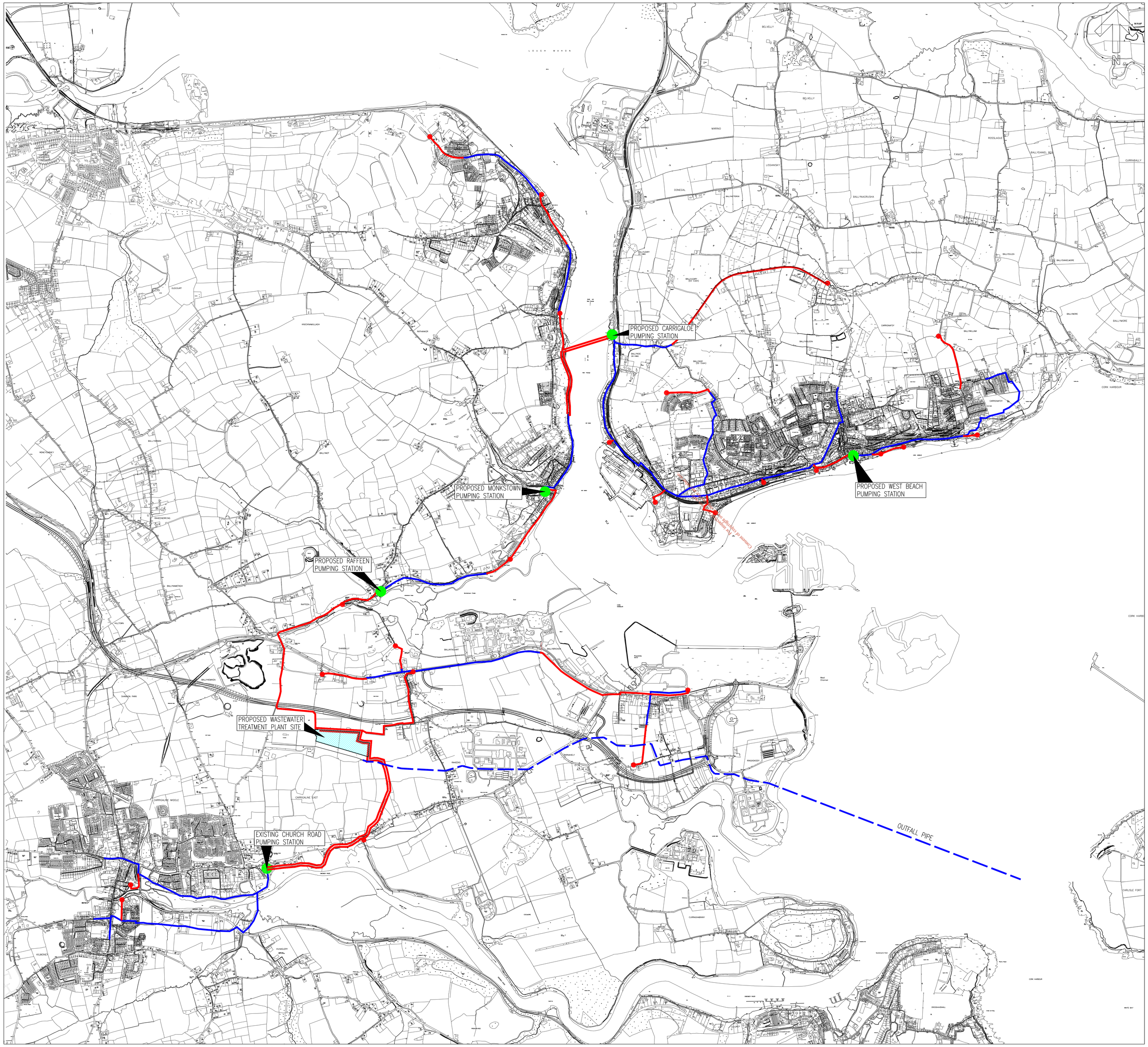

Notes

LEGEND:

- RISING MAIN
- GRAVITY SEWER
- PUMPING STATION
- MAJOR PUMPING STATION

LINEAR SCALE

−400m 0m 600m

Rev	Date	Drawn	Description	Ch'k'd	App'd

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Client

CORK COUNTY COUNCIL

Title

APPENDIX 1C
CORK HARBOUR
MAIN DRAINAGE SCHEME

HARBOUR OVERVIEW -
- PROPOSED SYSTEM

Designed			Eng.Chk.	O Freyne	
Drawn	S Trillaud		Coordination	-	
Dwg.Chk.	-		Approved	F McGivern	
Scale at A0		Project	234541		Status
N.T.S.		CAD file	5670FG93		FIG
Drawing No					Rev
234541-FG93					A

Filename: 5670FG93.dwg, Plotted by WCBRAD, on Jan 10, 2008 -3:42pm

Appendix 2A

Terrestrial and Marine Ecology Report

Mott MacDonald

Cork Harbour Main Drainage Scheme

Environmental Impact Assessment

Flora and Fauna

January 7th 2008 (Final)

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EXECUTIVE SUMMARY

Cork County Council is proposing to upgrade the existing drainage network of the Cork Harbour Main Drainage Scheme to modern standards and to expand the network in order to cater for the future needs of the area. This section of the EIS outlines the potential impacts of this development on ecology. Both positive and negative impacts on ecology could occur as a result of the construction and operation of this scheme. For example, the scheme is designed to bring about positive impacts on water quality in Cork harbour and this would have indirect benefits for marine flora and fauna. Active raw sewage outfalls in the proposed development area currently release an estimated 7,515 m^3 raw sewage into Cork Harbour daily. This results in reduced water quality, algal blooms that can cause shellfish poisoning, reduced marine diversity and public safety concerns. Negative impacts could occur in areas where construction works are required. However, these impacts can generally be mitigated and would be short-term in nature.

The proposed development would collect raw sewage and intercept numerous storm water outfalls, before treating collected sewage to a secondary level at a proposed new wastewater treatment facility near Carrigaline. The treated wastewater would be discharged inside the mouth of Cork harbour through the existing IDA outfall. Most of the proposed pipe network follows existing roads and disruption of terrestrial habitats would be minimal. One part of the pipeline would cross the River Lee west channel but this area is not biologically diverse and is frequently disturbed by ferry crossings. Use of a hydrodynamic dispersion model found that significant reductions in polluting substances would be realised throughout Cork Harbour following completion and operation of the proposed development. Subsequently, the ecological status of the marine environment would be raised, with beneficial impacts for the affected National Heritage Areas (NHA's) and Special Protection Area (SPA).

The current study was carried to provide baseline information on the ecological status of the study area and assessed both terrestrial and aquatic (marine and estuarine) ecology. This was undertaken through reviewing existing information of the harbour and consulting with numerous state agencies, NGO's and others. An extensive field sampling programme was also undertaken during June 2007. The desktop review was carried out to identify features of ecological importance within the study area and surrounding region. A hydrodynamic dispersion model formulated by the Civil and Environmental Engineering Department of the University College Cork was also consulted to assess the likely change in water quality and resulting ecological impacts of the proposed development.

Field survey work comprised a walk over study of the proposed WWTP site, pump stations and collection system, and adjacent marine / estuarine areas. All sightings and signs of fauna were recorded. A Phase 1 habitat survey of the study area was conducted using recognised standard methods, and habitats of conservation concern were classified and mapped accordingly. The results of the habitat survey were evaluated to determine the significance of identified habitats. The marine field survey comprised of standard quadrate, core and grab sampling in areas of soft sediment, mixed substrates and underwater, respectively. Survey work was undertaken from the shore at low tide and also from a hired charter boat. The organisms found were identified and used to gain an understanding of the ecosystems that could be affected by the proposed development. The means of assessing impact significance was based on the Institute of Ecological and Environmental Management draft guidelines on Ecological Impact Assessment.

The proposed development area includes a number of designated areas. Some sections of the proposed development are alongside the Cork Harbour SPA for birds, mainly adjacent to mudflats at Carrigaline and Monkstown. Proposed works associated with the development are also located within 2km of the Great Island channel Special Area of Conservation (SAC) (Site Code: 0001058), designated for the presence of the Annex I habitats; mudflats and Atlantic salt meadows. However, the proposed pipeline would mainly follow the course of existing roads that already form the border of the local protected areas. In addition, the proposed pumping stations would be on artificial surfaces and amenity grassland, areas of low ecological value. Some of the proposed pipeline routes and pump stations are adjacent to

the Annex I listed habitats estuaries/large shallow inlets and bays, which are of international importance. Again, these habitats are adjacent to existing roads and also comprise the SPA.

Terrestrial habitats affected by the proposed development would be improved agricultural grassland, hedgerows, mixed broadleaved woodland, treelines, arable crops, tilled land, stone walls, grassy verges, ornamental / non native shrubs, artificial surfaces, spoil and bare ground. Of these, hedgerows and mixed broadleaved woodland are of high local ecological importance while the remainder are either of local ecological importance or of little ecological significance. However, a large proportion of the pipeline routes would follow the paths of existing roads, or existing hard artificial surfaces. Protected terrestrial mammals that occur within the study area include badgers, bats, otters, hedgehogs, pygmy shrews, and Irish hares. A number of protected marine mammal species also use Cork Harbour. However, the proposed development is not predicted to a have a significant impact on any mammal species.

The potentially affected environment of Cork Harbour is a large, sheltered bay system, with several river estuaries including those of the Lee, Douglas and Owenacurra. Due to inputs of freshwater, the mixing of different waters gives rise to complex sedimentological and biological processes and patterns. Brackish water habitats typically have impoverished fauna due to fluctuations in salinity and water levels and Cork Harbour follows this trend. A variety of shore types occur within the study area, all being influenced by a range of factors including particle sizes, anoxic layer depths, re-suspension of sediments and suspended particles, currents, waves and freshwater inputs. Different shoreline types were inhabited by organisms suited to the environmental conditions provided by those shores. For example some sites around the ferry crossing had large numbers of mussels and a reduced diversity of organisms. This area is disturbed on a daily basis by the movements of the ferry between Cobh and the mainland, and tidal currents. Towards the mouth of the harbour, the shores and related fauna were more exposed and consist mainly of snails, small mussels, anemones, keelworms, green shore crabs and barnacles. The outer part of the harbour was more diverse, and habitats were of a marine nature as opposed to estuarine. Only one macroinvertebrate species – estuary ragworm - was found near the current IDA outfall in sub littoral mixed sediment during the grab sampling. Typical of the estuarine shores deeper within the harbour the benthic community was dominated by ragworms, catworms and Corophium. The prevalence of the ragworm on muddy shores was indicative of pollution. All of the sites examined during the current survey had a poor benthic community diversity. Cork Harbour is important as a nursery area for marine fish, however trawling within the harbour still takes place. Cork harbour also provides passage for migratory salmon, lampreys and European eels and is important for aquaculture.

According to the EPA, water quality in Cork Harbour is only moderate and is reflected by growths of *Enteromorpha* and *Ulva*. However, Lough Mahon (inner part of harbour) has recovered somewhat since the cessation of untreated sewage discharges into the Lee Estuary and Lough Mahon as part of previous phase of the Cork Main Drainage Project. The current project aims to bring similar benefits to the lower harbour area. High nutrient levels in the harbour have been linked to the occurrence of algal blooms in which certain species of phytoplankton reach very high densities, release toxins and contaminate shellfish. The most recent documented episode of contamination was in 2005 when Paralytic Shellfish Poisoning (PSP) showed up during a Marine Institute monitoring programme. Three locations in Cork Harbour are listed as Class 'B' Bivalve Mollusc Production Areas for shellfish, but were closed for a period during 2005 following an algal bloom affecting mussels. Algal mat growths, indicative of pollution, were recorded on some mudflats in the current survey adjacent to untreated sewage outfalls. Associated anoxic conditions (oxygen deprivation) were also recorded in the sediments at these locations.

Construction works associated with the proposed scheme would involve typical construction activities such as excavation, filling, lifting, pumping, pipe laying, concrete works and mechanical installation. The construction phase for the wastewater treatment plant is likely to extend over a two-year period on the site of WWTW. This site consists of portions of two agricultural fields that have already been zoned for a waste water treatment plant. 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). The fact that treated effluent would be discharged just inside the mouth of the harbour would increase the dilution rate. Potential exists through the operation of the proposed WWTP that an accidental pollution episode may affect water quality in the receiving waters. 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. Water quality in sections of Cork Harbour would be monitored periodically during the construction phase to confirm than no impact on water quality occurs.

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. Construction works mainly due to excavation of the foreshore areas are likely to deter birds from using the affected areas due to physical intrusion and indirect effects such as noise. However the extent of such areas is relatively limited and the degree of disturbance 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. Currently, traffic on roads around these areas is constant and fauna would be expected to be accustomed to some degree of background noise levels. Regular construction impacts could occur as a result of the release of suspended solids and contaminated runoff / deleterious substances into nearby estuarine areas. However, such potential impacts can generally be avoided with careful site management and appropriate timing of the proposed works. The placement of a pipeline across the River Lee west channel would not change the ecology of the wider environment in this area, as this area is already subjected to variable conditions and daily disturbance by the ferry.

Despite the predicted increase in population in the study area, the operation of the proposed development would enhance water quality in Cork Harbour. This would happen via interception of current raw sewage outfalls at various shores, secondary treatment of same, and release of treated effluent to an existing outfall in an area where dispersion rates would ensure lower concentrations of potentially harmful substances. Improved water quality would be expected to lead to an increase in diversity of organisms as well as reducing the incidence of algal blooms and shellfish poisoning. Furthermore, the overall conservation value of Cork Harbour would be expected to improve as a result of the scheme. During the operation of the plant, the treated discharge and adjoining areas of Cork Harbour would be monitored regularly and would include parameters such as suspended solids, heavy metals, organics, coliforms and faecal coliforms. The monitoring regime would be agreed in advance with Cork County Council, EPA, NPWS, SWRFB and the other relevant agencies. The fifth schedule of the *Urban Waste Water Treatment Regulations* would stipulate the monitoring requirements for this plant.

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3.2.1 INTRODUCTION

Cork County Council are proposing to construct a new urban wastewater treatment plant (WWTP) for Cork Harbour Lower. This plant would form an integral part of the Cork Harbour Main Drainage Scheme. Currently, the wastewater from the population centres in the drainage scheme is not treated and is discharged directly to the Lower Harbour. This is having a negative effect on water quality in the harbour. It is expected that the new plant would bring significant benefits to the ecology and water quality of the harbour.

The Cork Harbour Main Drainage Scheme involves upgrading the existing sewerage system of Cork Lower Harbour and environs together with the provision of a secondary wastewater treatment plant. Under the proposed scheme it is expected that wastewater and stormwater collection will be separated as far as possible. The population centres within the Cork Lower Harbour Drainage Scheme include Carrigaline, Ringaskiddy, Shanbally, Coolmore, Cobh, Monkstown/Passage West and Crosshaven.

A single WWTP at a site located to the east of Carrigaline near the townland of Shanbally is proposed. Sewage from Cobh would be pumped across the Harbour to Monkstown, from where the combined Passage West, Cobh and Monkstown flows would be pumped to the WWTP. Wastewater from Crosshaven and Carrigaline would be pumped via the existing rising mains to the WWTP. The treated effluent would be pumped to the existing Ringaskiddy outfall. The only marine work required would be a Cobh to Monkstown marine crossing. The proposed WWTP for the Cork Lower Harbour area is to be located at a site east of Carrigaline near the townland of Shanbally. This green field site has an area of approximately 7.36 hectares.

Although the scheme has the potential to have positive impacts, significant negative impacts could occur in the absence of suitable mitigation. The proposed storm water outfalls and the treated effluent outfall pipe all lay within the boundary of the Cork Harbour Special Protection Area (SPA). Pipelines associated with the proposal would also have the potential to impact on Monkstown creek NHA and the Owenboy River NHA. Potential impacts associated with the construction phase of the scheme would include habitat loss and the types of pollution and disturbance impacts associated with construction sites. Potential impacts during the operational phase of the scheme would be related to effects on water quality and general impacts due to maintenance requirements. However, with the mitigation measures proposed many of the potential impacts of the scheme can be avoided and the scheme will ensure that the water quality and conservation status of the affected designated areas is maintained while facilitating sustainable development in the lower Cork Harbour area. The proposed development would allow existing untreated effluent outfalls to be replaced with treated outfalls therefore the development should facilitate an improvement in water quality once operational.

This study was carried out with reference as applicable to the Environmental Protection Agency's (EPA) 'Guidelines on the Information to be Contained in Environmental Impact Statements' (March, 2002) and Advice Notes on Current Practice (EPA, 2003), the Institute of Environmental Assessment's 'Guidelines for Baseline Ecological Assessment' (1995), along with experience of 'best practice' in the ecological assessment. Preparation of this section included consultation with:

- National Parks and Wildlife Service (NPWS);
- Environmental Protection Agency (EPA);
- Cork County Council (Cork Co. Co.);
- Botanical Society of the British Isles (BSBI);
- South Western Regional Fisheries Board (SWRFB);
- Department of Communications, Marine and Natural Resources (DCMNR);
- Marine Institute (MI);
- Bat Conservation Ireland (BCI);
- BirdWatch Ireland (BWI);
- Irish Whale and Dolphin Group (IWDG);

- National Roads Authority (NRA);

This report was prepared by Ecofact Environmental Consultants Ltd. on behalf of Mott McDonald Pettit Consulting Engineers.

3.2.1.1 Cork Harbour

Cork Harbour is a large, sheltered bay system, with several river estuaries - principally those of the Rivers Lee, Owenboy, Douglas and Owenacurra. It is connected to the Atlantic Ocean by a narrow inlet between Roche's Point and Crosshaven, at the south of the harbour. The River Lee which flows through Cork City enters the harbour at the north-west, via the West-Passage. The Owenboy River flows through Carrigaline, to the south-east of Cork city, and enters the harbour at Crosshaven, to the south-west of the harbour.

