4 can be calculated easily by rescaling.

Outfall Location	UTM E	UTM N	Flow (DWF) m3/day	Flow (DWF) m3/sec	Faecal Coli Conc (raw) fc/ m3
Carrigaline/Crosshaven	550249	5740738	4,075	0.04716	1E+11
Passage West	545351	5747371	547	0.00633	1E+11
Glenbrook	546006	5745605	327	0.00379	1E+11
Monkstown	546081	5744680	185	0.00215	1E+11
Pilots Pier Outfall (Cobh)	549632	5744757	353	0.00410	1E+11
Corbett Outfall (Cobh)	549277	5744708	178	0.00206	1E+11
Kings Quay Outfall (Cobh)	548854	5744611	444	0.00515	1E+11
West Beach Outfall (Cobh)	548647	5744568	668	0.00774	1E+11
White Point Outfall (Cobh)	547098	5743748	634	0.00735	1E+11
Ringaskiddy Village Outfall	547064	5742895	101	0.00117	1E+11
Total Catchment			7,515	0.087	

Table 1-2 Loading on outfalls from MMP report

[4] Cork Harbour Main Drainage Scheme Preliminary Report, Volumes 1-5, E.G., Pettit & Company

[5] The growth in population was estimated by considering the Cork Area Strategic Plan as well as the future development plan for each individual town as reported by E.G., Pettit & Company in the report referenced above.

1.2 Previous study of the *Norovirus* by the Authors

The lead author of this report was asked by Cork County Council in 2006 to carry out an objective study into the contamination of the oyster farm in the North Channel of Cork Harbour by the *Norovirus*. The primary objective of the study was to estimate the relative contribution of all significant sources of municipal and domestic effluent to the contamination of the oyster bed.

A number of computer models, similar to the models used in this Environmental Impact Assessment, were developed as part of the study. These models simulated the transport and decay of *Norovirus* in Cork Harbour from all the relevant outfalls. This study is referenced on a number of occasions in this report.

1.3 Model Assumptions

The advection-dispersion models described in this report have a number of inherent assumptions. Models are a simplification of reality; there is always something missing. It is a matter of judgement what to include and what to exclude. The following are the most important assumptions:

1. The densities of bacteria and *Norovirus* are approximately the same as seawater and are neutrally buoyant.
2. Adsorption of *Norovirus* and bacteria onto sediment is not included in the models. The interaction of sediment and micro-organisms in the marine environment is a complex process and is incompletely understood in the scientific literature. Simple assumptions are appropriate in this case.
3. Density gradients and stratification due to variations in salinity are excluded. These are unlikely to occur in the areas of interest in the outer harbour and outside the mouth.

1.4 Structure of the report

Chapter one introduces the study and the models. Chapter two summarises the various datasets that were used in the development of the 'Old Head_2' model.

Chapter three describes the model and its parameters. The results for faecal coliforms, *Norovirus* and Nitrogen are given in chapters 4, 5 and 6 respectively.

Chapter 2 The Datasets

2.1 Introduction

The data used to develop the Old Head_2 model are listed below and described in section 2.2.

Data type	Format	Period	Source
Bathymetric data of Cork Harbour (type 1)	X,Y,Z soundings	-	Irish Hydrodata
Bathymetric data of the Belvelly Channel (type 2)	X,Y,Z stereoscopic data	-	DLR (German Aerospace Agency)
Water level recordings from the harbour	Time series	Feb – Mar 1992	Irish Hydrodata / Port of Cork
Current speed & direction recordings from the harbour	Time series	Feb – Mar 1992	Irish Hydrodata
Hydrodynamic output from CS3 model	Time series	Jan- Dec 2004	Proudman Laboratory (UK)
River flows from the Lee, Owenacurra and Owenboy Rivers	Time series	Jan - Dec 1992 & 2004	ESB/EPA
Wind speed & directions from Cork Airport	Time series	Jan - Dec 1992 & 2004	Met Eireann
Location of each outfall	UTM coordinates	-	MMP
Flow Rates from the Various Outfalls	Values in m^3/sec	-	MMP
No of fc per cubic metre	Spreadsheet	-	MMP
Efficiency of the proposed treatment plant	Spreadsheet	-	MMP

Table 2-1 Datasets

2.2 Datasets

2.2.1 Bathymetric data

Irish Hydrodata Ltd. undertook a bathymetric survey of Cork Harbour in 1992 as part of a study of locations for an outfall from the Cork Main Drainage Scheme. A number of other surveys have since been carried out by Irish Hydrodata Ltd. for smaller localised areas. These surveys were commissioned by different parties

to update the bathymetry in site-specific areas as part of various modelling studies. The main bathymetric datafile used in this study is an amalgamation of all these surveys and represents the most up-to-date dataset of the harbour bed profile that exists at present. A comprehensive quality-assurance of the dataset was carried out as part of the authors' previous study of the *Norovirus* in Cork Harbour[6].

