YOUGHAL URBAN DISTRICT COUNCIL

YOUGHAL MAIN DRAINAGE SCHEME

ENVIRONMENTAL IMPACT STATEMENT

Volume 3.

Technical Drawings and Appendices

Youghal Main Drainage Scheme

Environmental Impact Statement

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Technical Drawings and Appendices

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APPENDIX A

Flora and Fauna Assessment

Roger Goodwillie & Associates, Lavistown House, Kilkenny.

A Flora and Fauna

A.1 Introduction

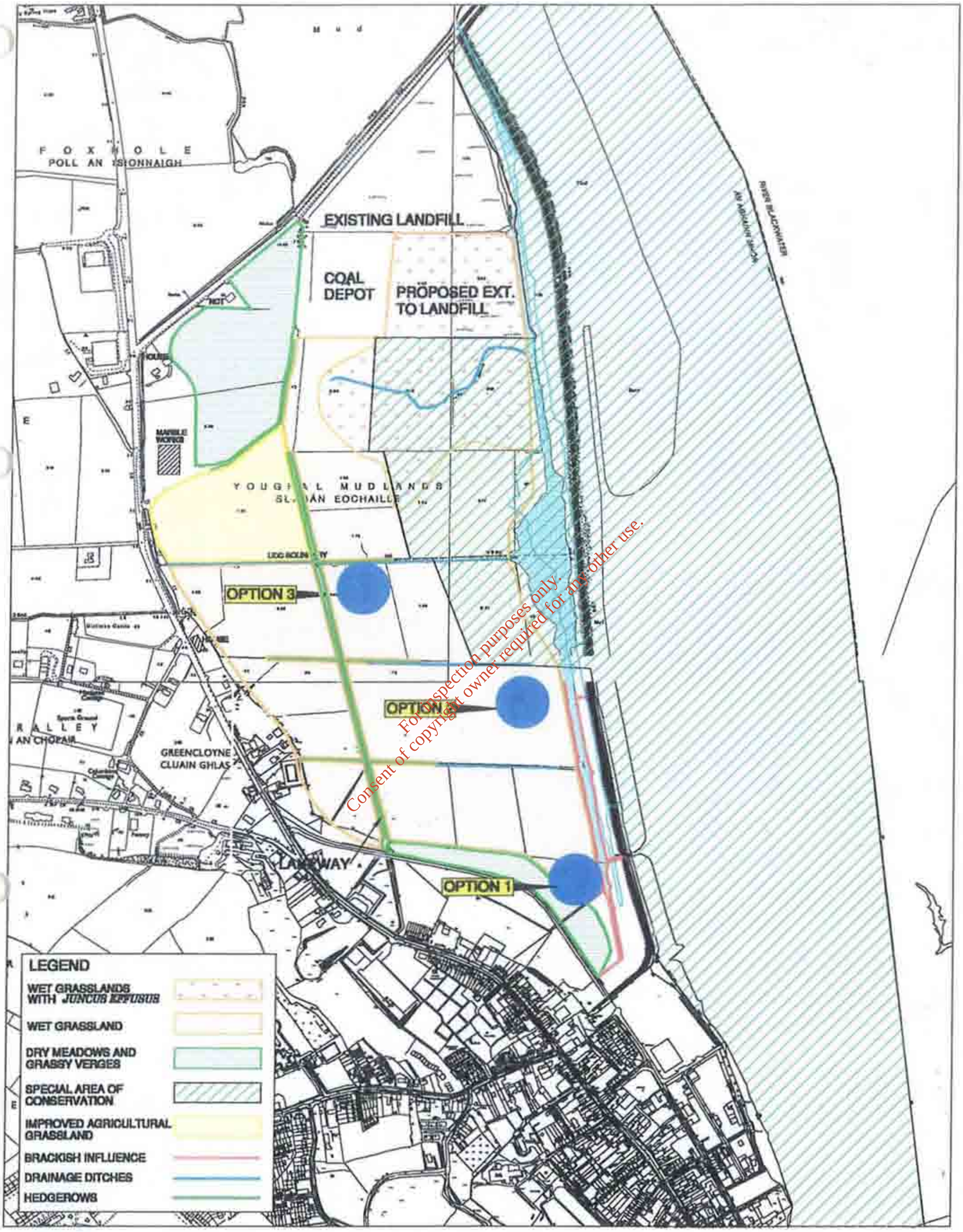
This report is written to assess the ecological impacts of a sewage treatment plant on the Youghal Mudlands and to compare three separate locations for it. It contains information on the habitat and flora and fauna of the potential sites. There is little natural vegetation that might conceal invertebrates of note.

The area was visited in April 2001 and assessed from an ecological viewpoint. The field method corresponds to a Phase I habitat survey (JNCC, 1991) but uses the habitat types of Fossitt (2000). Additional information is acknowledged from Pat Smiddy, the Dúchas Conservation Ranger for the area, and the Dúchas files – part of the area is included in the Blackwater River candidate SAC (Code No. 2170) while it adjoins the Blackwater Estuary SPA.

A.2 Habitats

The area is largely artificial in origin having been reclaimed from the estuary (as an intake) during Famine times. A small amount of pre-existing land was included in the survey, a piece of Foxhole townland in the north-western corner which is protected by a bank. The survey area consists of flat fields, mostly below high tide level although the northern tip has been raised by the landfill. The access laneway enters the mudlands (intake) from the south and is lined by hedges and ditches which extend along most of the field boundaries, petering out towards the sea. Animal enclosure is ensured by wire fences although the number of grazed fields are few – mainly the western ones. Many of the others are overgrown by dense rushes, particularly so in the north-eastern corner.