Cork Harbour has a surface water area of around 100km^2 and is a large, sheltered, naturally deepwater harbour. Strong estuarine influences dominate the upper reaches of the harbour in particular. The coastline is mixed, consisting of built infrastructure, shallow cliffs, intertidal mudflats, reedbeds, shingle and rocky foreshores, which are exposed by the tide. The mean range spring and neap tide variations throughout the Harbour are as follows (Source: Cork County Council);

Table 1 Tides in Cork Harbour.

	Mean Spring Tides	**Mean Neap Tides**
Cork	3.93m	2.16m
Passage East	3.72m	2.04m
Cobh	3.70m	2.00m

The bathymetry of the Harbour reflects the morphology of the coastline, with gentle slopes dropping to a depth of 28m near the mouth of the harbour (11m in the channel which is maintained at that depth for navigation). Riverine inputs originate from the Lee, the Owenacurra, the Glashboy and the Owenabue. Freshwater inputs from the Lee are controlled by the ESB dam upstream at Inniscarra. Nutrient loading is primarily from non-point agricultural sources distributed throughout the catchment, but primarily in the upper reaches of the Lee estuary (Source: Cork County Council). Point source discharges have been reduced by the recent Cork Main Drainage Scheme.

Cork Harbour is an important sea port and shipping area. It is an important site for the pharmaceutical and chemical industries, particularly the areas of Ringaskiddy and Little Island in the west and north-west of the area. Also a major oil refinery is located in the east of the harbour, while on Haulbowline Island there is a naval base. Cobh is important for fishing, tourism and recreation with many pleasure boaters and water sports enthusiasts using the harbour (Source: Cork County Council).

The north of the harbour, including the waterfront areas of Cobh is underlain by carboniferous limestone. To the south of this, encompassing Spike Island is an area of shales and sandstones while to the south of the harbour a band of old red sandstones extends across the mouth of the harbour through Crosshaven and Roche's Point. Owing to the sheltered conditions, the inter-tidal flats are often muddy in character (King, 2002).

Rapid industrialisation in the Cork Harbour area along with increased population growth has led to increased vulnerability to pollution in the harbour, water quality is variable, with the estuary of the River Lee and parts of the Inner Harbour being somewhat eutrophic. A study by the Environmental Protection Agency from 1999 to 2003 sampled water in the Lee river, Lee estuary, Lough Mahon, Owenacurra river, Owenacurra estuary, the North Channel of Great Island and in Cork Harbour. Nutrient enrichment was measured as Dissolved Inorganic Nitrogen (DIN) and orthophosphate (MPR) while undesirable disturbance was measured as

percentage saturation of Dissolved Oxygen (DO). The results of this survey are provided in Table 2.

Table 2 Assessment of the trophic status of the main water bodies of Cork Harbour 1999 – 2003. C: Compliant, B: Breach; U: Unpolluted, I: Intermediate, E: Eutrophic (adapted from Toner *et al*, 2005).

Water Body	Chl a (µg/L)(Summer)				DO (%) (Summer)				
	Median		90%ile		5%ile		95%ile		
Lee River	6.7	C	10.4	C	84	C	114	C	U
Lee Estuary	4.6	C	15.4	C	31	B	109	C	I
Lough Mahon	5.6	C	23.8	B	62	B	114	C	E
Owenacurra River	6.7	C	10.4	C	84	C	114	C	I
Owenacurra Estuary	8.4	C	35.9	B	80	C	134	B	E
North Channel Great Island	7.3	C	29.3	B	89	C	123	B	I
Cork Harbour	4.5	C	12.9	C	89	C	112	C	I

Water Body	Salinity				DIN (mg/l N^2)				MRP (µg/L P)			
	Winter	n	Summer	n	Winter		Summer		Winter		Summer	
Lee River	0.1	44	0.1	79	2.4	C	1.8	C	30	C	18	C
Lee Estuary	0	7	8.2	165	3.1	B	1.9	C	15	C	45	C
Lough Mahon	23.6	9	30.7	135	1.4	B	0.4	C	14	C	28	C
Owenacurra River	0.1	24	0	20	6.6	B	6.2	B	32	C	59	B
Owenacurra Estuary	11.6	2	17.6	51	3.2	B	1.3	C	14	C	18	C
North Channel Great Island		0	31.6	45			0.2	C			11	C
Cork Harbour	21.6	2	34.0	71	2.5	B	0	C	7	C	5	C

3.2.2 METHODOLOGY

The current study was carried out as a desk study, and a field assessment. The literature review and field sampling programme was designed primarily as a descriptive study to provide baseline information on the existing ecological status of the area under investigation. An integrated assessment approach was employed. This approach merges biological (effects) and chemical (causes) using a combination of field and desk study evaluations.

3.2.2.1 Desktop Review

A desktop review was carried out to identify features of ecological importance within the study area and surrounding region. A review of areas designated (or being considered) for designation for nature conservation was carried out by consulting the National Parks and Wildlife Service (NPWS). These included Special Areas of Conservation, Special Protection Areas for birds (both internationally important) and proposed Natural Heritage Areas (of national importance). Furthermore, a review of the published literature, including the Cork County Development Plan 2003-2009 was undertaken in order to collate data on species and habitats of conservation concern on and in the immediate environs of the proposed development site. The digital database of the New Atlas of the British and Irish Flora (Preston et *al*, 2002) was consulted to assess the presence of rare plant species recorded from the 10 km square in which the site is located. Likewise, "Exploring Irish Mammals" (Hayden and Harrington, 2000) was used to assess the importance of the study area for mammals. The results of the Irish Wetland Bird Survey (I-WeBS) (Crowe, 2005) were also reviewed. A range of additional sources of information including scientific reports produced by, and information on the websites of the Marine Institute and other agencies were also reviewed. A full bibliography of information sources reviewed is given in the references section. The responses received from statutory and non-statutory consultees consulted directly by Mott McDonald Pettit Consulting Engineers were also reviewed.

The collation of this information, as well as examination of Ordinance Survey Maps 87 and 81 and OS aerial photographs allowed areas of potential ecological importance to be highlighted prior to the field survey.

3.2.2.2 Field Survey Work

Terrestrial Ecology

Field survey comprised a systematic walk over of the proposed site, pump stations and collection system. Much of the pipeline route comprises existing road or built ground. A Phase 1 habitat survey of the site and other affected areas was conducted during June 2007 using methodology developed by the Joint Nature Conservation Committee (1993). Habitats were classified and mapped using habitat descriptions and codes published in the Heritage Council's 'A Guide to Habitat Types in Ireland' (Fossitt, 2000). Plant species nomenclature follows Stace's 'New Flora of the British Isles' (1997). All birds encountered during the course of the surveys were noted and the habitats present on the site were assessed as to their suitability for breeding and wintering bird species. The affected areas were also examined for signs of / or the presence of mammals (including potential bat roosts and badger setts).

Marine Ecology

The marine field survey also a systematic walk over and boat survey of the areas that would be potential affected by the proposed development (i.e. outfalls, areas adjoining pipeline routes etc.). Habitats were classified and mapped using habitat descriptions and codes published in the Heritage Council's 'A Guide to Habitat Types in Ireland' (Fossitt, 2000) and the JNCC 'Marine Habitat Classification for Britain and Ireland' (O'Connor, 2004). A marine fauna assessment of the affected areas was undertaken using JNCC Marine Monitoring methods (Davies *et al*, 2001).

Areas were examined during the low water of spring tides and also from a hired charter boat. Shore (littoral) and sub-littoral sampling was undertaken at 23 stations during low spring tides with a further 4 stations sampled from a boat. The location (including NOS grid references) and methodology used at the 27 stations is given in Tables 3, 4 and 5. Sampling involved the use of quadrates (quadrate area 0.25m^2), cores (0.01m^2) and a hand held grab (AMS type, 0.023 m^3) and conformed to JNCC methodology. Specimens were identified to the lowest possible taxonomic level, counted and weighed. Marine fauna nomenclature follows Barnes' 'The brackish-water fauna of North-western Europe' (1994).

3.2.2.3 Impact Assessment Methodology

The impact significance is a combined function of the value of the affected feature (its ecological importance), the type of impact and the magnitude of the impact. It is necessary to identify the value of ecological features within the study area in order to evaluate the significance and magnitude of possible impacts.

The results of the ecological survey were evaluated to determine the significance of identified features located in the study area on an importance scale ranging from international-national-county-local. The local scale is approximately equivalent to one 10 km square but can be operationally defined to reflect the character of the area of interest. Because most sites will fall within the local scale, this is sub-divided into high local importance to local importance-local value. The criteria used are shown in Table 6.

The means of assessing impact significance is based on the Institute of Ecological and Environmental Management draft guidelines on Ecological Impact Assessment (IEEM 2002). The evaluation methodology used in this assessment is presented in full in Appendix 1. The significance of impacts was assessed on a combined basis of the value of the feature being affected and the magnitude of the impact. Impacts on features of less than local value are not considered to be potentially significant. The terminology used to define impact significance is also described in Appendix 1. Impacts during both Construction and Operation of the proposed development are considered, as are impacts in the Short, Medium and Long term (as per EPA methodology).

Table 3 Locations and descriptions of the JNCC Core sampling stations. A total of 5 cores were taken at each station. Locations are also shown in Appendix 6.

Site Code	Location	Distance from LWMMT	Substrate	Grid reference
C1	Carrigaline. Downstream of bridge. On the north side of the channel.	0	Mud	W 73428 62420
C2	Carrigaline. Downstream of bridge. On the north side of the channel.	3 m below	Mud	W 73751 62349
C3	Carrigaline. Further Downstream of bridge. On the north of the channel.	2 m below	Mud	W 73996 62328
C4	Crosshaven. East of town centre on the southern shore.	10 m above	Mud	W 78312 61361
C5	Glenbrook, Passage West.	7 m below	Mud	W 77180 67863
C6	Great Island. South of River Ferry on east of R. Lee.	3 m below	Mud	W 77569 67318
C7	Rushbrook, Great Island.	5 m below	Mud	W 77520 66606
C8	Cobh. South facing mudflat at Whitepoint.	7 m below	Mud	W 78342 65604

LWMMT = Low water mark of medium tides.

Table 4 Locations and descriptions of the JNCC quadrate sampling stations. A total of 1 m^2 was sampled at each station. Locations are also shown in Appendix 6.

Site Code	Location	Distance from LWMMT	Substrate	Grid reference
Q1	Crosshaven. North of town centre on the southern shore.	15 m above	Mud/cobble	W 78849 61302
Q2	Crosshaven. Just east of the town centre on the southern shore.	10 m above	Rock, cobble, gravel, mud	W 79926 61534
Q3	Ringaskiddy. East-facing beach.	0	Rock, cobble	W 79081 63244
Q4	Ringaskiddy. East-facing beach.	0	Bedrock, boulder, cobble	W 79197 63603
Q5	Ringaskiddy. North-facing beach. Opposite Whitepoint, Cobh.	2 m above	Cobble, gravel, sand	W 78179 64636
Q6	Monkstown. Northern end of town on the western shore. North of pier.	1 m below	Mussels, sand, mud	W 77230 66451
Q7	Monkstown. Just south of River Ferry.	3 m below	Gravel, sand mud	W 77170 67427
Q8	Monkstown / Passage West. North of River Ferry.	5 m below	Rock, mud	W 77152 67695
Q9	Passage West. Near slipway at bottom of public green.	0	Rock, cobble	W 76620 69187
Q10	Great Island. Just north of River Ferry on east of R. Lee.	2m above	Cobble, gravel, mud	W 77587 67778
Q11	Great Island. South of River Ferry on east of R. Lee.	0	Gravel, cobble	W 77555 67495
Q12	Whitepoint, Cobh.	0	Cobble, gravel, mud	W 78544 65775
Q13	East Beach, Cobh. Bottom of the steps to the east of Lynch's Quay.	1 m below	Gravel	W 80071 66447
Q14	Cobh. East of red chimney stack.	3m below	Cobble, shingle	W 80420 66534
Q15	Cobh. Just east of fishing quay.	2m below	Cobble, bedrock	W 80877 66565

Table 5 Locations and descriptions of the grab sampling stations. A total of 5 grabs were taken at each station. Locations are also shown in Appendix 6.

Site	Location	Depth(m) LWMT	Substrate	Grid Reference
G1	IDA outfall pipe, to the west of Carlisle fort.	7.0	Sand	W 81576 63060
G2	IDA outfall pipe, to the west of Carlisle fort.	7.6	Sand	W 80927 62810
G3	Proposed pipeline crossing at West Passage. North side.	7.0	Silt / mud	W 77535 67616
G4	Proposed pipeline crossing at West Passage. South side.	8.2	Silt / mud	W 77184 67277

Table 6 Criteria used in assessing the ecological importance of ecological features.

Importance	Criteria
International	An internationally designated site or candidate site (SPA, pSPA, SAC, pSAC, Ramsar Site, Biogenetic Reserve). Also Sites which qualify for designation as SACs or SPAs – this includes sites on the NGO shadow list of SAC's.
National	A nationally designated site or candidate site (NHA, pNHA) (unfortunately there is no published criteria used in selecting these areas). Sites which hold Red Data Book (Curtis and McGough, 1988) plant species.
County	Sites which hold nationally scarce plant species (recorded from less than 65 10 km squares), unless they are locally abundant. Sites which hold semi-natural habitats likely to be of rare occurrence within the county. Sites which hold the best examples of a semi-natural habitat type within the county.
High Local Importance	Sites which hold semi-natural habitats and/or species likely to be of rare occurrence within the local area. Sites which hold the best examples of a high quality semi-natural habitat type within the local area.
Local Importance	Sites which hold high quality semi-natural habitats
Local Value	Any semi-natural habitat

3.2.3 EXISTING ENVIRONMENT

3.2.3.1 Background

It is proposed to develop a new wastewater treatment plant on an area of 7.36 ha to the northeast of the town of Carrigaline. This new wastewater treatment will facilitate the towns of Carrigaline, Monkstown, Passage West, Cobh and Ringaskiddy.

Foul effluent from these areas will be pumped to the new site of the proposed treatment plant via pipes located underneath roads or pipelines located through fields. With regard to the town of Cobh, all effluent will be pumped to the western shore of Great Island before being pumped to Monkstown via a pipe extending across the channel. From Monkstown the effluent will be pumped by means of a series of pipelines to the wastewater treatment plant. The construction will involve the excavation of many roadways throughout these areas in addition to the excavation of sections of green fields within the vicinity. The layout of the proposed development is shown in Figure 1.

3.2.3.2 Receiving Environment

Designated Areas

Designated areas in the vicinity of the proposed development works are shown in Figure 2 and Appendix 2. NPWS site synopses for these sites are also provided in this appendix. Parts of the proposed development are located within the Cork Harbour Special Protection Area (SPA) for birds (Site Code 004030). The Cork Harbour SPA is an internationally important wetland site, regularly supporting in excess of 20,000 wintering waterfowl. Several of the species which occur regularly within Cork Harbour are listed on Annex I of the E.U. Birds Directive, i.e. Whooper Swan, Golden Plover, Bar-tailed Godwit, Ruff and Common Tern. Proposed works associated with the development are located within 2km of the Great Island channel Special Area of Conservation (SAC) (Site Code: 0001058). The Great Island Channel stretches from Little Island to Midleton. It is designated due to the presence of the Annex I habitats; mudflats and Atlantic salt meadows.

Two nationally important designated areas are also directly affected by the proposed development. These are Monkstown creek Natural Heritage Area (NHA) (Site Code 001979) and the Owenboy River NHA (Site Code 001990). Sections of pipeline associated with the proposed scheme would run along the boundary of these sites (within the above SPA). Both of these designated areas are of national importance to wintering water birds. Table 6 provides a list of designated areas within the study area and indicates their distance from areas affected by the proposed development.

Evaluation: Sites designated as SAC's and SPA's are recognised as being of international importance. The study area includes areas designated as an SPA and NHA. The study area is of international importance due to the abundance of important bird species and also the presence of internationally important coastal habitats.

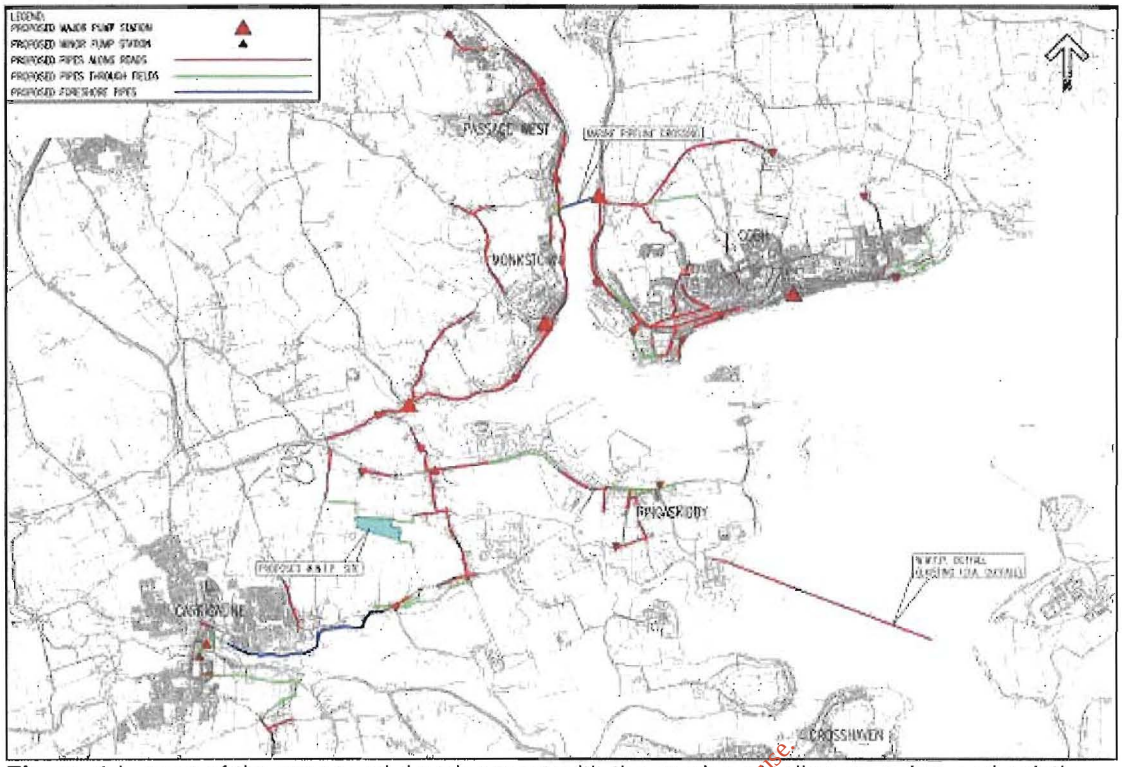

Figure 1 Layout of the proposed development with the marine pipeline crossing and existing outfall indicated.