2.2.2 Water Level & Current Speed Direction Recordings – 1992

In conjunction with the bathymetric survey undertaken for the 1992 outfall study, Irish Hydrodata Ltd placed a number of gauges in the harbour to record water levels, current speeds and current directions. Six automatic level recorders were deployed for a period of three months from the 6th of December 1991 until the 14th of March 1992. Readings were taken every minute. The current speed and direction meters recorded data from mid-December to mid-February, a period of approximately 65 days at 10 minute intervals. A number of the water level gauges shifted on their mountings during the first month of deployment and these data were discarded. Fig. 2.2 shows the location of the gauges. Table 2-2 lists the grid coordinates and dates of deployment.

These data were used to calibrate and validate the RP_2 and OH_2 models which are described in the following chapter. A comprehensive quality-assurance of the dataset was carried out as part of the authors' previous study of the *Norovirus* in Cork Harbour.

[6] O'Kane, J.P.J., & Barry, K. J., Modelling the *Norovirus* contamination of an oyster farm in Cork Harbour, Final Report to Cork County Council

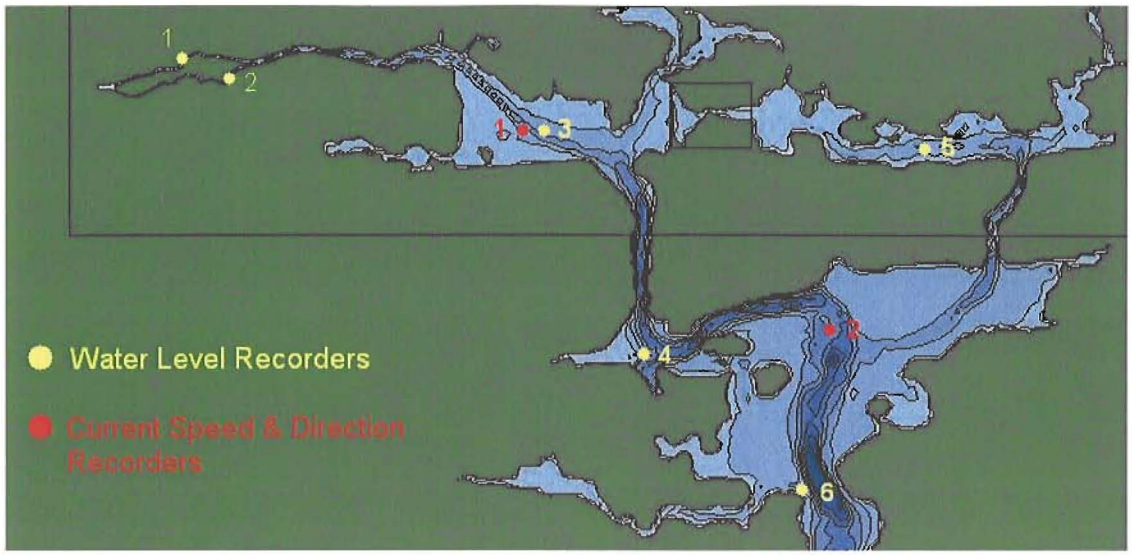

Fig. 2.1 Location of Gauges in Harbour

Site	From	To	Comments	I.N.G. Coordinates	
Lee Maltings	06 Dec 1991	06 Jan 1992	Not used	166760	71885
	06 Jan 1992	07 Feb 1992	Not used	166760	71885
	19 Feb 1992	16 Mar 1992	Not used	166760	71885
Albert Quay	06 Dec 1991	06 Jan 1992	Not used	167990	71750
	06 Jan 1992	06 Feb 1992	Not used	167990	71750
	10 Feb 1992	11 Mar 1992	Not used	167990	71750
Lough Mahon	06 Dec 1991	08 Jan 1992	Data invalid	175225	70400
	09 Jan 1992	06 Feb 1992	-	175225	70400
	10 Feb 1992	14 Mar 1992	-	175225	70400
Pfizer Jetty	06 Dec 1991	08 Jan 1992	Data invalid	177550	65225
	10 Jan 1992	26 Jan 1992	-	177550	65225
	08 Feb 1992	13 Mar 1992	-	177550	65225
Belvelly	06 Dec 1991	07 Jan 1992	-	183830	69580
	07 Jan 1992	08 Feb 1992	-	183830	69580
	08 Feb 1992	11 Mar 1992	-	183830	69580
Fort Camden	09 Dec 1991	08 Jan 1992	-	180870	62000
	09 Jan1992	07 Feb 1992	-	180870	62000
	07 Feb 1992	11 Mar 1992	-	180870	62000

Table 2-2 List of Water Level Gauges

Site	From	To	Comments
Spit Bank	08 Dec 1991	14 Feb 1992	4m above bed
Lough Mahon	15 Dec 1991	14 Feb 1992	2m above bed

Table 2-3 List of Current Speed and Direction Gauges