The soil contains sediment from the estuary and has an obvious shell content when turned. It is heavy, poorly drained and waterlogged. The main habitat is wet grassland



TERRESTRIAL HABITATS AT YOUGHAL MUDLANDS *FIGURE A.1*

(GS4 in Fossitt, 2000) although there are also dry grassland (GA1, GS2), hedgerows (WL1) and drainage ditches (FW4) present. A habitat map is shown in Figure A. 1.

A.2.1 Wet grassland (Habitat Type GS4)

The vegetation in the fields on each side of the access lane is consists of grasses, rushes and species such as meadow foxtail *Alopecurus pratensis*, meadowgrass *Poa trivialis*, creeping bent *Agrostis stolonifera*, Yorkshire fog *Holcus lanatus* and ryegrass *Lolium perenne* varying in frequency depending on the intensity of management. Brown sedge *Carex disticha* and hard rush *Juncus inflexus* are characteristic where water accumulates seasonally. Grazed fields have a selection of broad-leaved species, for example:

Ranunculus repens	creeping buttercup
R.acris	field buttercup
Bellis perennis	daisy
Cirsium arvense	creeping thistle
Taraxacum officinale	dandelion
Trifolium repens	white clover
T.pratense	red clover
Cerastium fontanum	mouse-ear
Rumex acetosa	sorrel

Seaward the fields usually become wetter and grass growth less vigorous. As well as brown sedge *Carex disticha* and hard rush *Juncus inflexus* there is meadowsweet *Filipendula ulmaria*, silverweed *Potentilla anserina*, knapweed *Centaurea nigra*, the moss *Brachythecium* cf *rutabulum*, woodrush *Luzula campestris*, ribwort plantain *Plantago lanceolata* and at the very eastern edge, fleabane *Pulicaria dysenterica*. Small relics of winter ponds add reed grass *Phalaris arundinacea*, jointed rush *Juncus articulatus*, curled dock *Rumex crispus* and sweet grass *Glyceria fluitans* which become frequent towards the east, along with reed fescue *Festuca arundinacea*, glaucous sedge *Carex flacca* etc. This eastern part borders a designated SAC under the EU Habitats Directive (92/43/EEC).

The fields that are overgrown by soft rush *Juncus effusus* – mostly north of the UDC boundary and east of the lane – have a slightly different flora, with additional species such as:

Festuca rubra	red fescue
Holcus lanatus	Yorkshire fog
Senecio jacobaea	ragwort
Lathyrus pratensis	meadow vetchling
Alopecurus pratensis	meadow foxtail
Cynosurus cristatus	crested dogstail
Cirsium palustre	marsh thistle

One of the fields, directly south of the coal depot, has a ditch-line running W-E across it from a spring. On this ditch fool's watercress *Apium nodiflorum*, sweet grass *Glyceria fluitans*, willowherbs *Epilobium* spp, fox sedge *Carex otrubae* and lady's smock *Cardamine pratensis* are present.

A.2.2 Dry grassland (Habitat Types GA1 and GS2)

A single field north of the UDC boundary and west of the lane has been reseeded recently and consists of a stand of ryegrass *Lolium perenne*, white clover *Trifolium repens*, rough-stalked and annual meadowgrass, *Poa trivialis* and *Poa annua*. It is mown for silage and is typical of improved agricultural grassland (GA1). North of it in Foxhole the fields are abandoned though dry and consist of ragwort *Senecio jacobaea*, docks *Rumex obtusifolius*, *R.conglomeratus* and *R.crispus*, tussocky cocksfoot *Dactylis glomeratus* and meadow foxtail *Alopecurus pratensis*. This area may be categorised as GS2 (dry meadows and grassy verges).

A similar community occupies the southern end of the intake, where Option 1 is located. Although below sea level it is rarely exposed to salt water which is restricted to the marginal stream. Here sea clubrush *Bolboschoenus maritimus*, sea aster *Aster tripolium* and scutch *Elytrigia repens* form a fringe. The latter species spreads widely into the field along with the tall grasses false oat *Arrhenatherum elatius*, cocksfoot *Dactylis glomerata*, reed fescue *Festuca arundinacea* and red fescue *F.rubra*. Some glaucous sedge *Carex* *flacca* and fleabane *Pulicaria dysenterica* also occur. There is a central rushy section in which hard rush *Juncus inflexus*, soft rush *J.effusus* and field buttercup *Ranunculus acris* are found.

A.2.3 Hedgerows (Habitat Type WL1)

The oldest and best developed hedges follow the access lane and were presumably planted when the intake was created. Grey willow *Salix cinerea*, wych elm *Ulmus* cf *glabra*, sycamore *Acer pseudoplatanus*, blackthorn *Prunus spinosa*, privet *Ligustrum vulgare*, hawthorn *Crataegus monogyna*, dog rose *Rosa canina* and bramble *Rubus fruticosus* are the main woody species present, with some honeysuckle *Lonicera periclymenum*, holly *Ilex aquifolium* and field rose *Rosa arvensis*. Gorse *Ulex europaeus* is occasional becoming more frequent on the eastern side in field hedges and at the northern end. The associated herbs include:

Brachypodium sylvaticum	false brome
Heracleum sphondylium	hogweed
Anthriscus sylvestris	cow parsley
Filipendula ulmaria	meadowsweet
Vicia sepium	bush vetch
Arum maculatum	lords-and-ladies
Polypodium vulgare	polypody
Polystichum setiferum	shield fern
Phyllitis scolopendrium	hartstongue
Potentilla reptans	cinquefoil
Torilis japonica	hedge parsley
Centaurea nigra	knapweed
Dactylis glomerata	cocksfoot

The townland boundary around Foxhole contains a hedge on a stone-faced bank with black splenwort *Asplenium adiantum-nigrum*, bittercress *Cardamine flexuosa* and violet *Viola riviniana* present here.