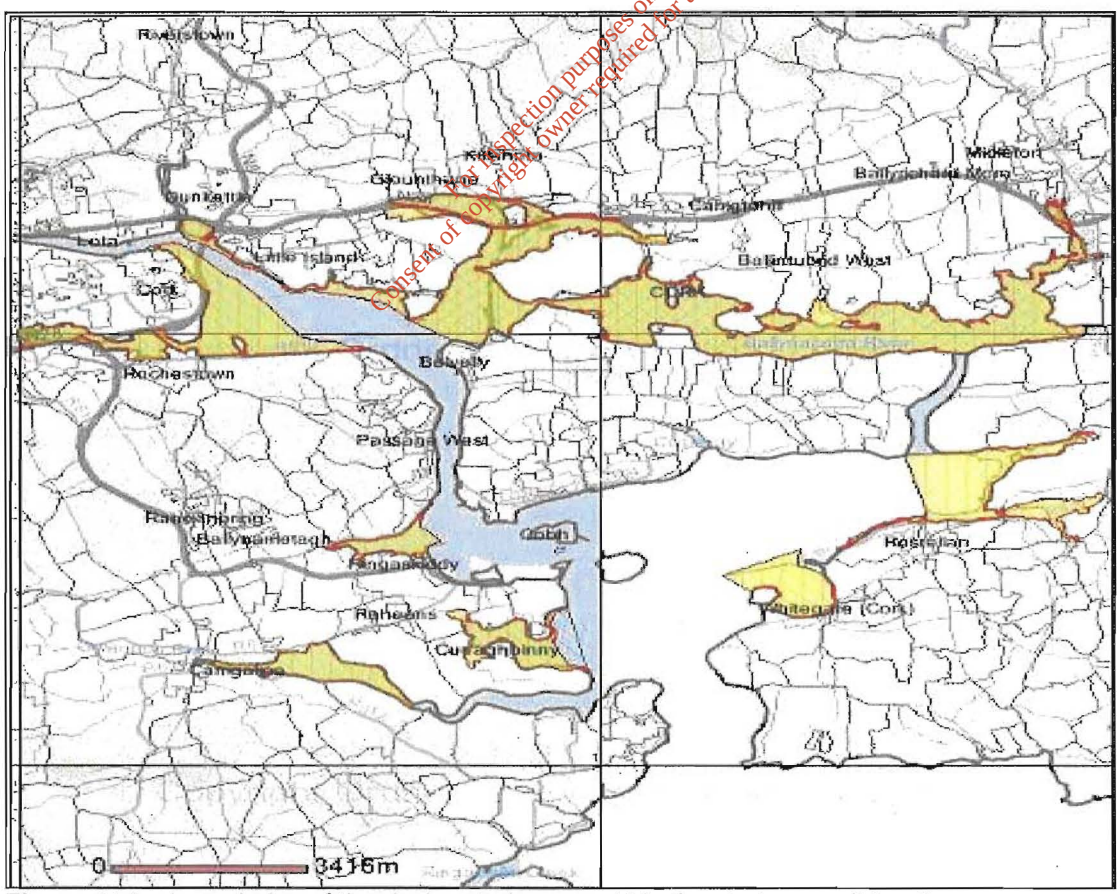

Figure 2 The boundaries of the designated areas within the study area (Map Source – NPWS. © Ordnance Survey Ireland. All rights reserved. Licence number Cork County Council CCMA 2004/07. See Appendix 2 for more information including NPWS Site Synopses of designated areas.

Table 7 Summary details of the Great Island channel SAC, Cork Harbour SPA and surrounding NHA's. See Appendix 2 for further details.

Name	Site Code	Designation	Distance from development areas	Notes
Great Island Channel	001058	S.A.C/ NHA	2km north east of passage west	Annex I habitats: mudflats and Atlantic salt meadows
Cork Harbour	004030	SPA	Mainly away from the proposed development areas. Pipelines run along the boundary near Carrigaline and Monkstown.	Annex I habitats mudflats and salt marshes Annex I species of the E.U. Birds Directive, i.e. Whooper Swan, Golden Plover, Bar-tailed Godwit, Ruff and Common Tern.
Templebreedy National school	000107	NHA	3.5km south of Ringaskiddy	Bat roost.
Douglas River	001046	NHA	4km west of Passage west	Estuarine area
Lough Beg	001066	NHA	0.5km south of Ringaskiddy	Mud flats/ wet grassland
Rockfarm Quarry	001074	NHA	1.4km north of Passage	
Rostellan lough, Aghada shore and Poulnabiba inlet	001076	NHA	3.2 km east of Cobh	Waterfowl
Dunkettle Shore	001082	NHA	4.2 km north east of Passage	Mud flats and sand flats
Whitegate Bay	001084	NHA	2 km east of Crosshaven	Mud flats and sand flats
Monkstown creek	001979	NHA	Directly affected by foreshore pipelines in the vicinity the above SPA	Mudflats and sandflats
Cuskinny Marsh	001987	NHA	Located 0.1 km east of development area	Semi natural woodland, waterfowl
Owenboy River	001990	NHA	Directly affected by foreshore pipelines in the vicinity the above SPA	Waterfowl

Table 8 Qualifying Interests of Great Island Channel SAC / Cork Harbour SPA

Site Code	Site Name	EU Habitat Code	Habitat Description
001058	Great Island Channel	1140	Mudflats and sandflats not covered by seawater at low tide
001058	Great Island Channel	1330	Atlantic salt meadows (Glauco-Puccinellietalia maritimae)

Flora and habitats

Following the Phase 1 habitat survey and marine habitat survey of the affected area, the different habitat types (as classified according to Fossitt, 2000 and O'Connor, 2004) were identified. The following is a description of the various habitats found within the affected areas. The habitat code according to Fossitt is in brackets after the habitat name. The habitats present in both terrestrial and coastal areas recorded in the study during the June 2007 survey are discussed below. The habitats of selected marine areas are indicated in Figure 3. Figure 4 shows the boundaries of local designated areas.

The proposed site for the wastewater treatment plant is located on an area of improved agricultural grassland. This area is intensively used for grazing by dairy cattle. This grassland is species poor and is dominated by rye grass *Lolium perenne*, meadow grasses *Poa* spp. and white clover *Trifolium repens*. Agricultural herbaceous species such as the common sorrel *Rumex acetosa*, broad leaved dock *Rumex obtusifolius*, thistles *Cirsium arvense*, *C. vulgare* and nettles *Urtica dioica* also occur frequently within this habitat. This habitat has a reduced plant biodiversity. The plant community is influenced by nutrient enrichment which results primarily in a grassland monoculture of grass species. Consequently this area is of local value only.

Hedgerows are located through the centre and around the field boundaries of the proposed wastewater treatment plant area. The hedgerow located through the centre of the site appears to be planted and is dominated by hawthorn *Crataegus monogyna*. However at the northern end of this hedgerow gorse *Ulex europeaus*, bramble *Rubus fruticosus* and cleaver *Galium aparine* become more common. The hedgerow located around the boundary of the site is dominated by gorse and hawthorn with abundant bramble and nettles. Also common are honeysuckle *Lonicera periclymenum*, blackthorn *Prunus spinosa*, dog rose *Rosa canina* and elder *Sambucus nigra.* Hedgerows are present along the field road boundaries throughout the development area. These habitats are an important aspect of the Irish landscape, as well as being of value as wildlife corridors. Hedgerow habitats are of high local ecological importance.

The existing pumping station at Church Rd, Carrigaline is located upon artificial surfaces. The four proposed pumping stations are partially situated on artificial surfaces. This is a habitat of low ecological value which supports little or no plant species due to consistent anthropogenic activity. This habitat contains little or no plant species and is therefore of little ecological significance.

Treelines are located nearby the proposed Monkstown pumping station. Tree species present within this habitat include beech, ash horse chestnut *Aesculus hippocastanum*, sycamore and poplar *Populus* spp. Treelines are usually planted for aesthetic or shelter purposes. They may be of some use to birdlife for feeding and nesting. Treelines are of local ecological importance.

Areas of amenity grassland are located nearby the site for the proposed Monkstown pumping station. Amenity grassland is dominated by grass species such as plantains; in particular ribwort plantain *Plantago lanceolata* and meadow grasses Poa spp. Broadleaf herbs are dominated by clovers *Trifolium* spp. dandelion *Taraxacum* spp and daisy *Bellis perennis*. This habitat is commonly used for recreational activities and is generally managed through frequent fertiliser application and mowing. This is a habitat of local ecological value.

Mud shore habitat occurs immediately south of the proposed Raffeen pumping station. These mud shores are formed primarily of very fine sediment and along the most sheltered sections of coastline. They are subject to variable, reduced or low salinity. The mud shores were found to support communities of polychaete worms (e.g. estuary ragworm and *Nephytes spp.).* This habitat is dominated by open areas of mud and is a feeding area for estuarine birds. This habitat is situated within the Monkstown Creek NHA and thus is categorised as being of national importance

Mixed substrata shore occurs near the proposed Carrigaloe pumping station. The shore comprises a mixture of rock and sediment; the sediments included gravel sand and mud. These shores occurred in moderately exposed to sheltered locations. Fucoid cover was incomplete at these habitats. This habitat is not located within a designated area and thus is categorised as an area of high local importance.

Sheltered rocky shore habitat occurs on the southern coast of the Great Island and near the proposed West beach pumping station. These habitats include sheltered to extremely sheltered rocky shores of bedrock, and stable accumulations of boulders, cobbles and pebbles. Dense growths of fucoids occurred. This habitat is of high local ecological importance.

The Owenboy and Monkstown Creeks are estuaries. These habitats are located nearby the existing Church rd and the proposed Raffeen pumping stations. This habitat type corresponds loosely with the EU Annex I Habitats 'Estuaries (1130) and 'Large shallow inlets and bays' (1160) and so is of international importance.

Terrestrial habitats

Improved Agricultural Grassland (GA1): The majority of the proposed routes running through fields are located on improved agricultural grassland. These habitats are utilised primarily for dairy and beef farming. This generally involves the intensification of farming practices (manuring, artificial fertilisation) in order to achieve optimum grassland conditions. Most of the areas located along the pipeline route are dominated by grass species such as rye grass, meadow grasses, Yorkshire fog *Holcus lanatus* and the common herbaceous species associated with agriculture i.e. the common sorrel *Rumex acetosa*, broad leaved dock *Rumex obtusifolius*, thistles *Cirsium arvense*, *C. vulgare* and nettles *Urtica dioica*.

Evaluation: These areas have reduced plant biodiversity. The plant community is influenced by nutrient enrichment which results primarily in a grassland monoculture of grass species. Consequently this area is of local value only.

Hedgerows (WL1): Hedgerows are located nearby the pipeline routes that are located on the nearby agricultural land areas. These habitats are dominated by hawthorn and blackthorn with species such as bramble, elder, honeysuckle, dog rose and ivy *Hedera helix* also occurring frequently. Other herbaceous species common within this habitat include navelwort *Umbilicus rupestris*, cleaver, speedwells *Veronica* spp, bush vetch *Vicia sepium* and tufted vetch *Vicia cracca*. Large deciduous trees such as ash *Fraxinus excelsior*, sessile oak *Quercus petraea*, pedunculate oak *Quercus robur*, sycamore *Acer pseudoplatanus* and beech *Fagus sylvatica* also occur occasionally on the hedgerows situated within the proposed pipeline routes.

Evaluation: Hedgerows are present along field and road boundaries throughout most of the development area. These habitats are an important aspect of the Irish landscape, as well as being of value as wildlife corridors. Hedgerow habitats are of high local ecological importance.

Mixed Broad leaved woodland (WD1): An area of mixed broad leaved woodland is present along the southern area of Cobh, a route taken by the proposed pipeline. This area of woodland which appears to be planted is dominated by sycamore *Acer pseudoplatanus*. Ash, sessile oak and beech *Fagus* sp. also occur occasionally. The shrub layer of the woodland contains many garden escapes such as Portugal laurel *Prunus lusitanica*, Fuschia *Fuschia magellanica*, juniper *Juniperus communis* and snowberry *Symphoricarpos albus* in addition to abundant bramble and nettles.

Evaluation: This is a fragmented area of woodland, possibly planted as part of a nearby demesne. It is dominated by the non native sycamore in addition to a shrub layer that contains many non native garden escapes. However this area of woodland may act as a wildlife corridor for mammals and a nesting area for bird species. This habitat is of high local ecological importance.

Treelines (WL2): Treelines are located along many of the proposed pipeline routes, both beside roadways and around field boundaries. Many of these treelines were also planted as shelter belts near dwellings. Tree species present within this habitat include beech, ash and oak while Scots pine *Pinus sylvestris*, horse chestnut *Aesculus hippocastanum*, sycamore and poplar *Populus* spp. are also common.

Evaluation: Treelines are usually planted for aesthetic or shelter purposes. They may be of some use to birdlife for feeding and nesting. Treelines are of local ecological importance.

Arable crops (BC1): Fields of wheat *Triticum* spp are located to the south of the proposed site for the wastewater treatment plant. Other areas located nearby the proposed pipeline routes

contain arable crops such as barley *Hordeum vulgare*, oats *Avena sativa* and potatoes *Solanum tuberosum*.

Evaluation: In general these habitats are highly modified and use of herbicides ensures that plant diversity is kept to a minimum. This habitat is of local ecological value.

Tilled land (BC3): An area of tilled land is located to the south of the proposed site for the wastewater treatment plant. This habitat is of local ecological importance.

Evaluation: This habitat is of local ecological importance.

Stones walls (BL1): Stone walls are located on some road and field boundaries throughout the site and pipeline routes. The stone walls in these are generally composed of shale and sandstone that typifies the geology of this area of Ireland. The common plant species include ivy, navelwort, hedge bindweed *Calystegia sepium*, bryophytes and ferns *Asplenium* spp, *Polypodium* spp.

Evaluation: Stone wall habitats that are not bound with mortar often contain diverse macroinvertebrate communities. These in turn are utilised as a food source by many birds and small mammals. As a result these habitats are an important food source in for terrestrial animals and are of local ecological importance.

Artificial surfaces (BL3): Artificial surfaces are located throughout the proposed development areas. This includes the roadways located along and the buildings located beside the proposed pipeline routes. Most of these roadways are not vegetated. The centre of the roadway leading to the proposed site of the wastewater treatment plant is vegetated by meadow grasses and plantains. Also sections of all five pumping stations are located upon areas of artificial surfaces.

Evaluation: These areas contain little or no plant species and are therefore of little ecological significance.

Grassy verges (GS2): Grassy verges are present beside most of the proposed pipelines located upon roadways. These habitats are dominated by grass species such as ribwort plantain *Plantago lanceolata*, cocksfoot *Dactylis glomerata*, bent grasses *Agrostis* spp, meadow grasses *Poa* spp and hairy brome *Bromopsis ramosa*. Herbaceous species such as vetch *Vicia* spp., cow parsley *Anthriscus sylvestris*, hogweed *Heracleum sphondylium*, nettles, thistles *Cirsium* spp., black knapweed *Centaurea nigra* and foxglove *Digitalis pupurea* are common along the roadside verges of the proposed pipeline routes. Wetter roadside areas contain abundant silverweed *Potentilla anserina.* Some shrubs and tree saplings also grow within this habitat and include ash, sycamore, hawthorn, blackthorn and gorse.

Evaluation: These habitats are generally located beside areas of intense anthropogenic use i.e. roads. However they generally support a moderately diverse assemblage of grasses and herbs due to an absence of fertilisation and repeated mowing. Like hedgerows, grassy verges may act as a corridor for wildlife present in the nearby area. This habitat is of local ecological importance.

Ornamental/ non native shrub (WS3): This habitat is located within garden areas that will be impacted by the proposed development works. The area where these habitats will be affected by the proposed pipeline route is located just east of the Cobh to Cork roadway R624, opposite the dockyard area. These habitats are present in garden areas of private dwellings. Plants include *Griselinia* spp., *Escalonia* spp, *fuscia Fuschia magellanica*, Portugese laurel *Prunus lusitanica* and Lawson's cypress *Chamaecyparis lawsoniana*.

Evaluation: This habitat contains many non native species introduced into garden and park areas for aesthetic purposes. Therefore this habitat is of local ecological value.

Spoil and bare ground (ED2): Areas of spoil are located nearby two of the proposed pipeline routes near the centre of the great Island. Spoil heaps have been created through the excavation of soil to possibly facilitate the laying of a pipeline. These habitats contained little plant diversity as they were recently excavated and colonisation of ruderal species has not yet occurred.

Evaluation: This habitat contains no plant species and is considered to be of little ecological significance.

Marine/estuarine habitats

Estuaries (MW4) and Sea inlets and Bays (MW2): Cork harbour and the River Lee channel at Passage West / Monkstown is a continuum between the above habitats. The Owenboy and Monkstown Creeks are estuaries. The salinity of these areas is variable due to riverine inputs and tidal currents.

Evaluation: This habitat type corresponds loosely with the EU Annex I Habitats 'Estuaries (1130) and 'Large shallow inlets and bays' (1160) and so is of international importance.

Infralittoral gravels and sands (SS1): This habitat is present in Cork Harbour at Haulbowline and also along the existing IDA pipeline in a moderately exposed to sheltered environment. The faunal communities here are influenced by high levels of disturbance from wave action or tidal currents and include robust fauna such as bivalve molluscs, anemones and robust polychete worms.

Evaluation: Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. This habitat has links to the Annex I habitat 'Sandbanks which are slightly covered by seawater all the time' (1110).