2.2.3 The POL CS3 model – Boundary Conditions of the OH_2 model

The Applications Group at the Proudman Oceanographic Laboratory (POL), UK, supplies hindcasts[7] of (a) tide-plus-surge, and (b) tide-only levels on a grid covering part of the North Atlantic Shelf at frequencies of 1 hour for (a) and 20 minutes for (b) respectively. The centre uses its POL CS3 model to provide the annual hindcast at the end of each calendar year. Hindcasts are available from 1992 onwards. The model makes use of meteorological data from the UK Met Office Operational Storm Surge Local Area Model (1992 to 1998) and the Mesoscale model (1999 onwards). The hindcasts from the POL CS3 Model use a combination of measured and modelled meteorological data. Surface elevations and currents in component form are provided at each grid point. The POL CS3 numerical model grid, which covers part of the North Atlantic Shelf, has a resolution of approximately 12km (Fig. 2.2). The level data has a relative accuracy of approximately 3% of the sea level range[8]. The absolute accuracy is unknown on the southern Irish Coast. A previous study[9] (1997-2001) of the Cashen Estuary in the outer Shannon showed that such data could provide very good boundary conditions for hydrodynamic models of Irish coastal waters. The Cashen/Feale model agreed with measurements within the estuarine network to within 10cm.

Two years of hindcast data (1992 & 2004) were purchased from POL for this project. Data from the three points closest to the mouth of Cork Harbour were selected from the CS3 grid and used to drive the hydrodynamics of the 'Old Head_2' hydrodynamic model by acting as the boundary conditions. The locations of these points relative to Cork Harbour are highlighted in Fig. 2.3.

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[7] A hindcast is where a numerical model is run for a fixed historic period of time in the past with recorded forcing functions (measurements of tide, wind etc) from that period.

[8] Smith, J. A. (1994). The Operational Storm Surge Model Data Archive, Proudman Oceanographic Laboratory, Report, No 34, 34pp

[9] Martin, J., 2002, De-Watering the Lower Feale – "A Virtual Water World", *Ph.D. Thesis*, Department of Civil and Environmental Engineering, National University of Ireland, Cork

Minor adjustments to the data provided by the Proudman Laboratory in this study.

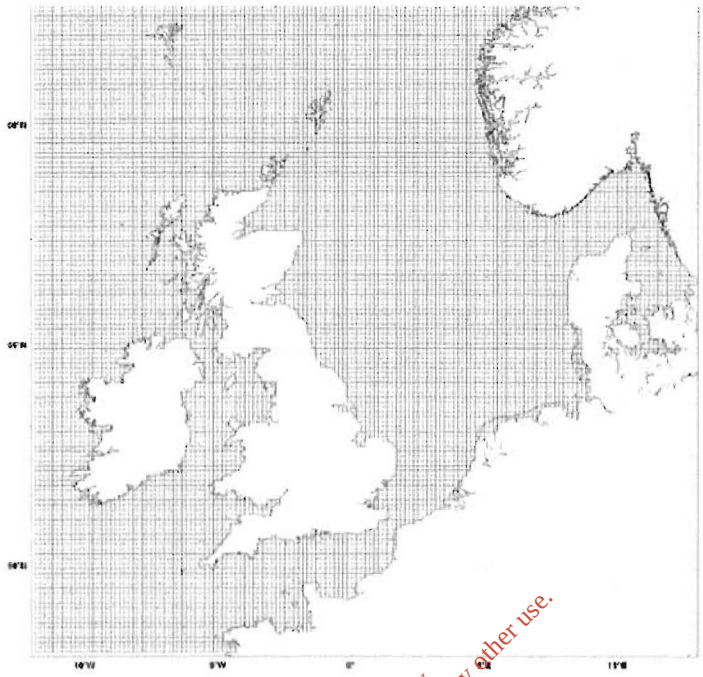

Fig. 2.2 CS3 grid (12km resolution)