Larger hedges on the western side of the lane consist of willows *Salix cinerea*, with some ash *Fraxinus excelsior* and occasional poplar *Populus* sp.

A.2.4 Drainage ditches (Habitat Type FW4)

The field ditches generally lie at the base of open hedges in which gorse *Ulex europaeus* and hawthorn *Crataegus monogyna* are the main species. Rushes *Juncus inflexus*, *J.effusus*, sweet grass *Glyceria fluitans* and wild angelica *Angelica sylvestris* are ubiquitous with reed fescue *Festuca arundinacea*, fleabane *Pulicaria dysenterica*, reed *Phragmites australis* and coltsfoot *Tussilago farfara* in places. Green algae are not uncommon in the seaward parts and also around the few streams that flow east to form the UDC boundary. Such waters appear to be enriched and their sides are generally overgrown by brambles *Rubus fruticosus*, nettles *Urtica dioica* and goosegrass *Galium aparine*. The stream just referred to also contains celandine *Ranunculus ficaria* which is not otherwise widespread.

A.2.5 Adjacent habitats

The site adjoins the wet grassland and pool of the candidate SAC on the eastern side. This is a water collection point for the mudlands (intake) - which subsequently flows south to escape at the southern end when tidal height allows it. On other sides there is rush-covered ground which is proposed as an extension to the landfill, the coal depot, a planned and existing industrial site at Foxhole and general urban land to the west and south.

A.3 Fauna

A.3.1 Vertebrates

The area has a reduced mammal fauna because of the prevailing damp conditions. Hares and foxes were found to occur at low density and there are rabbits in the north-west corner along the townland boundary. Otters may be assumed to use the pond under the seawall at times but would be unlikely to use the site under discussion. Small mammals are likely to include bank vole, wood mouse and pygmy shrew while some burrows of brown rat were seen at the northern end. Most of the site would be of little habitat value to bats which rely on hedges and taller trees to create foraging areas and communication routes. However the south-west corner (Figure A.4.1) is likely to be visited by these animals as there are tree lines in the hedges close enough to potential roosting areas (west of the main road).

The frog is likely to occur around the lane area and breed in transitory puddles and ditches. It would not be favoured by the eutrophic condition of the more permanent streams where there would also be fish predators (e.g. stickleback).

A.3.2 Avifauna

The study area is occasionally used for feeding by waders, e.g. black-tailed godwits (up to 150), lapwing (50) but these are irregular visitors and more likely to be seen within the SAC (Pat Smiddy, pers. comm.). The pond there provides regular feeding for little egret, heron, red-breasted merganser, teal (seen on this visit) and a few other duck, as well as curlew, redshank, dunlin and snipe. There is no regular use of the site (for feeding or roosting) by the shorebirds associated with the SAC (Smiddy, pers. comm.) as there are other more attractive habitats available.

Small birds include skylark and meadow pipit which were seen in the open fields and reed bunting, linnet, goldfinch, greenfinch, blackbird, robin, great tit and blue tit, associated with the hedges. The rush-filled fields appear to be suitable habitat for short-eared owls which would occur in winter with kestrels hunting there more regularly.

Table A. 1 lists the bird species observed at the site.

Table A. 1 Bird species found at Youghal mudlands (site of proposed WWTW).

Common Name	Latin Name	Preferred habitat	Legal Protection
Black-tailed Godwit	*Limosa lapponica*	Wetland	Birds Directive
Lapwing	*Vanellus vanellus*	Wetland	-
Little egrit	*Egretta garzetta*	Wetland	-
Grey Heron	*Ardea cinerea*	Wetland	-
Red-breasted merganser	*Mergus serrator*	Wetland	-
Teal	*Anas crecca*	Wetland	-
Curlew	*Numenius arquata*	Wetland	-
Redshank	*Tringa totanus*	Wetland	-
Dunlin	*Calidris alpina*	Wetland	-
Snipe	*Gallinago gallinago*	Wetland	-
Skylark	*Alauda arvensis*	Grassland	-
Meadow pipit	*Anthus pratensis*	Grassland	-
Reed bunting	*Emberiza schoeniclus*	Hedgerows	-
Linnet	*Carduelis cannabina*	Hedgerows	-
Goldfinch	*Carduelis carduelis*	Hedgerows	-
Greenfinch	*Carduelis chloris*	Hedgerows	-
Blackbird	*Turdus merula*	Hedgerows	-
Robin	*Erithacus rubecula*	Hedgerows	-
Great tit	*Parus major*	Hedgerows	-
Blue tit	*Parus caeruleus*	Hedgerows	-
Short-eared owl		Wet grassland	-
Kestrel	*Falco tinnunculus*	Wet grassland	-

A.3.3 Invertebrates

The invertebrate fauna was not examined and the only possibly interesting site is that of Option 1 – because of its unmanaged vegetation and proximity to brackish conditions.

A.4 Evaluation

The site is made up of typical habitats for land that has been reclaimed from an estuary as an intake and is little managed. Its vegetation consists for the most part of common plants though these become more specialised as the salt water is approached to the east. Again, however no rare species were observed. The hedges represent high species diversity with those present on each side of the access laneway being the richest.

No fauna of nature conservation importance were found in the area although some parts of the area are occasionally used in winter by shorebirds from the estuary. This use of the area by shore birds was probably more intensive when it was managed intensively as farmland in the past: several species (lapwing, golden plover, black-tailed godwit and curlew) feed in pastures as well as on mudflats. The general avifauna is characteristic of open coastal lands and is of amenity rather than heritage value.