Infralittoral muds (SS3): This habitat occurs in the river channel at Monkstown / Passage-West and consists of sandy muds and soft muds, with conditions ranging from fully marine to estuarine. The only plant or animal life recovered from this area during grab sampling were ragworms (*Hediste diversicolor*).

Evaluation: Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. Other areas are of high local importance.

Sea walls, piers and jetties (CC1): Sea walls are situated along the R610, the road leading to Monkstown and Passage West, at Rushbrook and at Cobh. This roadway is on one of the proposed pipeline routes. This habitat generally contains few species. Polypody fern *Polypodium* spp, herb robert *Geranium robertanium* and the salt tolerant grass red fescue *Festuca rubra* were recorded in sections of this habitat.

Evaluation: This is a highly modified habitat but is of local importance.

Shingle and gravel shores (LS1): This habitat is present at East Beach, Cobh. This is a moderately exposed shore with accumulations of mobile rocky material. Sediments here comprise mainly shingle, gravel and shells. Coarse mobile sediments typically support little marine life other than opportunist amphipod and isopod crustaceans and oligochete worms.

Evaluation: Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. Other areas are of high local importance.

Mud shore (LS4): This habitat occurs frequently within the harbour system; at Carrigaline, at Crosshaven, to the east of the town centre on the southern shore, at Passage- West at both sides of the river and at Rushbrook and Whitepoint, both on Great Island. These mud shores

are formed primarily of very fine sediment and along the most sheltered sections of coastline. They are subject to variable, reduced or low salinity. The mud shores were found to support communities of polychaete worms (e.g. estuary ragworm and *Nephytes spp.)*. One Oligochete worm, usually present where there is significant freshwater influence, was found at the uppermost site at Carrigaline.

Evaluation: This habitat is dominated by open areas of mud and is a feeding area for estuarine birds. Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. Other areas are of high local importance.

Sand Shore (LS2): This habitat occurs at Ringaskiddy, on the east facing beach. This is a sheltered shore of medium and fine grained sand, with a small proportion of mud. Scattered stones or shells occur on the surface. Mobile sand of the upper shore is typically impoverished of animal and plant life with the lower shore characterised by amphipod and isopod crustaceans, with some polychaete worms and bivalve mussels.

Evaluation: Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. Other areas are of high local importance.

Mixed sediment shore (LS5): This habitat occurs at Crosshaven, east of town centre on the southern shore. It is a sheltered shore with poorly sorted mixes of sediments of different grades. It supports some fucoids (*Fucus serratus,* Carragheen *(Chondrus crispus) and* sea lettuce *(Ulva lactula*). The habitat did not hold an abundance of fauna with Gammaridae, shore crabs and flat periwinkles found.

Evaluation: This habitat is dominated by open areas of mixed substrate. Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. Other areas are of high local importance.

Moderately exposed rocky shore (LR2): This habitat occurs at the eastern end of Cobh and at the east facing beach at Ringaskiddy. These consisted of moderately exposed shores of bedrock, boulders and stable cobbles. These shores were dominated by communities of barnacles, molluscs such as periwinkles, with bivalves also present. Common mussel beds occurred at Cobh. Fucoid cover was incomplete at these habitats.

Evaluation: This habitat forms shelter for a variety of marine/estuarine organisms. Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. Other areas are of high local importance.

Sheltered rocky shore (LR3): This habitat occurs at Passage West, near the bottom of the slipway at the end of a public green and at Whitepoint (at the southern tip of Great Island). These habitats include sheltered to extremely sheltered rocky shores of bedrock, and stable accumulations of boulders, cobbles and pebbles. Dense growths of fucoids occurred. The sheltered rocky shores surveyed were found to contain a diverse range of macro-fauna with barnacles (*Eliminus modestus*) Keel worms (*Pomatoceros lamarcki*) especially abundant.

Evaluation: This habitat is of high local ecological importance. Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance.

Mixed substrata shore (LR4): This habitat occurs at Crosshaven, just east of the town centre on the southern shore, at Ringaskiddy, on the north facing beach opposite Whitepoint and at Monkstown/ Passage West on both sides of the river. In these areas the shore comprises a mixture of rock and sediment, the sediments included gravel sand and mud. These shores occurred in moderately exposed to sheltered locations and macro-fauna included the

common mussel, periwinkles (*Littorina spp.*), and barnacles. Fucoid cover was incomplete at these habitats.

Evaluation: Areas of this habitat within an NHA must be assessed as being of national importance. Areas of this habitat within an SPA must be assessed as being of international importance. Other areas are of high local importance.

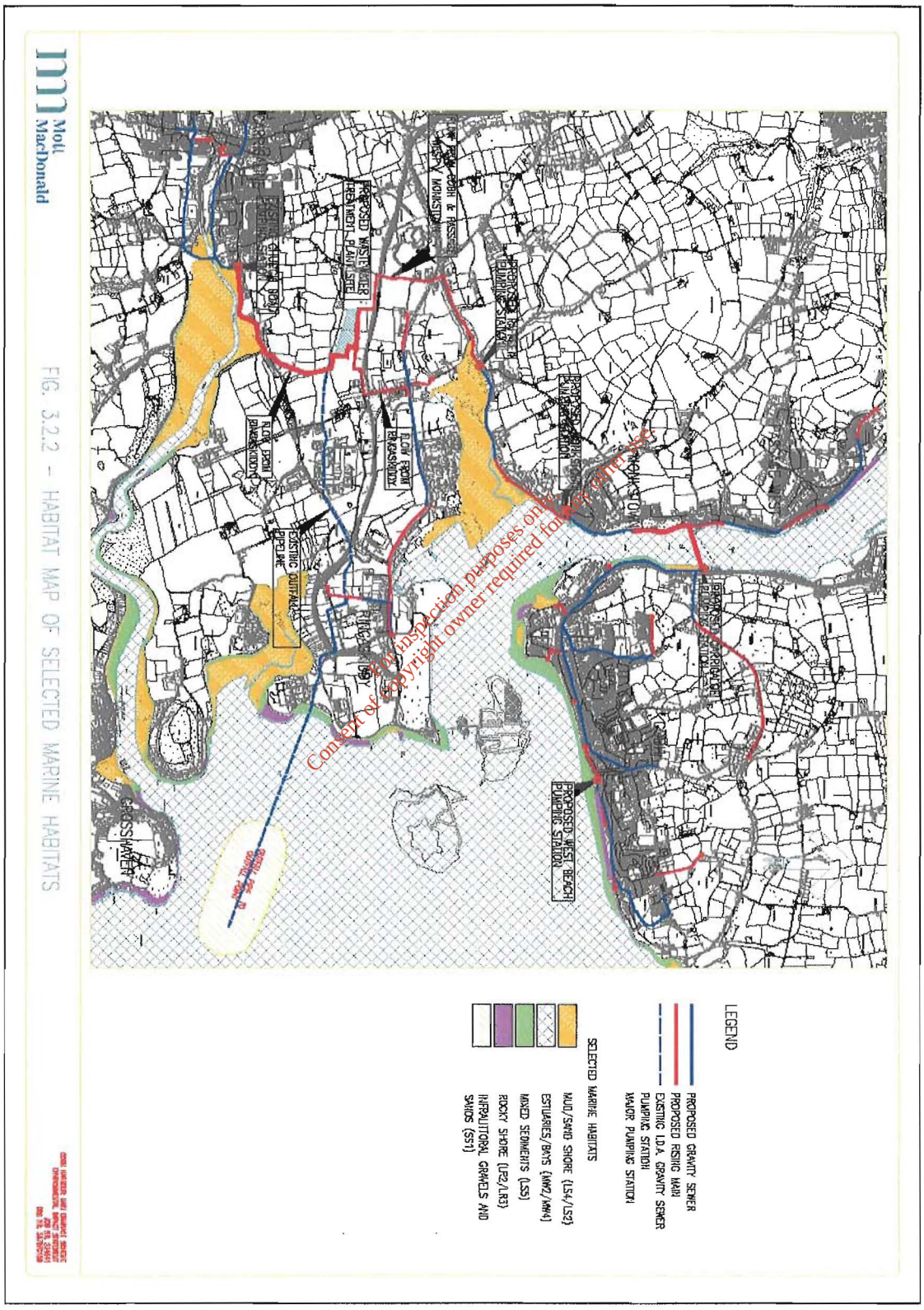

Figure 3 Selected marine habitats in the vicinity of the proposed development.

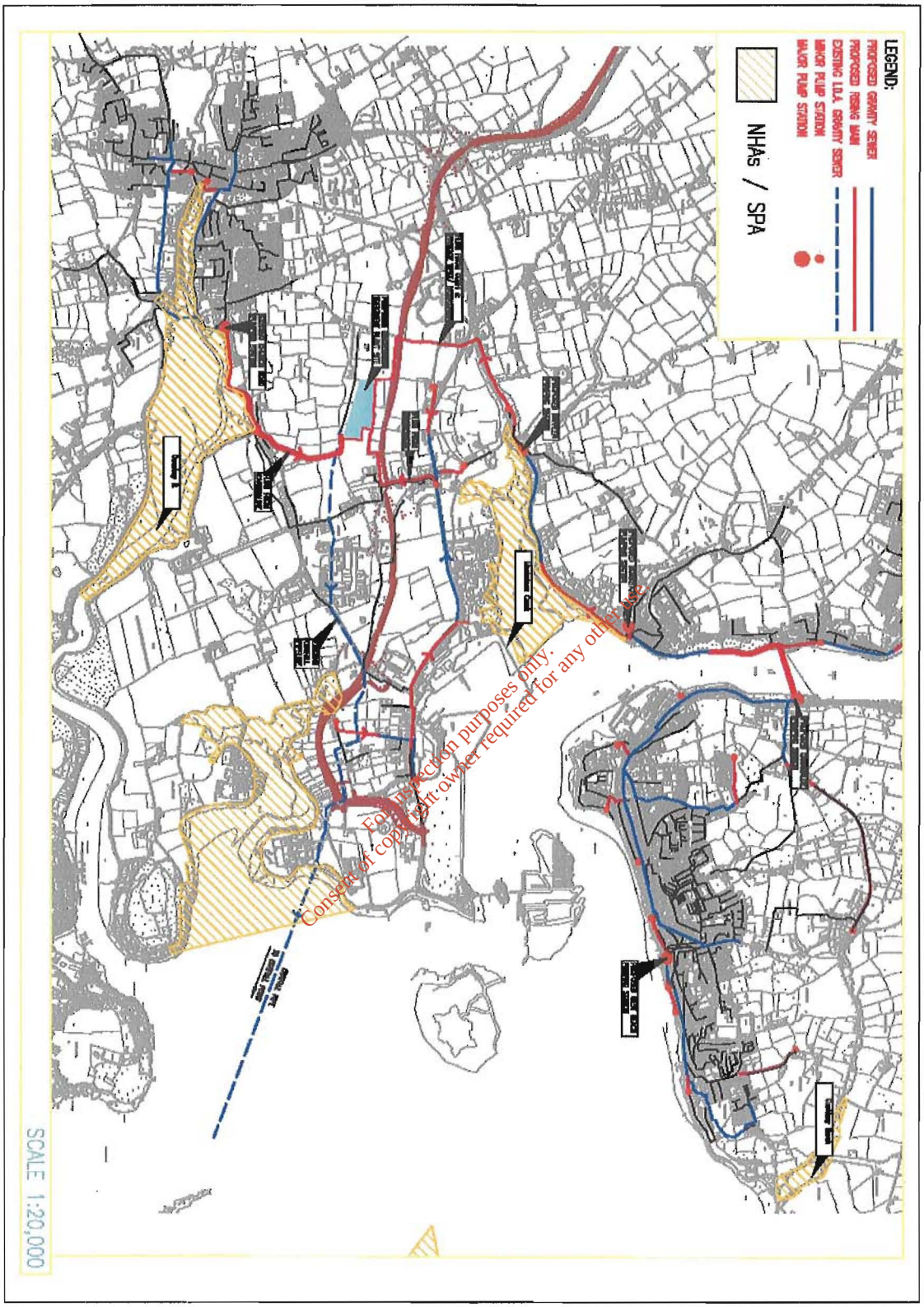

Figure 4 Boundary of the Owenboy River NHA, Monkstown Creek NHA, Cuskinny Marsh NHA and the Cork Harbour SPA in the vicinity of the proposed development.

Rare plant species

Common plant species recorded during the field survey are detailed in the habitat descriptions above. During the field survey, the habitats were also assessed as to their potential suitability for rare plants. The proposed development areas lay within three 10km square Ordnance Survey Grids W 76, W 77 and W 86. A plant species list for these three 10km square was generated from the CD-Rom version of the *New Atlas of British and Irish Flora* (Preston *et. al.,* 2002). This list was then compared to the lists of species protected under the Flora (Protection) Order of 1999; and those included in the Irish Red Data Book (Curtis and McGough, 1988).

Autumn knawel *Scleranthus annuus* is recorded by Preston *et al.* (2002) as being present in each of the three 10km squares W 76, W 77 and W 86 (recorded pre 1970). This species is included in the Irish Red Data Book on the basis of its protected status in the Republic of Ireland. Curtis and McGough (1988) describe this as a data deficient species. It occurs on waste places and roadsides on dry sandy soils. No optimal habitat for this species occurs in the study area and it was not recorded during the current survey.

Meadow barley *Hordeum secalinum*, is recorded by Preston *et al.* (2002) as being present in the 10km square W76 and W77 (recorded pre 1970). This species is included in the Irish Red Data Book on the basis of its protected status in the Republic of Ireland. Curtis and McGough (1988) describe this as a vulnerable species. It occurs mostly on damp heavy soils and has been recorded on meadows bordering estuaries. It is declining due to reclamation and embankment of lands fringing estuaries. However, no suitable habitat occurs in the vicinity of the proposed development due to nearby intensive agriculture.

Penny royal *Mentha pulegium*, was also recorded by Preston *et al.* (2002) as being present in the 10km square W76 (recorded pre 1970). It is a short lived perennial herb of seasonally inundated grassland overlying silt and clay. Penny royal is included in the Irish Red Data Book on the basis of its protected status in the Republic of Ireland. Curtis and McGough (1988) describe this as an endangered species. No suitable habitat for this species occurs in the study area and it was not recorded during the current survey.

Meadow saxifrage *Saxifraga granulata* is a perennial herb with a bulbiliferous rhizome, growing in moist but well-drained, often lightly grazed, base-rich and neutral grassland, in unimproved pastures and hay meadows, and on grassy banks. More rarely, it occurs on shaded river banks and in damp woodland. This plant was recorded by Preston *et al.* (2002) as being present within the 10km squares W67 and W86. Curtis and McGough (1988) describe this as a critically endangered species. This plant not recorded during the current survey and again habitats for this species are unsuitable in the areas surveyed.

Rough poppy *Papaver hybridum* is recorded by Preston *et al* (2002) as being present within the 10km square W77 (recorded pre 1970). It is common on sand and gravel areas. This species was initially thought to be extinct in Ireland until recently where it was found in a neglected barley field in north county Dublin. The decline in this species is attributed to improved methods of seed cleaning and weed control, in addition to a decline in tillage practices. Curtis and McGough (1988) describe *Papaver hybridum* as a critically endangered species. Again no evidence of this plant was recorded in the areas surveyed and it is considered that this plant species is unlikely to occur in the areas affected.

Red hemp nettle *Galeopsis angustifolia*, an annual of arable land, waste places and open ground on calcareous substrates, (including limestone pavements and scree) also found on eskers and on coastal sand and shingle is recorded by Preston *et al* (2002) as being present within the 10km square W77 (recorded pre 1970). Curtis and McGough (1988) describe the red hemp nettle as an endangered species. This plant was not recorded during the current survey and no suitable habitat for this plant was recorded during the current investigations.

Weasel's snout *Misopates orontium* is an annual of light soils, found in arable and other cultivated ground including among horticultural crops, and in gardens and waste places. This species was recorded by Preston *et al* (2002) as being present within the 10km square W67

and W76 (pre 1970) but it was not recorded in the affected areas surveyed. Webb *et al.* (1996) reported weasel's snout to be established in arable fields in Co. Cork. Curtis and McGough (1988) categorise weasel's snout as an endangered species.

None of these species were recorded during the current survey and habitats recorded are generally sub-optimal for the above species. These plant species have all been recorded by BSBI recorders in this general area of Cork previous to 1970.

Fauna

Birds

Estuarine birds: Cork Harbour is an area of international importance for wintering waterfowl (i.e. wildfowl and waders)[1]. Cork Harbour is recognised as one of the most important wetlands in the country with total counts of just under 30,000 waterfowl annually between 1999 and 2005 (see Appendix 4). Of particular note is that the site supports an internationally important population of Redshank and Black-tailed Godwit. A further 15 species present in the site have populations of national importance (Crowe, 2005).The importance of Cork Harbour for wintering waterfowl (i.e. wildfowl and waders) has been recognised through the designation of sections of Cork Harbour as a Special Protection Area for Birds (SPA site code 4030) under the EU Birds Directive (79/409/EEC). Sections of the harbour are also designated a candidate Special Area of Conservation and proposed Natural Heritage Areas. The SPA site synopsis for Cork Harbour is provided in Appendix 1.

The waterbird populations of Cork Harbour have been monitored periodically since the 1970's (Smiddy *et al*, 1995; Gittings, 1996). Since the winter of 1994/95, annual monitoring of the area has also been carried out as part of the Irish Wetland Bird Survey (I-WeBS). A review of the birds of Cork Harbour has recently been provided in the book 'Ireland's Wetlands and their Waterbirds: Status and Distribution' by Crowe (2005). According to Crowe (2005), the wildfowl and wader population of Cork Harbour is usually taken as a single population as they move readily among subsites depending on tidal state and feeding conditions. However, the Douglas Estuary and Dunkettle in the northwest of the harbour are the most important areas, particularly for Shelduck and several wader species, including Golden Plover, Lapwing, Dunlin, Black-tailed Godwit, Bar-tailed Godwit and Redshank. All regularly occur there in nationally important numbers. The Douglas Estuary is known to be a very important high tide roost. An area of adjacent pasture provides secure roosting area for several wader species, and a feeding area for Wigeon. The Dunkettle mudflats are rich in invertebrates, and attract large numbers of feeding waders. Adjacent waste ground resulting from land reclamation, has also proven attractive as a high tide roost.