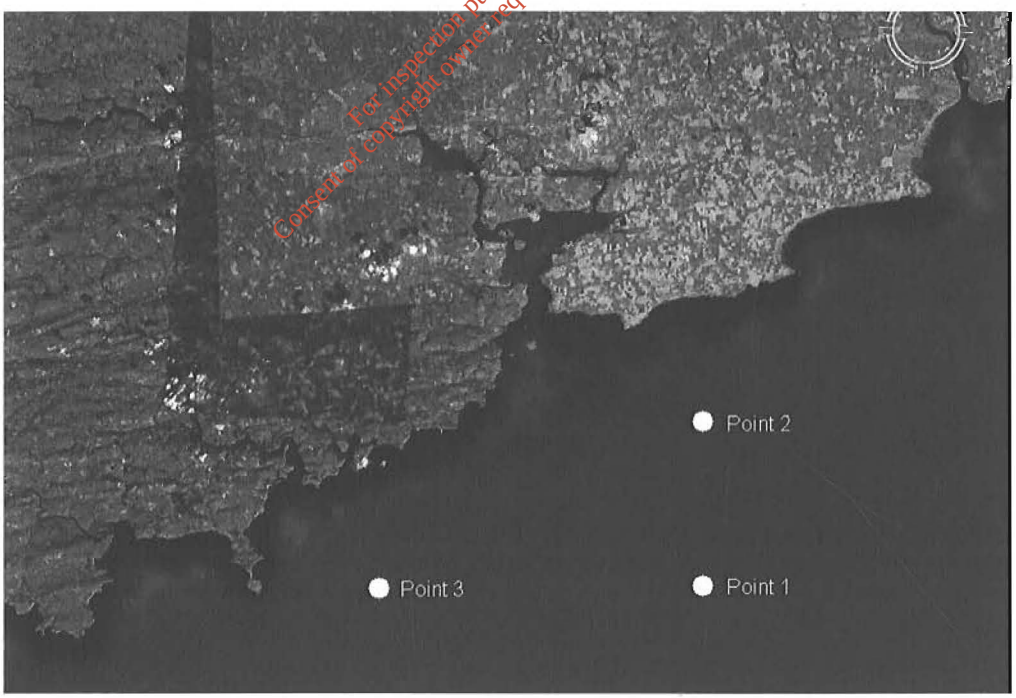

Fig. 2.3 Location of points on the CS3 grid used for the OH Hydrodynamic model boundary conditions (Image from Google Earth)

2.2.4 River & Wind Files

River flows and wind influence the hydrodynamics of the estuary. Cork County Council, EPA, OPW and the ESB supplied measurements of flow in all the rivers discharging into Cork Harbour for 1992 and 2004. In this Environmental Impact Statement we have included the influence of the River Lee, Owenboy and Owenacurra rivers.

The archive of the 1992 survey carried out by Irish Hydrodata Ltd contained the wind records at Cork Airport (Met Eireann), Roches Point (Met Eireann). and Ringmahon Point (Bord Gais/Cork Corporation). The 1992 survey report by Irish Hydrodata Ltd states that the Cork Airport and Roches Point datasets "show very similar wind patterns". It also states in reference to the Cork Airport and Ringmahon Point sites that there is "little difference between the sites". Consequently, we have relied on the data from Cork Airport exclusively.

2.2.5 Water level recordings from Cork Harbour

The Port of Cork supplied time series of water level from the gauges they maintain at Tivoli and Cobh. This data has been used to validate the OH_2 model.

2.2.6 Outfall Loading

As part of the preliminary investigation carried out for the proposed scheme, Mott MacDonald Pettit undertook a comprehensive study of the population and industry serving each outfall in 2001[10]. We have used the values given in this report in our models. The projected loadings for 2010 and 2030 were also taken from this report.

[10] Cork Harbour Main Drainage Scheme, Volumes 1-5, EG Pettit & Company