A.4.1 Designations

No part of the site is included in the candidate Special Area of Conservation (designated under the EU Habitats Directive 92/42/EEC) which is based on the estuary, taking in the pond beside the seawall and the adjacent fields. As outlined above there is comparatively little ecological connection between the site itself and this area. Adjacent land, outside the seawall is part of the Blackwater Estuary SPA (designated under the EU Birds Directive 79/409/EEC).

No habitats or species listed in the Annexes of these Directives occur on the site with the exception of the common frog (Annex V – Habitats Directive) and there are no plant species present that are included in the Flora Protection Order 1999. However the otter (Annex II – Habitats Directive) and black-tailed godwit (Annex II/2 – Birds Directive) occur on adjacent land. These three species are included in the Irish Red Data Book 2 (Whilde, 1993).

A.5 Impacts of the proposed scheme

The physical presence of the proposed WWTW will have very little effect on the (limited) ecological value of the area. On a local scale, existing habitats will be removed for construction of the WWTP. However, these are not of nature conservation importance so the impact is not considered significant.

Construction and pipe-laying has more potential to create disturbance in the natural communities though there is adequate land available to limit this to a minimum with suitable mitigation. Provided there is no impact on the SAC area it should not be a significant impact. A little extra disturbance could be caused by plant operation but it is considered that the bird life will easily readjust to this. The construction of a road to the WWTW will impact habitats through direct removal of habitat and temporary disturbance of nearby habitat during the construction phase. This will have the least impact in the case of Option 1 which is the shortest route.

There is little to choose between the site options. Option 1 would have the greatest impact on vegetation as this plot has not been managed in recent years. However it would have least impact on birdlife. The other options are located in similar terrain to each other. Option 3 is on a slightly drier and more modified field than Option 2.

A.6 Mitigation Measures

The construction of the plant and associated pipe-laying should be designed to remove as few hedges as possible. In particular the laneway from the southern end should be retained in its present form and a new access be provided from the west. The lane could in time form an attractive walking route, parallel to the sea wall.

During the construction phase, sedimentation of drainage ditches should be avoided if possible.

All vehicular traffic should avoid the vicinity of the SAC boundary to restrict to a minimum the potential inflow of sediment or oil.

References

Fossitt, J.A. 2000. *A guide to habitats in Ireland.* Heritage Council.

JNCC (Joint Nature Conservation Committee) 1990 *Handbook for Phase I habitat survey - a technique for environmental audit.* Peterborough.

Whilde, A. 1993. *Threatened mammals, birds, amphibians and fish in Ireland. Irish Red Data Book 2: Vertebrates.* HMSO, Belfast.

APPENDIX B

Marine Ecology Assessment

Ecological Consultancy Services Ltd (EcoServe), 17 Rathfarnham Road, Terenure, Dublin 6W.

B MARINE ECOLOGY ASSESSMENT

B.1 Introduction

A wastewater treatment works has been proposed for Youghal, Co. Cork. It is proposed that a secondary treatment plant with disinfection will be developed with outfalls discharging into the Blackwater estuary. The proposed scheme will require the construction of an outfall pipe, and the suitability of two sites for the outfall are being examined.

Ecological Consultancy Services Ltd (EcoServe) have been asked by Atkins McCarthy, Cork to prepare an assessment of the marine and estuarine ecology of the area and to provide recommendations and mitigation measures to minimise the impact of the proposed sewage treatment plant on the marine and estuarine flora and fauna of the Blackwater estuary.

B.2 Study area

Youghal town is situated on the western side of the mouth of the River Blackwater. Two main options are being considered for the outfall locations from the new sewage treatment plant, Option 1 and Option 3. Option 1 would be a short sea outfall located at the southern end of Allin's Quay in Youghal town. Option 3 would be a short sea outfall situated north of the quays at Youghal town and at the southern end of the Youghal mudlands.

The western side of the estuary is designated as a Special Area of Conservation (Blackwater River, Site Code 002170), under the European Communities (Natural Habitats) Regulations, 1997. This site is important because it contains a number of E.U. Habitats Directive Annex 1 priority habitats including alluvial habitats, estuaries, mudflats, sandflats, perennial vegetation of stony banks, Atlantic and Mediterranean salt meadows, floating river vegetation and old Oak woodlands. The Blackwater Callows and Estuary are designated as a Special Protection Area under the E.U. Birds Directive and hold internationally important numbers of the wintering waterfowl, the Blacktailed Godwit. Other birds using the estuary include Shelduck, Wigeon, Mallard, Goldeneye, Oystercatcher, Ringed Plover, Grey Plover, Lapwing, Dunlin etc. Seventy-five percent of the wintering waterfowl of the estuary are located in the Kinsalebeg area on the east of the estuary and the remainder are concentrated on the Tourig Estuary on the west side.

The study area extends from the northern end of the Youghal mudlands to the mouth of the estuary. Sublittoral sampling was undertaken in the estuary and littoral surveys on the western shore.

B.3 Methods

The Blackwater estuary was sampled between the 10th and 11th May 2001. All littoral sites were sampled from the shore, at low water spring tides, whilst sublittoral sites were sampled from a boat using a biological dredge.

B.3.1 Littoral survey

The littoral habitats, fauna and flora (biotopes) along the western shore of the Blackwater estuary, from the northern extent of the Youghal Mudlands to Knockaverry, were mapped, in order to provide an assessment of the marine/estuarine fauna, flora and habitats present (Appendix B.1, Figures B.1 and B.2). Species lists were compiled and identified to species level where possible. The biotopes on the shore were mapped using techniques developed during the SensMap project (Emblow *et al.* 1998) and the results compared to existing data and interpreted using the biotope classification (Connor *et al.* 1997).