Crowe (2005) reports that the southern shore of Little Island (north shore of Lough Mahon) is used as a feeding area by many species, including Black-tailed Godwit. However, not many birds remain there at high tide, although some groups of mixed wader species, including Oystercatcher, Grey Plover and Dunlin, do roost along the shore and on one or two of the disused piers. The north channel subsites, east of Marino Point to Ballynacorra, support nationally important numbers of Cormorant, Shelduck, Pintail, Golden Plover, Lapwing, Dunlin, Black-tailed Godwit and Redshank. All mudflats support feeding birds, and the main roost sites are located at Weir Island and Brown Island and to the north of Fota Island at Killacloyne and Harper's Island. Crowe (2005) also reports that further east Ahanesk also supports a roost, but comments that this is highly sensitive and subject to disturbance.

Harper's Island regularly supports nationally important numbers of Shelduck, Black-tailed Godwit and Redshank, and occasionally Lapwing and Dunlin. Numbers of Black-tailed Godwit occasionally reach international importance. The polder area in the north section is used for

[1] For bird sites, a wetland qualities for international importance if it regularly holds at least 20,000 waterfowl or at least 1% of the population of a species.

feeding and roosting, particularly when fields are wet. Crowe (2005) comments that Brown Island is also important, supporting internationally important numbers of Black-tailed Godwit, and occasionally nationally important numbers of Dunlin.

In the southwest of the harbour, Dunlin, Redshank and Curlew regularly frequent the Owenboy Estuary (Crowe, 2005). Occasionally large wader roosts form in fields near Rabbit Point at high tide. The marsh at Monkstown Creek provides a secure winter refuge to several species of waterbird, with Shelduck, Teal, Redshank and Dunlin the most abundant. At times, nationally important numbers of Cormorant have been recorded using the jetty as a roost. According to Crowe (2005), Lough Beg regularly supports nationally important numbers of Black-tailed Godwit and Dunlin, and the area is valuable as a secure roosting site for flocks of all waterbird species when their feeding areas on the mudflats are covered by the tide.

The section of the harbour south of Great Island is important for Great Crested Grebe and Red-breasted Merganser, both of which regularly occur in numbers of national importance, particularly in offshore waters at Aghada and Whitegate Bay. Rostellan supports nationally important numbers of Little Grebe, while the mudflats westwards as far as Aghada are used by feeding waders. Shoveler regularly occurs in nationally important numbers at Whitegate Bay (Crowe, 2005).

Inland bird populations: The habitats present at the proposed development WWTP site and inland pipeline network are typical of this part of county cork and support bird populations typical of agricultural grassland, hedgerow and suburban habitats. During the walkover study a wide range of relatively common species were noted including skylark, starling, blackbird, dunnock, pied wagtail, jackdaw, rook, wren, robin, chaffinch, blue tit, song thrush, great tit, wood pigeon, collard dove, sparrow, stonechat, swallow, pheasant, kestrel, and song thrush. 'The new atlas of breeding birds in Britain and Ireland: 1988-1991' by Gibbons *et al* (1993) was used to generate a list of inland bird species of conservation concern previously recorded breeding in the study area. A list of these species and the likelihood of them breeding in the areas affected by the proposed development is provided in Table 9.

According to Birdwatch Ireland Peregrine falcons nested at a quarry located approximately 600m northwest of the proposed treatment works site in 2002. This species is listed under Annex 1 of the E.U. Birds Directive and is a species of very high conservation importance. Peregrine Falcons have made a successful comeback in Ireland since the 1960's when they were driven to low levels as a result of persecution and recruitment failure due to bioaccumulation of organochlorine pesticides. These birds have quite large territories and may use parts of the study area for foraging. However, no potential nest sites or important areas for this species would be in any way affected by any aspect of the proposed development.

Table 9 Inland bird species of conservation concern which have been previously recorded breeding in the 10km squares where the study area is located (adapted from Gibbons *et al*, 1993). The likelihood of these species breeding in the affected areas is indicated.

Species	Conservation status	Likelihood of breeding in the affected areas
Barn owl	Red listed	Some suitable habitat may breed.
Yellow hammer	Red listed	Some suitable habitat may breed.
Coot	Amber listed	No suitable habitat
Cormorant	Amber listed	No suitable habitat
Cuckoo	Amber listed	No suitable habitat
Grasshopper warbler	Amber listed	No suitable habitat
Kingfisher	Amber listed	No suitable habitat
Sand martin	Amber listed	No suitable habitat
Skylark	Amber listed	Some suitable habitat, may breed.
Snipe	Amber listed	Little suitable habitat, unlikely to breed
Spotted flycatcher	Amber listed	Some suitable habitat, may breed.
Stonechat	Amber listed	Some suitable habitat, may breed.
Swallow	Amber listed	Likely to breed
Water rail	Amber listed	No suitable habitat

Evaluation: The bird populations of Cork harbour are of International Importance and mach of the harbour is designated as a SPA. The bird populations of the proposed WWTP site and areas affected by pipelines are of local importance.

Mammals

Hayden and Harrington (2000) give the distribution of mammal species in Ireland by 20km squares, each of which is composed of four National Grid 10km squares. The subject lands lie within two 20km squares comprising National Grid 10km squares, W66, W67, W76, W77, W86, W87, W96, and W97. The protected mammal species recorded in this 40km square by Hayden and Harrington (2000) are listed in Appendix 5.

Badger *Meles meles* is common in this part of County Cork. One badger sett was recorded on the west side of the hedgerow located along the eastern boundary of the proposed WWTP site (at IG W75265 63901). This sett was located away from the footprint of the proposed WWTP but is located within 30m of the proposed development. This sett had 3 entrances and was considered to be active at the time of the survey. Badger hair was found on a barbed wire fence nearby. No other setts were recorded during along the pipeline routes; although it must be noted that not all areas could be viewed in detail due to land access restrictions. The badger is protected in Ireland under the Wildlife Acts 1976 and 2000. Despite protection, the illegal killing of badgers is widespread and common.

Otter *Lutra lutra* is listed in Annex II of the EU Habitats Directive and is protected under the Irish Wildlife Acts 1976 and 2000. No otters holts or other important otter features were found in the immediate vicinity of the proposed / existing outfall sites or foreshore pipeline routes. However, otters are present in the area and are known to forage along the affected areas of shoreline. Persistent wet weather during the current foreshore survey may have made signs of otters (i.e. spraints, footprints) difficult to detect.

All Irish Bats are protected by the Bonn Convention 1992 (Agreement on the Conservation of Bats), the Bern Convention 1982, and the Wildlife (Amendment) Act 2000. No potential or known bat roosts would be directly affected by the proposed development. Many of the hedgerows and treelines in the study area are likely to be used by bats for foraging and commuting.

Plate 1 Badger sett located near the proposed WWTP site.

Bat Conservation Ireland (BCI) recorded 3 species within 10km of Monkstown. Table 10 lists the BCI records of bat roosts in the Carrigaline area. Roosts for common pipistrelle *Pipistrellus pipistrellus*, soprano pipistrelle *Pipistrellus pygmaeus* and Leisler's bat *Nyctalus leisleri* are present, with additional records for unidentified pipistrelle bats. A total of 101 roosts have been recorded and 50 transect records exist since 1987. BCI recommended that a bat survey to determine the roosting, commuting and foraging potential for local bat populations. However, it was concluded that the current proposal has a low likelihood of affecting bat populations. The treatment plant site itself is not considered to be of any importance to bats and the marine areas affected by the proposal are not used by this group of animals. Most of the proposed pipeline route follows existing roads and felling of significant numbers of mature trees / building demolition is not a feature of this project. No trees along the corridor of the pipeline were identified as being of particular importance to bats. Any trees felled during the construction phase of the project would however need to be checked for bats in advance. Once installed, the proposed pipeline would in no way affect bat foraging or commuting, as would say a road scheme.

Table 10 Bat records from the study area currently available on the BCIreland database.

Species	W7666		
	Roost	Roost	Details
Common pipistrelle	NR	2	Grid Refs: W78148 67380, W66786 61559
Soprano pipistrelle	NR	1	Grid Ref: W73982 62775
Pipistrelle sp.	1	1	Maternity roost at W6657, Transect Grid Ref: W69742 67868
Leisler's bat	NR	2	Grid Refs: W73982 62775, W66786 61559.

Other protected species, listed under Appendix III of the Berne Convention which are likely to be present in the study area are hedgehog *Erinaceus europaeus*, pygmy shrew *Sorex minutus*, and Irish hare *Lepus timidus hibernicus*. These species were not recorded during the site walkover however they are present throughout the Irish countryside and it is most likely that they occur within the study area

Cork Harbour is known to contain both resident and vagrant populations of common dolphins *Delphinus delphis*. For example, in February 2001 common dolphins were observed on 9 days in groups ranging from 300-1,000 inside Cork harbour (Source: IWDG). The Annex II listed harbour porpoise *Phocoena phocoena* and bottlenose dolphin *Tursiops truncatus* have also been recorded in Cork Harbour as well as common, striped and Risso's dolphin and killer whales (IWDG, pers comm.).

While Hayden & Harrington (2001) show seals as having not been recorded from Cork Harbour, both harbour and grey seals are recorded all around the Irish coast and are

therefore likely to be present in the harbour occasionally. Seals have been observed in Cork Harbour (Ecofact, unpublished) and reference has been made to the presence of both harbour and grey seals occurring here in the scientific literature (e.g. Smiddy, 1998). While it seems likely that at present Cork Harbour is not an important habitat for seals, nevertheless they are likely to receive some benefit from the cleaner waters expected in the harbour as a result of the proposed development as cetaceans such as seals are potentially vulnerable to a wide range of human and livestock pathogens.

Reptiles and Amphibians

Two reptile species occur in Ireland; the viviparous lizard *Lacerta vivipara* and the slow worm *Anguis fragilis*. The viviparous lizard occurs in County Cork and may be present in the general study area. These reptile species were not recorded within the study area during the walkover survey, however, suitable habitat occurs in the study area and lizards are likely to be present. Terrestrial invertebrates in general are an understudied group. However, it is likely that the invertebrate populations present within the proposed development area are typical of Irish farmland and urban areas. It is unlikely that any rare species occur due to the generally highly modified nature of the habitats present.

Terrestrial Invertebrates

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Marine Invertebrates and their habitats

The results of the on-site marine/estuarine macroinvertebrate survey are presented in Appendix 6. The macroinvertebrate species recorded were the typical species that would be expected from a sheltered Irish estuary such as Cork Harbour. All the species were common, euryhaline and pollution tolerant species (with the exception of the Common starfish *Asterina rubens* – mainly a marine species – which was recorded at three sites). Brackish water habitats usually have impoverished fauna due to fluctuations in salinity and water levels (Barnes, 1994). However, the main species present in these areas can often form high densities and, as is the case in Cork Harbour SPA, provide valuable feeding opportunities for wintering birds. The results from the individual stations are outlined in Table 11. A general discussion of the reports is provided below.

Cork Harbour is a large, sheltered bay system, with several river estuaries. It is classed as a bay since it's a semi-enclosed waterbody more than 50% enclosed by land (Fossitt, 2000). However, the harbour is strongly influenced by the Rivers Lee, Douglas, Owenacurra and other freshwater inputs and is similar to an estuary and the mixing of the very different water masses can be expected to give rise to complex sedimentological and biological processes and patterns.

The River Lee west channel up as far as Passage West is 12-16 m deep (O' Kane, 2007). Three general types of shore were identified in this general area. One of these was rocky shores, characterised by the habitats of 'Moderately exposed rocky shores' (LR2) at Ringaskiddy and Cobh, and 'Sheltered rocky shores' (LR3) at Passage West. The corresponding biotopes for these areas were 'Moderately exposed littoral rock' and *'Fucus serratus* and large *Mytilus edulis* on variable salinity lower eulittoral rock'. Another prevailing shore type was 'Mixed substrata shores' (LR4) on the River Lee west passage, Ringaskiddy and Crosshaven. The other main type of shore was composed of littoral sediment, namely mud shores (LS4). This was the main habitat on the Owenboy Estuary near Carrigaline and Crosshaven, at the south western part of Great Island near Cobh, and the lower shore near the ferry crossing. The biotope for these locations was "*Hediste diversicolor* in littoral mud".
Marine soft sediments, estuaries, and brackish waters are places of extraordinary biological interest, and home to an immense diversity of plants and animals (Little, 2000). Brackish water bodies are those waters found close to the sea and are intermediate in salinity between

freshwater and sea water. The east facing shore at Ringaskiddy could be described as a minor bay of muddy sandy shoreline grading to rocky shore at the northern and southern reaches. With the exception of the sandy beach, this part of the shore, as well as the shoreline east of Cobh could be classed as 'marine rocky shores'. The results of the quadrate survey illustrate this via the distribution of limpets. The rocky shores at Ringaskiddy and Cobh appeared 'clean' except for populations of the encrusting barnacle *Elminius modestus.* In fact, such rocks are covered by a thin layer of diatoms and cyanobacteria that provide food for mobile grazers such as the common limpet *Patella vulgata.* Limpets, a keystone species were generally present other than on the River Lee west passage and the Owenboy River estuary, with highest densities recorded at Ringaskiddy (Q5-6/m^2) and Cobh (Q15-36/m^2). Keystone species have a disproportionate effect on its environment relative to its abundance, affecting many other organisms in an ecosystem and help in determining the types and numbers of various others species in a community. An ecosystem may experience a dramatic shift if a keystone species is removed, even though that species was a small part of the ecosystem by measures of biomass or productivity.

'Estuarine rocky shores' at the mouths of estuaries, on the other hand, have communities similar to those on nearby open coasts (Little and Kitching, 1996). With distance up the both the Owenboy estuary and River Lee west passage, there was a general decline in species numbers (except Site Q9). Partly, this may have been due to decreasing and increasing salinity variation. The decline is also related to two other effects. In some places the rocks were covered with a layer of deposited silt, and in other places rocks would be exposed to currents with a high suspended sediment load, acting as a scouring agent in abrading the rock surface. A classic example of this phenomenon was observed in the current study where the River Lee west passage showed an increase in diversity 'upstream' at Passage West (Q9), in contradiction to what one would expect in terms of salinity variation and species diversity. This could be attributed to the constricted channel width between Glenbrook at the west side and Ballynoe at the east side of the channel, thus increasing the flow of water. The width of the channel at this location was the obvious reason for the choice of the ferry crossing. Water velocity determines sediment type, but only in combination with factors like supply of sediment, and effects that the organisms themselves have on the sediment. As well as the supply of oxygen, the other major factor which is brought by the water is food. Water supplies the suspension feeders with plankton, and deposit a rain of detritus on the surface that supplies the deposit feeders. Water flows in the harbour vary according to the tide.

Silt layers like those on the River Lee western passage (typical of estuarine rocky shores) may inhibit settlement by larvae of animals and spores of plants so that in some cases, estuarine rocks may stay bare of macro-flora and fauna for years (Little, 2000). This was not the case in this study though there were generally more grazers such as edible and flat periwinkles in the outer parts of Cork Harbour, thereby increasing the value of outer harbour in terms of diversity. Mussels *Mytilus edulis* formed dense continuous growths on the lower and middle shore on the western shore of the River Lee western passage. Attached by long threads (byssus) to rocks, they were growing on top of each other and occupied a lot of space. Densities in the order of 500/m^2 were recorded from the River Lee west passage at Site Q10. These mussels would be preyed upon by terrestrial animals such as birds and otters when the tide is out and by a variety of marine organisms including green shore crabs, common starfish, and fish when the tide is in (Suchanek, 1986). Thus, it can be said that mussels are a potentially important source of food for fauna in the region. However, mussels are responsible for considerable movements of sediment with each individual depositing over 600mg wet-weight of pseudofaceal and faecal matter per day (pseudofaeces are the materials taken in by filter feeders but rejected, instead of being consumed). Some mussels have been found to deposit a layer of mud 60cm thick in a two year period (Ehlers, 1988).

The ragworm *Hediste diversicolor* was found in all the core samples taken but was most abundant in the Owenboy Estuary area. Numbers increased from the upper part of the mudflat (7 at C1, 43 at C2 and 57 at C3) to the most seaward site. The highest density recorded in the River Lee west passage was at Glenbrook (N=21). The success of the ragworm in the harbour can be explained by its array of feeding strategies. It will catch and consume other animals smaller than itself, eat pieces of green seaweeds, scavenge, even pulling small dead fish into it's burrow, consume the surface layers of sediment and can

secrete a filter of mucus to trap plankton and other suspended particles (Barnes, 1994). The common ragworm is responsible for considerable loss of saltmarsh and mudflat habitats on the southeast coast of England. They can feed in several ways but predominantly they partially emerge from their burrows in the mudflats and eat pieces of plants, seeds, seedlings and the small algae that inhabit the mud surface and also help reduce mudflat erosion. There is also some evidence that the increased abundance of this worm over recent decades has had negative consequences for other mudflat invertebrates and this may have an effect on the food availability for wading birds. This is thought to be a reason for the decline in some species of wading birds on some estuaries in SE England, identified by the British Ornithological Union surveys (NERC website).

Evidence of lugworms *Arenicola spp.* in the form of holes and casts were recorded at 50% of core sampling sites but only one specimen was recovered in a core sample. The low incidence may have been due to the relatively small area surveyed by core sampling. The mechanical disturbance brought about by ragworms or lugworms is known to increase the emigration rate of *Corophium volutator,* and at these times are at greater risk from casual predation. (Morrisey,1998). The ragworm interacts with *Corophium volutator* by predation, interference and disturbance (Olaffson and Persson, 1986) and this may also explain the general absence of *Corophium volutator* in the current study. Indeed, the only location where *Corophium volutator* were recorded on the River Lee west passage was at core sampling Site C8 with a correspondingly low density of ragworms. This trend was also observed in the Owenboy Estuary Site C1 where the JNCC biotope was "*Hediste diversicolor* and *Copophium volutar* in littoral mud". *Corophium volutator* may have densities as much as 100,000/m^2 and can reach into low salinities (Little, 2000). Distributions of brackish water species are dynamic and individual populations may not occupy the same patches of sediment from year to year. What is a dense patch of *Corophium* this year may be occupied by ragworms or lugworms next year (Barnes, 1994).

Another habitat type encountered was 'Mixed sediment shores' (LS5), characterised by a poorly sorted mixture of sediments of different grades, including pebbles, gravel, sand and mud. The western site At Crosshaven (Q1) was a habitat of this type where larger cobbles were present and supported some cover of fucoids, crabs, amphipod crustaceans and flat periwinkles. An area of the biotope 'barren littoral shingle' or 'shingle and gravel shore' (LS1) was identified at Cobh. The latter habitat is known to support little marine life other than opportunist amphipod, isopod crustaceans and oligochaete worms. However, no macrofauna were detected in this habitat during the current survey. Intermediate sizes of sediment such as shingle are usually 'intertidal deserts', in which macrobiota are absent. These circumstances arise because shingle shores on which particles may range from something like 5mm to 250mm diameter are usually only deposited where currents are quite fierce and particles are continuously moved around. When this happens, they grind against each other making life on their surface and between them virtually impossible (Little, 2000).

During the sublittoral survey of the harbour, four sites were investigated. In the region of the IDA outfall pipe, infralittoral mixed sediments were recorded at two locations. Infralittoral muds were recorded at the River Lee west passage. Only one ragworm was recorded from the Site near the existing outfall.

Crustaceans: Arthropods are the most numerous animal group. Arthropods have an external skeleton and paired, jointed limbs. Phylum Arthropoda includes crustaceans, insects and spiders. Crustaceans include crabs, lobsters, shrimp, krill and barnacles (Hayward and Ryland, 2005). From the sampling of 25 sites along the intertidal part of the shore in Cork Harbour, a total of 7 species of crustacean were recorded. Only 2 species were recorded from core sampling; the mud shrimp *Corophium volutator* was found at the upper site on the Owenboy Estuary (C1) at Carrigaline and also at Cobh (C8) while the green shore crab *Carcinus maenas* was found at the lower site on the Owenboy Estuary (C3). The small numbers of crustaceans recorded by core sampling was expected due to the nature of this sampling technique i.e. sampling to depths on mudflats where crustaceans cannot live.

In the quadrate sampling, crustaceans were recorded at all sites with the exception of the barren site (Q13) at Cobh. Where there was suitable habitat such as rocks and boulders,

barnacles were present in their hundreds. *Elminius modestus* was well distributed (found at 9 sites) and was the dominant sedentary crustacean species. *Semibalanus balanoides* was found at two sites on the western channel; Q4 at Ringaskiddy and Q6 at Monkstown. Also recorded at sites adjacent to these was *Balanus crenatus*, as well as at Site Q11 on Great Island south of the ferry crossing. The habitats where barnacles were recorded were 'Moderately exposed rocky shore' (LR2) and 'Mixed substrata shore' (LR4). The ubiquitous green shore crab was generally common throughout the intertidal area and the highest densities were recorded at Sites 7 (38/m^2) and 9 (28/m^2) on the Monkstown/Passage west side of the channel, and at Sites 14 (24/m^2) and 15 (28/m^2) at the eastern end of Cobh town on Great Island. The preferred habitat for the crab was 'Mixed substrata shore' (LR4), 'Sheltered rocky shore (LR3)' and 'Moderately exposed rocky shore' (LR2). Through macroalgae, stones and other invertebrates, these habitats offer refuge and feeding opportunities to these scavengers.

The freshwater shrimp *Gammarus deubeni* was recorded at 4 sites and was most common at Site 14 in Cobh. It was sparsely distributed around other parts of the harbour, occurring at Passage west and Ringaskiddy. Fair numbers of mud shrimp were recorded at the eastern side of the channel at Site Q11. Another gammarid, *Chaetogammarus marinus* was present on 'Mixed Sediment shore' at Crosshaven. This species was only found at this site.

Crustacean food supply is probably the most important factor in determining the distribution of fish. Some fish, such as flounder fish feed on benthic infauna. For example, the flounder consumes *Corophium*, snails such as *Hydrobia* and some bivalve species and is generally found where these dominate the benthos. Bass specializes on the shrimp *Crangon* and mysids while whiting feeds on *Crangon,* mysids, amphipods and cumaceans (Henderson *et al*, 1992). In winter, most crustaceans migrate out to deeper water; so generally, numbers are higher in estuaries in summer.

Life on soft shores versus life on rocky shores: Owing to the sheltered conditions in Cork Harbour, the intertidal flats are often muddy in character. Most of the animals that live on soft shores spend their time below the surface of the sediment – these are the infauna. The animals that live on the surface of the sediment are known as the epifauna. These include nearly all crabs and snails, though these may burrow at times. Large numbers of grazing animals and predators invade the mudflats at specific times. At high tide, fish such as mullet and flatfish such as flounder move up the shore. (Little, 2000). Plants, on the other hand, must at least keep part of their structure in the light for photosynthesis.

Perhaps the primary difference between all particulate shores and rocky shores for organisms is one of dimensions. Rocky shores are mostly two dimensional environments, except where heavy growths of algae form vertical canopies, while particulate shores offer three dimensions. Thus for organisms on rocky shores, there is no escape from predators: many rocky shore animals are sessile and their defence can exist only in terms of heavy armament, as for example in barnacle or limpet shells. This was reflected in the number of shelled mollusc species recorded at the more exposed sites at Ringaskiddy (six species at Q3 and Q5) and Cobh (4 species at Q15) while the River Lee west channel generally had only two species of shelled mollusc.

In sand or mud, however, animals can retreat into the depths when predators appear. One of the other beneficial effects of sediments is that the finer ones at least retain a large amount of water at low tide. Death from dessication is not such a problem as it is on rocky shores, except high on the shores in coarse sands. At high tide, the sediment acts as a buffer against changes in salinity, temperature and pH that may occur in the overlying water (Little, 2000). Yet another bonus is that because organic materials usually end up as small particles, they accumulate in sediments – so it is often possible to make a living simply by eating the sediment, especially in the finer muds. Very few rock dwellers can do this, unless the rock is permeated with burrowing algae. There are however some hazards for organisms living in sediments. First, there is nothing to anchor to, unless the organisms happen to be very small, like microalgae or bacteria. In addition, particles are far from stable so that while a particular patch of shore may be here today, it may be gone tomorrow. This calls for flexibility of lifestyles, and particularly flexibility of feeding behaviour.

Filter feeding (by mussels, cockles, etc.) is less prevalent in brackish environments than it is on sandy or rocky marine shores, perhaps because the especially high content of silt in estuaries would tend to clog any filter and render food collection and sorting energetically expensive. However, the oyster has been recorded in waters turbid with silts ceased to sort the potential food particles form the background silt, but simply swallowed the lot (Barnes, 1994). Turbid estuaries are well known for the paucity of suspension feeders such as sea squirts, hydroids, and sponges probably due to the clogging of the feeding apparatus with silt (Little, 2000). None of these animals were found during the current survey.

The distribution of sediments: The movements of sediments on exposed sandy beaches are controlled mainly by the forces of wave action, while in sheltered bays and estuaries waves are less important and tidal forces predominate. The influences of waves and tide are not mutually exclusive. The relative importance of wind-driven waves and of tidal currents to a great extent determines coastal landforms and sediment distribution. In particular, as tidal range is a measure of the strength of tidal currents, it is often a good descriptor of tidal processes. The tidal range at Cobh is greater than 4m (ISA website) and is therefore termed macrotidal. It can be said that tidal forces predominate the movement and sorting of sediments. The overall balance between tidal forces and the forces of wave action greatly influences the sedimentary regime in which soft shore organisms live. Nowhere was this more evident than at the sites around the ferry crossing (near the proposed marine crossing) where there was a reduction in the diversity of organisms.

Particle size, sorting, and consequences for the biota: For plants as well as for animals, conditions within the sediments are crucial because they affect such factors as the supply of water, oxygen, and nutrients, and the stability of the system. Many of these factors are in turn determined by the size of the particles involved in the sediment, and the degree to which the particles are sorted. This is because size and sorting determine how 'open' the sedimentary environment is and therefore how much water flows through it, bringing with it fresh supplies of oxygen (Little, 2000). The muds at Cork Harbour 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.

Very often, it is impossible to analyse all the size fractions of sediments completely, but a good idea about its properties can still be obtained by estimating just the proportions of the finer particles. If the proportion of finer particles (fine sands, silt, clay) is high, drainage will be poor and oxygen concentrations will be low. If the proportion of silt-clay fraction is high, the organic fraction is likely to be high, and the sediment will also usually show cohesive properties. These cohesive properties are caused by electrochemically charged sites on clay particles and allow hydrogen bonding and the particles therefore bind together.

Smaller particles fill the gaps between particles and reduce the porosity. The importance of this is the way it determines the permeability or the rate at which water passes through the sediment. In general, if the proportion of fine grains is high, the permeability is low. For organisms living below the surface this means low oxygen content, so they have to adjust or bring in oxygenated water. Porosity is also important in determining the density of a sediment bed. When porosity is low and density high, the sediment is compacted and generally hard. Such sediments behave as solids, are difficult to erode and often have restricted biological activity.

During core sampling all the sites investigated on both the Owenboy Estuary and the River Lee west passage, it was noted that the mud was fairly cohesive but was also soft. On a scale of 1-5 where 1 is firm and 5 is soft, all sites scored 4. Porosity and stability was therefore deemed to be moderate at these locations.

How organisms affect sediments: Organisms themselves can affect the structure and chemistry of the sediment, and thus alter their own micro-environments and those of others. In contrast to plants, most animals in sediments create disturbance rather than stability. Some organisms act to bind sediment together and others loosen sediment structure and are called

'bioturbators', while many have complex effects that may act in both directions. Disturbance by some polychaete worms takes place by forming burrows. Irrigation of these burrows effectively raises the RPD (redox potential discontinuity) for these worms. In the current survey, casts of lugworm *Arenicola spp.* were recorded at 50% of the core sampling sites. These worms create a roughly U-shaped tube, through it draws oxygenated water by pumping movements of the body. Throughout mudflats, the polychaete worm *Nereis diversicolor* can increase porosity dramatically (Hansen and Kristensen, 1997). In general, the effects of disturbance are negative, and it has been suggested on a wider scale that deposit feeders as a whole may increase sediment stability so much that they make life impossible for suspension feeders.

Tube building worms in some cases have positive effects. The tubes of the polychaete *Lanice conchilega* act like steel reinforcing rods in concrete, and increase the rigidity of the sand (Jones and Jago, 1993). In a study on the Exe Estuary (SW England), it was found that resuspension from substrate with 100% mussel cover was about three times lower than the 0% cover (Widdows *et al,* 2002).

Anoxic layer: In coarse sands and much finer substrates conditions change with depth but the changes are slight in the former and dramatic in the latter. Near the surface the redox potential (a measurement which reflects the balance between oxidation and reduction) is positive, showing that oxygen is present and that oxidation is the primary chemical process. Lower down the potential decreases and then becomes negative, showing a reducing environment. The oxidised surface sediments are yellow or brown while the reduced sediments are black. In between is a grey layer in which the redox potential decreases rapidly (RPD layer). The depth of the RPD reflects how rapidly oxygenating water passes through the sediment. In the oxic zone, the animals have 'normal' aerobic metabolic processes like those of surface dwelling species. In the reducing zone, there are high levels of hydrogen sulphide and ammonia, both of which are toxic. Animals in this zone have to employ anaerobic processes, or provide their own oxygen supply. The supply of oxygen to the infauna is without doubt the most important chemical influence on the biology of sediments. In the summertime, the RPD rises due to increased infaunal respiration resulting in quicker consumption of oxygen and a decline in oxygen levels.

The RPD depth in the Owenboy Estuary was generally in excess of 20cm, meaning that the oxic zone was on this mudflat was usually more than 20cm deep. The implications for the infauna are that they can penetrate deeper in to the substrate and therefore more of them can exist in this habitat. The bivalve filter feeder *Spisula elliptica* as well as the ragworm was present at site C2, while the mudflat at Crosshaven (Site C4) was home to ragworm and catworm polychaetes, both sites with the deepest RPD in this estuary. With the exception of the ragworm, only epifauna were recorded at other sites on the Owenboy Estuary – those with shallower RPD. On the River Lee west passage, only the site on the mudflat at Glenbrook (C5) had an RPD greater than 20cm. This site had, by far, the highest density of ragworms in this part of the harbour (N=21). Sites C6, C7 and C8 were all located south of the ferry crossing and had RPD of between 1cm and 20cm and between them, supported ragworm, catworm, lugworm, cockle and *Corophium*. The current survey was carried out in June and so the RPD would have been approaching its highest level. The RPD depth fluctuates seasonally in accordance with temperature (Little, 2000). The RPD is an important factor in the ecology of Cork Harbour and should its mean depth rise, a reduction in diversity would be expected.

Resuspension of sediment and suspended particles: When shear water velocity exceeds a critical value, sediment is eroded and when it falls below a critical value, sediment is deposited. These two crucial values are usually different however, particularly for fine sediments where shear velocity for deposition is very much lower than that for erosion. When sediments are moved back into the water column, the process is called re-suspension. Re-suspension is caused by a combination of tidal currents, wave action, bioturbation, and human activities such as dredging and trawling, when a mixture of inorganic sediment, organic particles, bacteria, diatoms, and so forth move into the boundary layer (layer of water just above the sediment).

In estuaries which show a high tidal range, where there is usually a rich supply of particles, the boundary between deposited and suspended states may be hard to determine. During spring tides (those of high amplitude), fine particles are brought into suspension. Many estuaries have regions where suspended concentration is high - the so called 'turbidity maximum'. During neap tides (those of low amplitude), current velocities fall and the fine sediments are deposited again. The mixture that results is called fluid mud and may travel considerable distances with the tide. As it tends to become anoxic quickly, its passage over the substrate may have far reaching consequences for the infauna.

Conclusions: Phytoplankton is the first level of the food chain (primary producer) in the study area, followed by the zooplankton, which feeds on the phytoplankton. The zooplankton are then eaten by small fish and crustaceans, which all go on to be eaten by bigger fish, seals etc. Any changes in primary production will have implications for the whole ecosystem.

In the marine environment, nutrient enrichment is suspected when surface phytoplankton blooms are seen to occur more frequently and for longer periods. Changes in the relative abundance of phytoplankton species may also occur, with knock-on effects throughout the food web, as many zooplankton grazers have distinct feeding preferences. In 2005, many Irish shellfisheries were closed for a prolonged period as a result of harmful phytoplankton species. In sheltered areas, high nutrient levels appear to favour the growth of green macroalgae ('seaweeds') belonging to such genera as *Enteromorpha* and *Ulva*. These macroalgae are common in Cork Harbour.

In the ABC method (abundance-biomass comparisons), there is high diversity of large species but few individuals in the unpolluted community, whereas the polluted community has low diversity of many small individuals, particularly polychaetes (Warwick, 1986). In the core samples taken during the current survey, a low diversity and large numbers were recorded from mudflats, implying a polluted status. In the contrary, the pollution tolerant polychaete worm *Capitella capitata* was not recorded during the current survey. An average of two species was recorded at core sampling sites. The nature of such quantitative sampling however is such that a small area is sampled, and many of the larger fauna can be missed easily. This is especially true of subsurface bivalves such as the common cockle *Cerastoderma edule*, and lugworms. In combination, these two species occurred at only four core sampling sites.

Estuarine waters enriched by nitrogen from fertilizers and sewage have been responsible for the decline of a number of estuarine invertebrate species, often by causing oxygen depletion of bottom water (Barnes, 1994). Currently, Cork Harbour and the Owenboy Estuary receives untreated sewage from at least 10 locations. In estuaries, elevated rates of microbial respiration deplete oxygen, and periods of anoxia occur more frequently, especially in summer when water temperatures are high and there is slow water circulation.

Changes take place in benthic communities in shallow coastal waters following eutrophication. Where there is a deep RPD depth, the structural diversity afforded by the plants and the availability of oxygen in the sediment promotes a diverse community of animals. The sites examined on the mudflats of Inner Cork Harbour and the Owenboy Estuary did not hold a diverse community, indicative of reduced oxygen levels.

This loss of structural diversity and oxygen from the benthos causes the animal community to be replaced, in part by one of bacterial decomposers. Algal mats, associated with anoxic conditions were recorded on a mudflat to the west of Cobh (Site C7) and also on a rocky shore east of Cobh (Site Q15). Both of these sites were adjacent to outfalls. The cord grass (*Spartina anglica*), which has spread rapidly around the coasts of Britain in the past 100 years is aided by the increased nutrient supply to saltmarshes (Barnes, 1994). The spread of this species in Cork harbour is currently of conservation concern (Source NPWS).

The prevalence of the ragworm in the samples obtained during the current assessment is indicative of pollution. This species contributes to the degradation of mudflats through its feeding habits and has knock on effects for birds and fish. The presence of the common starfish *Asterina rubens* at three sites during the current survey - usually an indicator of good

water quality - cannot be relied upon in the current case as it has been found that those in estuaries have special adaptations, thereby limiting their use as an indicator. Kowalski (1955), for example, found *Asterias rubens* from the Baltic Sea to have a longer righting time, smaller body size, different organic and inorganic composition, later maturation, and lower reproductive capacity than individuals from the North Sea. Indeed, some estuarine populations are sterile and are maintained only by recruitment.

Overall, it can be said that the outer part of the harbour is more diverse, and habitats are of a marine nature as opposed to estuarine. However, in general the situation of reduced diversity within estuaries is observed within the study area but is more profound that would be expected if the area was not affected by organic pollution. It is clear from the data collected during the current study that the existing untreated inputs of sewage in the harbour are having a significant negative of the benthic macro-invertebrate community. Reducing these inputs as is currently proposed would have a significant positive impact on the ecology of Cork harbour.

Table 11 Summary of macofauna surveys undertaken in the study area during 2007.