Adjacent to the proposed outfall pipes quantitive sampling was carried out down a transect line. Four replicate sediment samples were taken using a 6.5 cm diameter corer (to a depth of 20 cm). Samples were passed through a 0.5 mm mesh sieve and the material collected were preserved in 70 % Industrial Methylated Spirits (IMS) and returned to the laboratory for identification. Species were identified to species level where possible and a voucher collection of specimens retained.

B.3.2 Sublittoral survey

Nine stations were sampled along the Blackwater estuary, from the northern end of the Youghal mudlands to Knockavery in the south (Appendix B.2, Tables B.1 and B.2, Appendix B.1, Figure B.1).

The benthos was sampled using a biological dredge (approximately 50 cm by 25 cm) with a 1 cm mesh bag. The dredge was deployed from a boat fitted with a pot-hauler for retrieval. Deployment was over the side of the boat for between 1 and 4 minutes, depending on the substratum. The samples were passed through a 1 mm mesh sieve, the material collected was sorted onboard and the fauna and floral species recorded. Species which could not be identified *in situ* were preserved in 70 % Industrial Methylated Spirits (IMS) and returned to the laboratory for identification. Notes on the substratum type was recorded.

Species nomenclature follows Howson & Picton (1997) and relative abundance was noted. Specimens were identified to the lowest possible taxonomic level, using Crothers and Crothers (1988) for crabs, Smaldon (1993) for shrimps and prawns, Graham (1988) for marine molluscs and Picton (1993) for echinoderms. A voucher collection of representative specimens was retained.

B.4 Results

B.4.1 Littoral

Twenty biotopes (habitats and species) were recorded from the littoral survey (Appendix B.1, Figures B.1, 2a – 2f; Appendix B.4). The majority of these biotopes occurred on the narrow sea wall (approximately 2 metres in length), vertical harbour walls and bedrock which back the shore along the western coast. The wall along the length of the Youghal

Mudlands supported a range of biotopes. The typical profile of the wall had a band of yellow lichens (LR.YG) at the top, followed by zones of green ephemeral algae, *Enteromorpha* sp. (MLR.Ent), the channel wrack, *Pelvetia canaliculata* (SLR.Pel), *Fucus vesiculosus* (SLR.Fves) and *Ascophyllum nodosum* (SLR.Asc), with the sand-binding red alga *Rhodothamniella* sp. and ephemeral *Cladophora* sp. underneath the canopy. Below this zone a band of coarse gravely sand occurred with *Fucus vesiculosus* (SLR.FvesX) or *Fucus serratus* on mixed substratum (SLR.FserrX) (Appendix B.3, Plate 3). Below this an extensive area of very soft, fine anoxic mud (LMU) occurred. Very few macrofaunal species were recorded from this zone, however the shore **crab** *Carcinus maenas*, the bivalue *Macoma balthica* and polychaete *Nepthys* sp. were recorded. Lugworm casts, *Arenicola marina,* were observed, although specimens were not collected in cores.

The harbour walls in Youghal town supported a different range of biotopes. These wall typically had *Entermorpha* sp. at the top (MLR.Ent), followed by *Fucus vesiculosus* (SLR.Fves), barnacles and limpets (ELR.BPat), *Fucus vesiculosus* (SLR.Fves) and mussels with barnacles (ELR.MytB). At the base of the walls soft, anoxic mud occurred. The series of harbours were generally muddy with some *Nepthys* sp. Present. However, further south towards the mouth of Youghal Harbour, they became more sandy. A talitrid zone occurred at the top of the shore with large areas of *Enteromorpha* sp. on rocks on the lower shore (Appendix B.3, Plates B.4 and B.5). The bedrock which backed the shore had zones of yellow lichens (LR.YG), black lichens (LR.Ver), barnacles and limpets (ELR.BPat), *Enteromorpha* sp. (MLR.Ent) and *Fucus vesiculosus* (SLR.Fves). Barren sand (LGS.BarSnd) and *Enteromorpha* sp. on rocks occurred on the lower shore.

At the location of outfall Option 1 the vertical wall was covered by barnacles and limpets (ELR.BPat) with mussels and barnacles (ELR.MytB) in the zone below. The lower shore was dominated by serrated wrack, *Fucus serratus* with mussels and green algae (*Enteromorpha* sp.) and red algae (*Chondrus crispus* and *Ceramium* sp.) on mixed gravel, boulders and mud (MLR.Myt.FR).

Outfall Option 3 is located adjacent to an existing outfall pipe at the southern end of the Youghal Mudlands. The biotopes which occurred at this location were *Fucus serratus* (SLR.FserX) and *Fucus vesiculosus* (SLR.FvesX) on mixed substrata. A mosaic of barnacles and limpets (ELR.BPat) occurred in patches on rocks throughout the *Fucus serratus* zone. A cluster of mussels, *Mytilus edulis* (MLR.MytX) occurred on the pipe at the seaward edge. Core samples were taken from the substrata around the pipeline and they were characterised by the crustacean *Corophium volutator*, the polychaete *Hediste diversicolor* and cockle *Cerastoderma edule*.

62% of the biotopes mapped on the horizontal surface consisted of LMU (Littoral mud), while 21% consisted of LGS (Littoral gravel and sands) biotopes with approximately 17% consisting of rocky biotopes. However, this figure is a rough estimate as it does not take into account biotopes mapped on vertical surfaces such as walls which represented most of the area mapped (see Appendix B.5).