Station	Results
Station C1	This site was located in Carrigaline to the east of the bridge over the Owenboy River on the northern muddy shore. A total of 3 invertebrate species were recorded in the core samples taken at this site. These were the ragworm *Hediste diversicolor*, another polychaete worm (family Naididae) and the crustacean *Corophium volutator*. The latter was the most common species with 16 recorded. In the town of Carrigaline just upstream of this site, grey mullet *Chelon labrosus* were seen foraging upstream of the bridge. Raw sewerage was seen discharging into the river from a pipe on the northern bank in this area.
Station C2	A core sample was carried out at this site which was located on the northern muddy shore of the Owenboy Estuary. This site was approximately 400m east of Site C1 and both sites had similar physical characteristics. Two species of invertebrate were found; the ragworm *Hediste diversicolor* and the bivalve *Spisula elliptica.*
Station C3	This site was located in the mudflats of the Owenboy Estuary. A total of 57 ragworms *Hediste diversicolor*, one green shore crab *Carcinus maenas* and a bivalve *Spisula elliptica* were recorded in the core samples taken.
Station C4	This site was located at Crosshaven to the east of the town centre on the southern shore adjacent to the R612. Two species of ragworm were recorded in the cores takenat this site; *Hediste diversicolor* (12) and a catworm *Neptys sp.* (2). Though numbers were low the size of the individual worms was large. The combined weights of the two worms were 15.2g and 3.63g respectively.
Station C5	At Passage West, core sampling was undertaken on the mud shore adjacent to the R610 at Glenbrook. The only invertebrate recorded at this site was the ragworm *Hediste diversicolor* (n= 21). The accumulated weight of these worms was 17.9g.
Station C6	This core sampling site was located on a muddy shore adjoining the R624 on Great Island to the south of the ferry crossing. Three ragworm and one lugworm were recorded at this site. One sea anemone (family Actinidae) was also recorded. Lugworm *Arenicola marina* casts were recorded on the surface of the mud at this site.
Station C7	This site was located at Rushbrook on Great Island on a muddy shore. One invertebrate species was found here in the core samples - the catworm *Nephtys sp.* A total of 7 of these bristleworms were recorded and weighed 7.54g, averaging at just over a gram each. An outfall pipe was seen to be discharging untreated sewage onto the mid shore near this site.
Station C8	This site was located near the south tip of Cobh at White point. The vicinity of the site was characterised by a muddy shore. Three invertebrate species were recorded at this location; the catworm (4), *Corophium volutator* (1) and the cockle *Cearstoderma edule* (1).

Station	Results
Station Q1	This site was located at Crosshaven on a mixed sediment shore adjacent to the R612 road. JNCC quadrate sampling was undertaken at this site. Three species of organism representing 3 groups were recorded at this site. Flat periwinkles *Littorina obtusata,* green shore crabs *Carcinus maenas* and a single shrimp *Chaetogammarus marinus* were recorded
Station Q2	A quadrate sample was carried out also at the foreshore to the northeast of Crosshaven. The shoreline was characterised by *Fucus serratus* on mixed substrata. A total of 11 invertebrate species were recorded in the quadrates. Calcified housing of both the keel worm *Pomatoceros lamarcki* and the barnacle *Elminius modestus* was abundant on hard substrata. The sand mason *Lanice conchilega* (Polychaeta) was also present with one specimen recorded in the quadrates. Two green shore crabs were noted. The most diverse group were the snails (Gastropoda) and 4 species were recorded. These were the edible periwinkle *Littorina littorea* (50), grey topshell *Gibbula cineraria* (5), flat periwinkle *Littorina mariae* (20 and the common limpet *Patella vulgata* (1). The total weight of the edible periwinkles was 229g. Two chitons *Lepidochitona cinereus,* two Snakelocks anemone *Anemonia viridis* and a common mussel *Mytilus edulis* were also recorded at this site.
Station Q3	This site was located to the east of Ringaskiddy between Paddy's point and golden rock. This site was to the south of the proposed WWTP outfall pipe on a shore typified by bouders and stable cobbles and was near a muddy sand beach. Thirteen macrofauna species were found at this location and the most diverse group were the snails. The edible periwinkle was the dominant snail (n=29). Other snails recorded were the grey topshell (7), flat periwinkle *Littorina obtusata* (5), flat topshell *Gibbula umbilicalis* (3), common limpet (2) and the flat periwinkle *Littorina mariae* (1). Two barnacle species were found *Elminius modestus* and *Balanus crenatus*. The former was the more abundant of the two. Small numbers of the sand mason, *Gammarus deubeni*, snakelocks anemone and the edible mussel were recorded at this site.
Station Q4	This site was located to the east of Ringaskiddy between Paddy's point and Golden rock. This site was to the north of the proposed WWTP outfall pipe. Some bedrock as well as boulders and cobbles occurred at his site. There was a sandy beach approximately 30 meters to the south of this site. Six invertebrate species were recorded in the quadrates. The most frequent organisms were the common limpet and the common mussel. Two green shore crabs were recorded. Edible periwinkles (3) and snakelocks anemone (1) were also recorded at this site.
Station Q5	A quay at the eastern end of a sea wall at Ringaskiddy was the location of this site. It was opposite Whitepoint in Cobh across the west channel of the Lee Estuary. The shore had a significant slope and was composed of bedrock, boulders and stable cobbles with some fucoids. Eleven invertebrate species were identified from this site. The periwinkle *Littorina littorea* was numerous with 59 specimens recorded in the one m^2 quadrate. Five other species of snails were recorded at this site; common limpet (6), the flat periwinkles *Littorina mariae* (5) and *Littorina obtusata* (4), *Littorina rudis* (5), and the flat topshell (1). Four large common mussels were recorded and weighed 23.8g. A snakelocks anemone, a chiton, green shore crabs (3) and *Gammarus deubeni* (4) were also recorded at this site.
Station Q6	This site was located at Monkstown immediately north of the pier adjacent to the R610 road. The shoreline type was mixed substrata with mussel beds and 9 invertebrate species were found here. Twenty nine common periwinkles were recorded. Over one hundred each of the barnacles *Elminius modestus* and *Semibalanus balanoides* were recorded making these the most common invertebrates at this site. Fifteen green shore crabs weighed 8.67g and 5 common mussels weighed 73.2g. Other organisms recorded were the common starfish *Asterina rubens* (1), Hediste diversicolor (1), common limpet (2) and the chiton *Lepidochitona asellus* (1).
Station Q7	At Monkstown, another quadrate survey was carried out just south of the ferry pier on a mixed substrata shore dominated by the common mussel *Mytilus*

Station	Results
	edulis. The barnacles *Elminius modestus* and *Balanus crenatus* were numerous along with juvenile green shore crabs (38). The crabs had a total weight of 44.88g. The common periwinkle was abundant. A total of 104 of these snails were found and weighed 567g. The only other organism found at this site was the Beadlet anemone starfish *Actinia equina.*
Station Q8	This site was located between Monkstown and Passage West adjacent to the R610 road to the north of the ferry. This was a fairly sheltered location and there was a mixture of rock and sediment at the site. The most common invertebrate was the sand mason *Lanice conchilega*, a polychaete worm. Three other invertebrate species were recorded; common mussel (21), common cockle (1) and green shore crab (1).
Station Q9	Located near the bottom of a slipway in Passage West, this site was a sheltered rocky shore with dense growth of fucoids (mainly *Fucus serratus*). Eleven invertebrate species were recorded at this site with the barnacle *Elminius modestus* being the most common. The predatory green shore crab was numerous with a total of 28 recorded. Most of these were juvenile crabs with an average weight of less than 1g. Common mussels (19) were recorded and most were not yet fully grown. Eight small beadlet anenomes were noted. The most diverse group recorded at this site were the snails and three species of periwinkle were recorded; *Littorina mariae* (5*), L. obtusata* (3) and *L. littorea* (1). Five *Cirratulus cirratus* (polychaete worm) and in excess of 20 keel worms *Pomatoceros lamarcki*. The freshwater shrimp *Gammarus deubeni* and a common starfish were also recorded at this site. The occurrence of freshwater and marine organisms at the same site indicates the estuarine nature of the site.
Station Q10	This site was located on Great Island just north of the river ferry adjacent to the R624 road. The shoreline was mixed substrata and no mounds or casts were noted at this site. Edible mussels were abundant at this site with 476 specimens weighing in excess of 5kg. Another bivalve, the common cockle (4) weighed an average of 20g each. Two sea anenomes were found at this site, the beadlet (10) and snakelocks (8). Other invertebrates recorded were green shore crabs, barnacles, and two species of periwinkle.
Station Q11	This site was on a mixed substrata shore on Great Island south of the ferry crossing. A total of 52 common mussels recorded at this site. Two species of barnacles (*Elminius modestus* and *Balanus crebnatus*) were abundant. The sand hopper *Corophium volutator* was common with 20 specimens recorded. Beadlet anemone, edible periwinkle and green shore crab were also present. Four of each of *Cirratulus cirratus* (Polychaeta), flat periwinkle and common starfish *Asterina rubens* were recorded at this site.
Station Q12	Near the town of Cobh at Whitepoint, a quadrate survey was carried out on a shore typified by boulders and cobbles with *Fucus serratus*. A total of 8 marine invertebrates were recorded at this site. The most diverse group were the Polychaete worms where the keelworm *Pomatocerous lamarckii*, the sand mason *Lanice conchilega* (3) and *Cirratus cirratus* (3) were recorded. Two snails were recorded in abundance but were generally small. These were *Littorina rudis* (681) and the edible periwinkle *Littorina littorea* (328).
Station Q13	On a shingle and gravel moderately exposed shore, a survey was carried out on the East beach tot the east of Lynch's quay. No macroinvertebrates were found at this site. The gravel was loose and being shifted constantly by the by the action of the waves.
Station Q14	This site was located in Cobh to the east of Red chimney stack on a shingle and gravel shore. A total of 9 macroinvertebrate species were found here. The shrimp *Gammarus deubeni* was numerous as was the barnacle *Elminius modestus.* Snails were abundant at this site with *Littorina rudis* (681*), L. littorea* (122) and grey topshell (4) recorded. The periwinkles were generally very small, averaging at less than 1g. Indeed, 691 *Littorina rudis* weighed only 118g. The common mussel was also numerous, 152 were recorded and weighed approximately 1.3kg. Other organisms found were the green shore

Station	Results
	crab (24), beadlet anemone (16) and the isopod *Lekanespharea rugicauda* (8).
Station Q15	The shore here consisted of bedrock, boulders and stable cobbles and had a sparse cover of fucoids. An algal matt was also recorded at this site. Eight invertebrate species were recorded during the quadrate sampling here. The most diverse group were the snails where 4 species ranged from common (flat topshell) to abundant (common periwinkle and *L. rudis*). Over 1kg of mussels accounted for 220 individuals of small size. The green shore crab was frequent among the coble and boulders and 28 recorded weighed 18.9g. The keelworm *Pomatoceros lamarckii* occurred on the seaweed and on hard substrata. Three beadlet anenomes *Actinia equina* were recorded at this site.
Stations G1-G4	No organisms were recorded in the grabs taken at Sites G1-G3. One *Hediste diversicolor* was recorded at Site G4.

Fish and fisheries

The majority of fish found in estuaries feed primarily on the benthos (organisms living on or at the bottom of a body of water). Estuarine opportunist species typically enter estuaries from the sea for a period each year, but do not stay there permanently. The majority drift into estuaries as larvae from eggs spawned in coastal waters and as young fish they take advantage of the rich benthic food sources of the harbour. The harbour is therefore deemed important as a nursery ground for juvenile fish before they return to the sea as recruits to their adult population. Adult mullet were seen grazing on algal films from the soft substrata at the Owenboy estuary and also on the River Lee western passage near Cobh during the current survey.

Cork Harbour is an important habitat for fish and is an important location for shore and boat angling. However few fish surveys have been undertaken in the area. A marine fisheries survey of Cork Harbour was undertaken by the Central Fisheries Board during 2001 (King, 2002). A total of 33 sites were examined over a five-day period. A wide range of species was recorded, consistent with the large diversity of habitat niches available in this extensive expanse of water. The fish species encountered included more truly estuarine forms as well as those from surf beaches and areas of steeply sloping bed close to shore. However, no specimens of the Annex II listed juvenile twaite shad *Allosa fallax* or lamprey species were recorded during the assessment. The most commonly encountered groups were juvenile sprat/herring, flounder, gobies, mullet, sand smelt and the 15-spined stickleback. Many species were found in single locations only. The most upstream location was a slipway formerly used for salmon draft netting opposite the ESB power station at Marino. This site yielded four species in the CFB survey, including young scad. This was one of four locations in the harbour where scad were taken. Scad are an important commercial fish species. The highest species diversity was found in the lower Harbour area. A total of 13 species was taken at the north most point of Ringaskiddy, directly south of Haulbowline. As well as the commonly-recorded species, this site yielded two species of pipefish, two wrasse species, blenny, bullhead and butterfish. Species diversity was also higher at the stations at Rushbrook, Cuskinny Beach and the slipway at Crosshaven.

Cork Harbour is an important location for sea angling in Ireland and both shore and inshore angling takes place. Cork Harbour is also an important launching point for deep sea angling. According to the Central Fisheries Board, shore angling is the most important form of sea angling in Ireland. This type of angling is undertaken from land and is divided into three forms; beach, rock and pier fishing. Inshore angling is carried out from small 4-6m boats, usually fitted with outboard engines. It is normally confined to sheltered bays and inlets and is popular in Cork Harbour. A total of eight deep sea angling charter boats registered in the Irish Charter Boat Directory are based within Cork Harbour, and numerous other private boats are also utilised for sea angling in the area. The species most frequently taken by shore and inshore fishing in Cork Harbour are turbot *Psetta maxima*, ray (especially blonde ray *Raja brachyura*), conger *Conger conger*, plaice *Pleuronectes platessa*, dab *Limanda limanda*, codling *Gadus morthua*, and dogfish *Scyliorhinus* spp. (Dunlop & Green, 1992).

Cork Harbour is an important location for angling for marine fish qualifying for Irish Specimen Fish Committee (ISFC) awards. The ISFC was established in 1955 in order to investigate, authenticate and record fish of exceptional size captured on rod and line in Irish waters. The committee consists of both government and angling representatives. A fish qualifies as a specimen (or a record) if it exceeds a specific minimum qualifying weight and is captured according to rules determined by the ISFC. A list of authenticated specimens (and records) is published annually by the ISFC. During the period 1955-1996, a total of 8,863 marine specimens were authenticated by the ISFC (Quigley & O'Connor, 1997). Of these, 46.4% were from the south west region of Ireland. Cork Harbour accounted for 13.11 % of all the specimens recorded in the southwest region, including five Irish records; electric ray *Torpedo nobiliana* (32.9 kg, Crosshaven, August 1933); blonde ray (16.57 kg, Cork Harbour, September 1964); turbot (15.43 kg, Cork Harbour, June 1982); homelyn ray *Raja montagui* (3.76 kg, Cork Harbour, September 1983); and grey mullet *Crenimugil labrosus* (4.13 kg, Cork Harbour, September 1993). Of the 539 specimen fish captured in Cork Harbour during the period 1955-1996, the most important species in terms of specimen numbers was blonde ray (108). Pollack *Pollachius pollachius*, turbot, ling *Molva molva*, and bass *Dicentrarchus labrax* were also important species with 72, 40, 39 and 38 specimens respectively captured during the period 1955-1996. Boat fishing in Cork Harbour usually takes place during the period April to October, while shore angling is from April to January. The main shore angling marks in Cork Harbour are described in Appendix 6. The nearest fishing important fishing location to the proposed development is at Monkstown where cod, conger, dab, dogfish, flounder, thornback ray, rockling and whiting can be caught (SWRFB website)

While it has not yet been quantified, the effects of trawls on the benthos may be severe, causing disturbance and hence decreasing the amount of benthic biomass available as food to a variety of organisms (Little, 2000). This undoubtedly happens in Cork Harbour, where local anglers called for an end to this exploitation. In a web based the Passage west and Monkstown news, the news article 'Fished Out' by Leo McMahon (13th September, 2007, Passage west Monkstown news) described how sea anglers at Glenbrook and Monkstown were being fished out every time a commercial fishing boat and trawled the Lee Channel. A letter from South Western Regional Fisheries Board was welcomed which agreed it was very desirable there should be no trawling for cod or other fish in that section of the inner harbour in order to enhance sea angling resources and recreational angling. Commercial activities may thus have direct effects on the biology of substrata.

Cork harbour is also used by a number of anadromous and catadromous fish species migrating to and from rivers which flow into the harbour. Anadromous fish migrate into freshwater to spawn and their progeny pass down into the sea to grow to maturity. Catadromous fish have an opposite life cycle and migrate to the sea to spawn and their progeny move into freshwater to grow to maturity. Species important in this respect are Atlantic salmon, River lamprey and Sea lamprey (anadromous) and the European eel (catadromous). The main river of fisheries importance flowing into Cork Harbour is the River Lee which is known to contain all of these species (O'Halloran *et al,* 1998). These species are discussed as follows:-

1. Atlantic Salmon: The Atlantic salmon is listed under Annexes II and V of the EU Habitats Directive and Appendix III of the Bern Convention. It an economically important species and salmon recreational fisheries occur on the lower River Lee. Salmon migrate into the River Lee and other rivers flowing into Cork harbour during all months of the year. The largest runs probably occur during the period May to July as in other Irish rivers. Downstream migrations of young salmon (smolt) occur during April and May when water temperatures are in the 12-18 degree C range (O'Halloran *et al,* 1998). The reported salmon catch on the River Lee and Owenboy Rivers in 2005 was 419 and 1, respectively (Wild salmon and sea trout statistics report, CFB, 2005).

2. Lampreys: River lamprey and Sea lamprey are listed in Appendix II, while river lamprey is listed in both Appendices II and IV, of the Habitats Directive (92:43:EEC). All three species are listed in Appendix III of the Bern Convention. Sea Lamprey (*Petromyzon marinus*) and River Lamprey (*Lampetra fluvialitis*) migrate upstream to

the River Lee during the period March to May. Sea Lampreys is larger and more common than the latter. Spawning takes place in freshwater habitats when water temperatures exceed 15 degrees C. After hatching, the larvae (ammocoetes) drift downstream and distribute themselves in suitable silt beds and remain there for 4-5 years. The upper estuary may be used to some degree in this respect. Young lampreys on the River Lee are thought to migrate downstream during April and May as is suspected for other rivers.