B.4.2 Sublittoral

A total of 9 dredges were taken in the Blackwater estuary, (Appendix B.1, Figure B.1). Twenty four species or higher taxa were recorded (Appendix B.2, Table B.3). The fauna was dominated by hydroids, polychaetes, crustaceans and molluscs.

Opposite Youghal town and adjacent to the north and centre of the Youghal Mudlands, the substratum was very soft anoxic mud with some sand, organic matter and shell debris. Few macrofauna species were recorded from these sites, although polychaetes, in particular, tube worms were characteristic. To the north, south and opposite Ferry Point the substrata was very coarse shell debris with sand. More species were recorded from these sites. At the mouth of the Harbour the substrata again changed and consisted of cobbles, pebbles and rocks and with a different macrofaunal community, characterised by hydroids, crustaceans and seaweeds.

B.5 Discussion

B.5.1 Littoral

In general the biotopes recorded along the inner part of the estuary are typical of more wave sheltered locations than those recorded along the outer estuary. The biotopes recorded are commonly found along the Irish coast (EcoServe, unpublished data) and no species or habitats of conservation importance were recorded. To the authors knowledge no previous survey data has been conducted along the west shore of the Blackwater estuary, however, a detailed survey was conducted by the BioMar survey on Kinsalebeg, a small inlet off the east side of the Blackwater estuary (Picton and Costello, 1998). Kinsalebeg is known to be of ornithological importance (see Study area). A transect was examined down the shore and the dominant species recorded were found to be the polychaetes, *Hediste diversicolor*, *Arenicola marina* and *Nepthys* sp. and the bivalve *Scrobicularia plana*. These results are similar to the current survey although *Macoma balthica* was the dominant bivalve in the current survey.

B.5.2 Sublittoral

The species recorded in the survey area are commonly found in estuaries on the south coast of Ireland (EcoServe unpubl. data). No species or habitats of conservation importance were recorded. Typically species diversity and abundance was low. The sites with the highest number of species were recorded from the middle and outer estuary where the substrata consisted of coarse sand, gravel and shell and cobbles (D3, D6, D7 and D9). Sites with the least number of species mainly occurred in the inner estuary where the substrata consisted of anoxic mud and muddy sand (D1, D2 and D4).

No previous survey data of the benthic flora and fauna of the Blackwater estuary have been collected to the authors knowledge.

B.6 Predicted Impacts

B.6.1 Short term impacts

- Loss or alteration of habitat

Habitat will be lost in the short term during the construction of a trench for laying the outfall pipe. The loss of habitat is likely to be temporary as the trench will be back filled. It is expected that the habitat will be returned to its natural state.

However, the habitats likely to be impacted by the development at Option 1 and Option 3 are however widespread in the survey area and percentage loss in area is expected to be minimal.

- Loss of species

Species will be lost in the short term during the construction phase of the outfall pipe, directly through the removal of habitat when the outfall trench is made, and indirectly through the loss of feeding grounds. Epifaunal species will be most affected as they are attached to the substratum.

Once the habitat has been reinstated it is expected that species from the sites at Option 1 and Option 3 will readily recolonise the area from the surrounding habitat. The loss of species due to loss of feeding and spawning grounds is likely to be negligable due to the small area of seabed likely to be impacted in relation to the wide area of similar habitat available in the area.

- Increased turbidity

There will be an increase in the turbidity of the water during construction of the pipeline trench. This could result in increased siltation, smothering of organisms and reducing light for phytoplankton and seaweed.

Estuarine environments are typically sedimentary with a high sediment load in the water. Species living in estuaries have adapted to these conditions and therefore additional short term sedimentation from the pipeline construction is likely to have minimal impact.

- Pollutants and waste

Contamination of the area due to accidental spillage of pollutants or waste, e.g. oil and other chemicals, or litter, could occur during the construction phase. However, if suitable precautions are taken and best practice for the storage, handling and disposal of such material followed, this should be minimal.

B.6.2 Long term impacts

Long term positive impacts from the wastewater treatment scheme are predicted to occur from the outfall discharge into the Blackwater estuary through an improvement in water quality in the estuary over time. The present sewage treatment plant discharges untreated waste into the estuary, while the new development will provide secondary treatment.

B.7 Recommendations & Mitigation Measures

B.7.1 Pipe location

- Increased turbidity/suspended solids

To minimise the amount of suspended solids released into the water column during construction, efforts should be made to minimise the area of seabed disturbed. Construction should be carried out over periods of slack tide to minimise the dispersion and removal of material from the area.

- Loss of habitat and species

In order to reduce the amount of habitat and species lost, it is recommended that the area impacted upon is restricted to the site.

- Pollutants and waste

It is important to minimise the likelihood of any spillage or contamination. Potential contaminants should be stored in suitable storage facilities both on land, and at sea. The use of bunded containers would minimise the likelihood of spillage's.

Waste and litter generated during construction should be returned to the shore for authorised disposal at suitable facilities. Utmost care and vigilance should be followed to prevent accidental contamination of the site and surrounding environment during the construction of the pipeline. Construction and on site operating procedures should be followed to the highest standard to minimise unnecessary disturbance and prevent accidental spillage of contaminants.

B.7.2 Site management

Utmost care and vigilance be followed to prevent accidental contamination of the site and surrounding environment during the construction of the pipeline and infrastructure. In particular, measures should be taken to prevent disturbance to habitats and species outside of the immediate pipeline location.

Habitats disturbed during the construction process should be restored as close as possible to their previous status after construction.

Sewage treatment will be undertaken at a level which maintains EU water quality standards for bathing and shellfish directives, to minimise adverse future impacts to the marine environment.

B.7.3 Operational standards

The highest possible standards should be maintained during the operation of the WWTW and outfall pipe to minimise future impacts on the marine environment. Sewage treatment should be undertaken at a level which maintains EU water quality standards for bathing and shellfish directives.

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APPENDIX B.1. MAPS

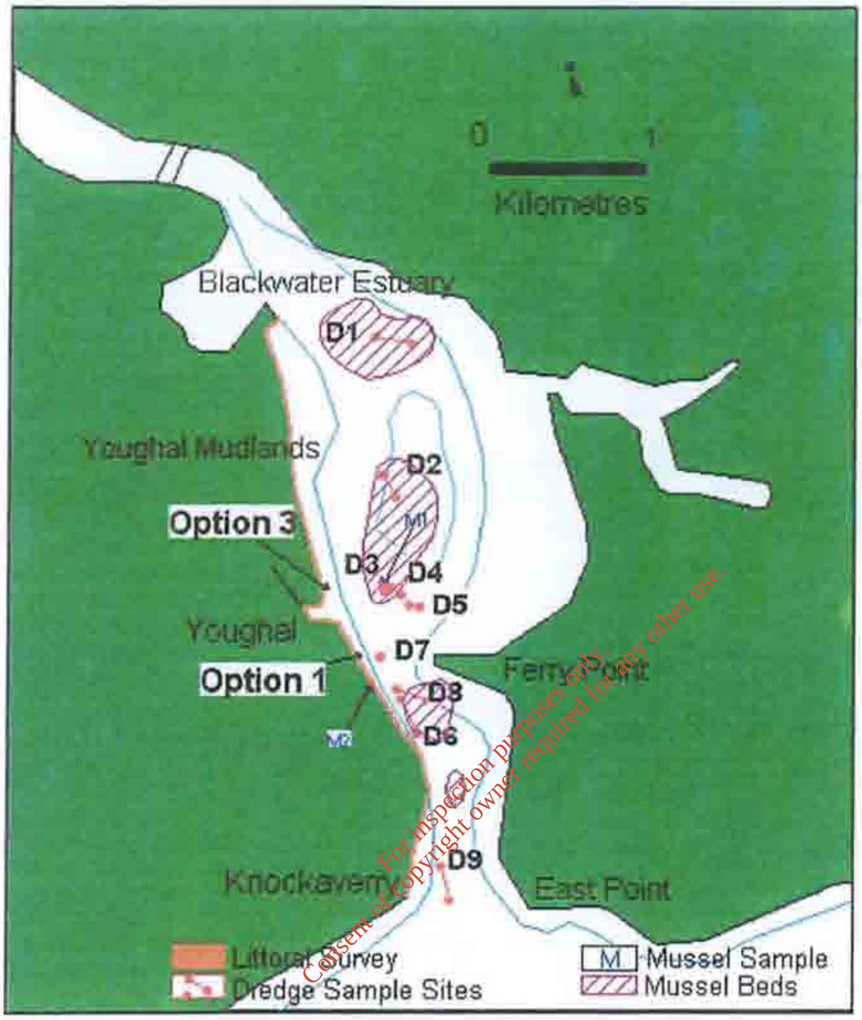


Figure B.1. Map showing locations of dredge sampling sites, the extent of the littoral survey and the two locations where the mussels samples were collected.