3. European Eel: Juvenile European Eel (*Anguilla anguilla*) or elvers migrate upstream into freshwater habitats such as the River Lee during April and May. The upstream migration occurs when water temperatures exceeding 12 degrees C are associated with flood spring tides and normal river discharges. Resident eels also occur in estuarine / marine habitats and are likely to occur in the study area.

Bait collection is an important activity prior to shore and inshore angling expeditions. Anglers dig for lugworm *Arenicoli* spp. at low tide or collect crabs *Carcinus maenas* from under rocks. The main bait collecting areas and fishing hotspots in Cork Harbour are presented in Appendix 7.

Table 12 Fish species expected in areas affected by the proposed development.

Location	Fish species expected to be present
Crosshaven.	Flounder, mullet, electric ray, eel, common goby, plaice, pollack, mackerel, garfish, wrasse, bull huss, bass, salmon, sea trout, sea lamprey, river lamprey.
River Lee West Channel (Ringaskiddy, Monkstown, Cobh)	Pipefish, wrasse species, blenny, bullhead and butterfish, sprat/herring, flounder, common goby, sand goby, mullet, sand smelt, 3-spined stickleback, scad, pipefish, bull huss, coalfish, bass, mackerel, turbot, electric ray blonde ray, homelyn ray, thornback ray, grey mullet, conger, plaice, dab, rockling, whiting codling, dogfish, eel, sea lamprey, river lamprey, salmon, sea trout.
Owenboy River Estuary	Mullet, flounder, salmon, sea trout, eel, 3 spined stickleback, sea lamprey, river lamprey

Adapted from Dunlop and Green (1992), SWRFB website, sea-angling-ireland.org

Shellfish

Cork Harbour is a shellfish production area (Code CK-CH). This area lies north of a point from Roberts Head (coordinates -8.30375 51.74379) to Roches Point (coordinates -8.25113 51.79285) up to and including the mean high water mark. In Ireland the main bivalve species are mussels, native and pacific oysters, razorfish, scallops, clams and cockles. All the shellfish production areas have been described and given sample codes in the molluscan shellfish production area maps. Shellfish Areas are classified by the microbiological quality of the water. Areas are assigned a classification of A, B or C by the Department of Communications, Marine & Natural Resources based on microbiological monitoring. In order to ensure the quality of shellfish for human consumption controls are placed on the waters used for shellfish cultivation and harvesting. These controls are driven by the EU Directive 'laying down the health conditions for the production and the placing on the market of live bivalve molluscs' (91/492/EEc) and by 1996 regulations (S.i. no. 147 of 1996) implementing the directive. The Department of communications, marine and natural resources (DCMNR) is the competent authority in Ireland for classifying shellfish production areas.

The Status of Shellfish Production Areas: The Department of Communications, Marine and Natural Resources (DCMNR) is contracted by the Food Safety Authority of Ireland (FSAI) to implement the Marine Biotoxin Monitoring Programme in Ireland. The Marine Institute is the National biotoxin reference laboratory and carries out marine biotoxin testing on behalf of the DCMNR. The Marine Institute carries out a range of toxin analysis at its own laboratories and also contracts regionally located laboratories to carry out analysis.

The status of a production area depends on the result of the last sample for each species in that area. Before harvesting from any production area, two samples, taken a minimum of 48 hours apart, must have biotoxins below the regulatory limit. With the first of these two clear samples the area is assigned a "Closed Pending" status and with the second the area is assigned an "Open status". If a result is positive for biotoxins then the area is assigned a Closed status and the area will need two clear results a minimum of 48 hours apart to return to an Open status again. The frequency of testing is laid down for each species and this may have seasonal variation. If the frequency is not adhered to then the area loses its Open status.

The most recent published information on the Cork Harbour shellfishery is from 2005 when three shellfish bed production areas were examined (Table 13). Shellfish species sampled were the king scallop *Pecten maximus* at Cobh (Code CK-CH-CH), flat/native Oyster *Ostrea edulis,* pacific oyster *Crassostrea gigas* and edible mussel *Mytilus edulis* on the north channel (Code CK-CH-NC), and pacific oyster at Rostellan (Code CK-CH-RN). (FSAI website). The current classification (B) means that the oyster may be taken alive from those regions in the bed in column III, and sold for consumption following purification in an approved plant for two days.

Table 13 Annex ;Designated Bivalve Mollusc Production Areas In Ireland,_October 2005, from the Live Bivalve Molluscs (Production Areas), Second Designation 2005.

I	II	III	IV	V	VI
Production Area	**Boundaries**	**Bed Name**	**Species**	**Previous Classification**	**Current Classification**
Cork Harbour	Between 8°16.4' W and 8° 15.6' W.	North Channel West	Oysters	B	B
Cork Harbour	Between 8°14.6'W and 8°13.2'W.	North Channel East	Oysters	B	B
Cork Harbour	Ahada Pier to Gold Point	Rostellan	Oysters	B	B

Marine Biotoxins and Shellfish Species: A very intense bloom was recorded in 2005 around parts of the western coast of Ireland and resulted in discolouration of seawater and foaming in coastal embayments. This coincided with a warm spell of weather. Major mortalities of benthic and pelagic marine organisms were observed and a complete decimation of marine faunal communities was reported and observed in several locations. Deaths of echinoderms, polychaetes and bivalve molluscs were observed in County Donegal and Mayo, while farmed shellfish and hatchery raised juvenile bivalve spat suffered significant mortalities along the Galway and Mayo coasts (Silke *et al,* 2005).

Only the shellfish classed as bivalve molluscs feed by filtering the water that washes over the shellfish bed. The microscopic planktonic algae (phytoplankton) in the marine environment are critical food for filter-feeding bivalve shellfish (e.g. mussels, oysters, scallops and clams). The bivalves feed directly on the phytoplankton, using their gills as sieves to strain them from the water. In some situations, however, phytoplankton can have a negative effect causing serious economic losses to aquaculture, fisheries and tourism operations and having major human health impacts. Because of their feeding mechanism, these shellfish can accumulate chemical and/or bacteriological pollutants and naturally occurring toxins from the surrounding waters even at a considerable distance from pollution sources. A single mussel, for example, may filter up to 300 times its weight in one hour. This represents a substantial amount of water. Thus, the health of molluscan bivalve shellfish and the waters in which they grow are closely related. The vast majority of phytoplankton are beneficial and are the ultimate determinants of the size of fish stocks and can proliferate into enormous concentrations of up to millions of cells per litre when sufficient light and nutrients are available (Raine, 2003).

There are four main toxic algal groups that occur in Irish waters. These are the phytoplankton species that produce the toxins that cause Diarrhetic Shellfish Poisoning (DSP), Paralytic Shellfish Poisoning (PSP), Amnesic Shellfish Poisoning (ASP), and Azaspiracid Poisoning (AZP). In previous years, closures in shellfish growing areas around the Irish coast mainly resulted from DSP events, with localised closures in Cork Harbour due to PSP events.

Paralytic Shellfish Poisoning: Paralytic Shellfish Poisoning (PSP) toxins - saxitoxins - are produced by *Alexandrium* spp. Due to the potential severity of the toxin, the presence of this species in water samples triggers increased testing of shellfish samples for PSP toxins. To date the main production area that has experienced closures due to PSP toxins is North Channel in Cork Harbour. Paralytic Shellfish Poisoning toxicity occurred in mussels in early to mid June 2005 in the north channel, Cork Harbour (Clarke *et al.* 2006), which corresponded a rise in *Alexandrium spp.* levels to 1080 cells/litre.

It is now well established that the *Alexandrium* community is mixed in the Cork harbour area, with the presence of the non-toxic *A. tamarense* and the PSP toxin-producing *A. minutum*. The latter species has been identified as the organism responsible for the PSP events recorded in the region, as the toxin profiles obtained from cultures derived from locally *A. minutum* isolates coincided with those obtained from contaminated shellfish samples taken in 1996. (ISSSW, 2005). In mid-September 2003 shellfish sites in the Cork Harbour area were closed as a result of a small bloom of *Alexandrium spp* following positive bioassays and confirmatory chemical tests (Cusack *et al*, 2004).

In the *Status of Irish Aquaculture* report (MERC Consultants, 2006), all native oyster (*O. edulis)* growing areas were tested twice during the year for the presence of the List II parasites *Bonamia ostrea* and *Marteilia refringens*. A total of 2,099 oysters were tested in the course of this screening programme. In 2005, the entire coastline of Ireland was free of *M. refringens.* Areas infected by *Bonamia ostrea* included Cork Harbour.

Trace metal contamination: In a report for trace metal and chlorinated hydrocarbon concentrations in shellfish from Irish waters in 2001 (Glynn *et al,* 2001), it was found that water and shellfish quality were similar to previous years and conformed to the requirements of the Directive. Copper levels were found to be 11.1mg kg^{-1} wet weight for pacific oyster, well below the Spanish standard of 60mg kg_{-1} set for oysters. Levels for other trace metal and chlorinated hydrocarbon levels continued to be very low. The results of bioassay testing for algal toxins in mussels and in oysters (*Ostrea edulis* and *Crassostrea gigas*) in the current and previous reporting periods show that there was generally a much higher level of positive results for the mussel than there was for the two oyster species; this difference is likely to be accounted for both by the greater volumes of water filtered by mussels per unit body weight as well fact that they are cultured in the upper part of the water column where exposure to phytoplankton is likely to be greater than it is for the bottom growing oysters. The data also shows that the proportion of samples of all species giving positive results was much greater in the years 1999 to 2001 than it was in the earlier and later years of the period covered. In the case of the oysters, all samples gave negative results in 2002 and 2003. In the EIA modelling study carried out by O' Kane and Barry (2007), 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 would be also a relative improvement throughout the Outer Harbour.

Water quality

The Environmental Protection Agency undertakes an annual survey of the water quality of estuaries and near shore coastal waters. In general, the water quality status of these waters is considered to be high. Some estuaries, mainly those in the south and east, however, are over-enriched with nutrients and have been classed as eutrophic. In the latest Water Quality In Ireland 2005 report, which covers the period 2001-2005, a total of 10 estuaries or less than 15% of those waters surveyed were classified as eutrophic (EPA website).

Rapid industrialisation in the Cork Harbour area along with increased population growth has led to increased vulnerability to pollution in the harbour, water quality is variable, with the estuary of the River Lee and parts of the Inner Harbour being somewhat eutrophic. A study by the Environmental Protection Agency from 1999 to 2003 sampled water in the Lee river, Lee estuary, Lough Mahon, Owenacurra river, Owenacurra estuary, the North Channel of Great Island and in Cork Harbour (Toner *et al*, 2005). Nutrient enrichment was measured as Dissolved Inorganic Nitrogen (DIN) and orthophosphate (MPR) while undesirable disturbance was measured as percentage saturation of Dissolved Oxygen (DO). The results of this survey are provided in Table 14.

The Lee Estuary remained in an impacted condition due mainly to the severe levels of deoxygenation consistently observed in the reach between the Port of Cork and Blackrock Castle; the criteria for nitrogen was also breached in this water body in both assessments, though only in the winter period in 1999–2003. Phosphate levels also appear to have fallen since the last assessment, when both winter and summer levels were in breach compared to neither being excessive in the current period. However, since the chlorophyll criterion was not breached in either assessment, the Lee Estuary has not been classified as Eutrophic in either period, though this may at least partly result from physical limitations on algal growth such as low transparency.

Lough Mahon exhibited a partial degree of recovery in respect of dissolved oxygen levels in both periods. It is of note, however, that, while all four of the individual nutrient criteria were breached in Lough Mahon in the 1995–1999 assessment, only one of these, the winter nitrogen criterion, was in breach in the current period. This may to some extent reflect the developments being undertaken under the Cork Main Drainage Project, which was largely completed in 2004 and has achieved the cessation of the discharges of untreated sewage into the Lee Estuary and Lough Mahon. Biological treatment processes are currently in operation at the recently commissioned WWTP at Carrigrennan, Little Island. It is too early to predict whether the addition of nitrogen removal will be required to reverse the eutrophic status of Lough Mahon, recently designated, along with the Lee Estuary, as a Sensitive Area. The most recent information available rates the estuarine and coastal water quality for cork harbour in the period 2001-2005 as being intermediate.

The municipal outfalls to tidal waters and corresponding population equivalents (domestic and industrial) served is shown in Table 15. Under the OSPAR convention, eutrophication is defined as: "*The enrichment of water by nutrients causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned, and therefore refers to the undesirable effects resulting from anthropogenic enrichment by nutrients.*"(OSPAR 2000). Eutrophication may occur in the coastal zone and effects include increased production of phytoplankton and macroalgae, deoxygenation of the water column, and changes in composition of species (including indirect impacts on ecological health as a result of enhanced primary production) (OSPAR 2000b). Eutrophication may have the potential to trigger algal blooms and of particular concern is the potential to increase harmful algal production.

The moderate status of water quality in Cork Harbour (EPA Estuarine and Coastal Water Quality Map) is reflected by growths of *Enteromorpha* and *Ulva*. These arise from high concentrations of nutrients such as nitrates and phosphates (left in solution even after primary and secondary sewage treatment). High nutrient levels have been linked to the occurrence of algal blooms in which dinoflagellates reach very high densities, releasing toxins and contaminating shellfish (Raffaelli *et al*, 1998). Parts of the shoreline have faecal coliform counts in excess of 1500/100ml near outfalls at Ringaskiddy, Cobh, and Passage West and also at the existing IDA outfall in the outer harbour.

Industrial effluents and urban run-off contain an enormous variety of substances in addition to the faecal derived organic matter and nutrients of sewage. Two other categories that are important for estuaries are the halogenated hydrocarbons (such as the pesticide DDT and polychlorinated biphenyls, PCB's) and heavy metals (such as zinc, cadmium, lead and mercury). These substances are not readily broken down in the natural environment and

many tend to be taken up by organisms but are not excreted; the phenomenon of bioaccumulation. Concentrations may build up to higher concentrations at higher levels in the food chain (Clarke, 1997). One reason for the apparent tolerance of fauna to heavy metals is their ability to sequester metals in granular form. Mussels, for example store lead in granules in its digestive gland.

Another compound, tributly tin (TBT) used in anti-fouling paints has extensive sublethal effects. Very small quantities of this compound cause changes to reproductive systems of molluscs and can reduce populations of shellfish. In the oyster *C. gigas* TBT also causes reduced growth of tissues, but excessive growth of the shell, so the oysters never grow large enough for sale. In a monitoring of tributyl tin contamination undertaken by Minchin (2003), there were indications of shell thickening in oysters in the North Channel. The lowest value, 0.2, was found in the East Passage. Gel was found in the lamellae of some shells.

Currently, there are two sewerage schemes in Ringaskiddy; sewers constructed by the IDA that serve industry and the others serving the village. In the second half of the 1970s, the IDA purchased large land banks in the harbour area, notably at Little Island and Ringaskiddy. It invested in the required drainage infrastructure, including a major marine outfall for discharge of effluent in Ringaskiddy. The sewer which serves the village is a combined sewer, and discharges directly to Cork Harbour. There is no treatment at present but there is a proposal to connect Ringaskiddy to the proposed Cork Harbour Sewerage Scheme. Although most existing industries have their own on-site treatment prior to discharging to the IDA outfall sewer, there is no secondary treatment plant and the macerated effluent is discharged to the harbour. (Cork County Council, 2006). The EIA conducted by O' Kane and Barry (2007) modelled the existing faecal coliform concentrations in the untreated discharge from the study areas. Currently (2010) the untreated discharge from the Cork Lower Harbour area are contributing a concentration of 1500fc/ml to parts of the Passage West, Cobh, and Ringaskiddy shores. These areas of high concentration extend during neap tides (O' Kane and Barry, 2007). Currently, there are active raw sewage outfalls at Carrigaline/Crosshaven, Passage West, Glenbrook, Monkstown and Ringaskiddy village. At Cobh, there are operating outfalls at King's Quay, west beach, White Point, Pilot's Pier and Corbett outfall.

Table 14 Municipal outfalls to tidal waters and corresponding population equivalents, smaller outfalls (< 2000 p.e.) are not included. Table adapted from Boelens *et al.* 1999, data modified from O'Leary *et al.* 1997.

Location	Carrigaline	Monkstown Creek	Passsage West	Cobh
Population Equivalent	2000-10,000	15,000-150,000	2000-10,000	2000-10,000

Table 15 Assessment of the trophic status of the main water bodies of Cork Harbour 1999 – 2003. C: Compliant, B: Breach; U: Unpolluted, I: Intermediate, E: Eutrophic (adapted from Toner *et al*, 2005).

Water Body	Salinity				DIN (mg/l N^2)				MRP (µg/L P)				Chl a (µg/L)(Summer)				DO (%) (Summer)				
	Winter	n	Summer	n	Winter		Summer		Winter		Summer		Median		90%ile		5%ile		95%ile		
Lee River	0.1	44	0.1	79	2.4	C	1.8	C	30	C	18	C	6.7	C	10.4	C	84	C	114	C	**U**
Lee Estuary	0	7	8.2	165	3.1	B	1.9	C	15	C	45	C	4.6	C	15.4	C	31	B	109	C	**I**
Lough Mahon	23.6	9	30.7	135	1.4	B	0.4	C	14	C	28	C	5.6	C	23.8	B	62	B	114	C	**E**
Owenacurra River	0.1	24	0	20	6.6	B	6.2	B	32	C	59	B	6.7	C	10.4	C	84	C	114	C	**I**
Owenacurra Estuary	11.6	2	17.6	51	3.2	B	1.3	C	14	C	18	C	8.4	C	35.9	B	80	C	134	B	**E**
North Channel Great Island		0	31.6	45			0.2	C			11	C	7.3	C	29.3	B	89	C	123	B	**I**
Cork Harbour	21.6	2	34.1	71	2.5	B	0	C	7	C	5	C	4.5	C	12.9	C	89	C	112	C	**I**