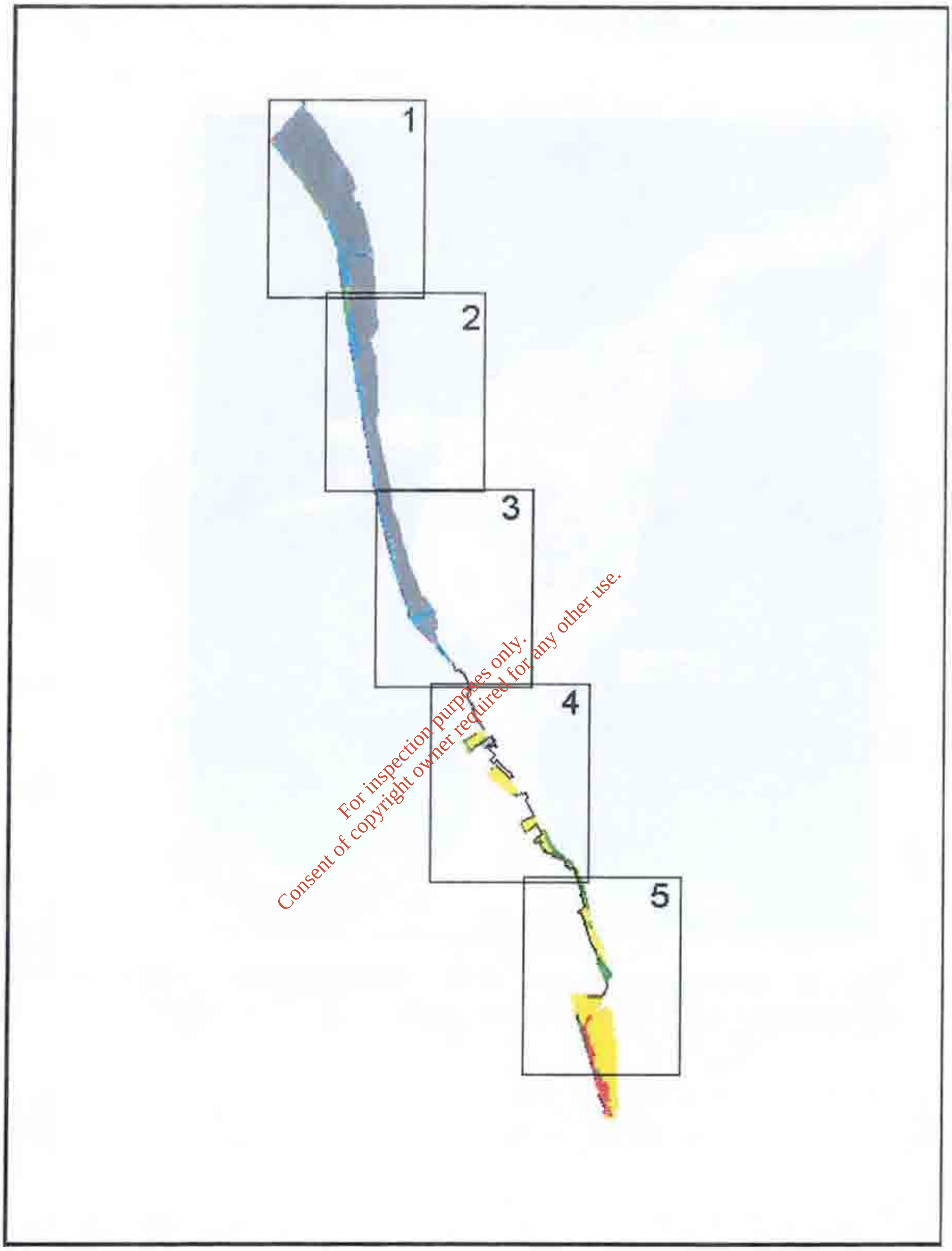


Figure B.2(a) The number and width of the biotopes in the survey are too detailed to be displayed for the whole map. For this reason an insert of a blown up section of the biotopes typically found along this stretch are shown in each case. The higher biotope codes, which represent the wave exposure of the site are however indicated, where grey symbolises a muddy habitat, blue a sheltered biotope, green a moderately exposed biotope, red an exposed biotope and purple the littoral rock.

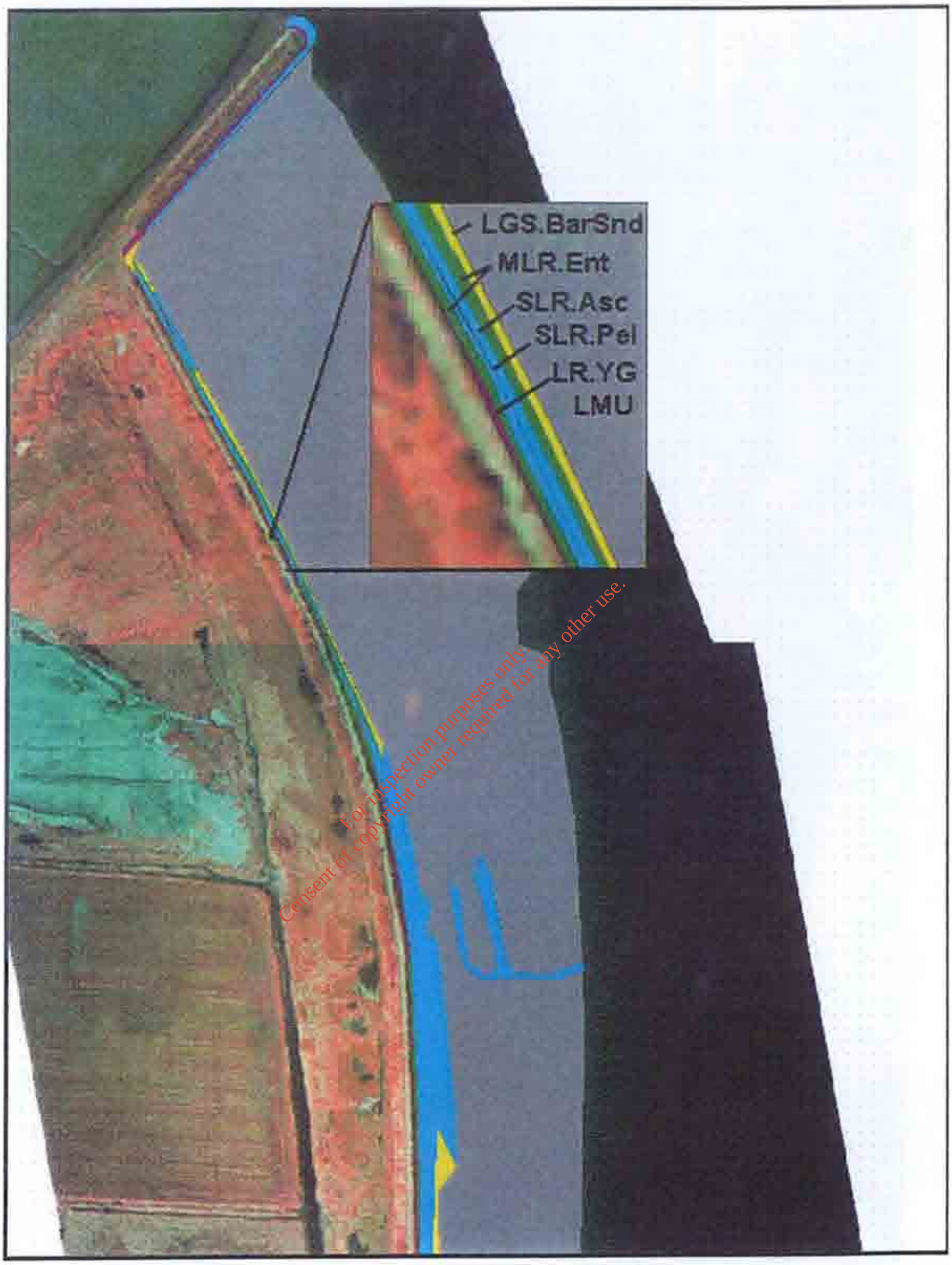
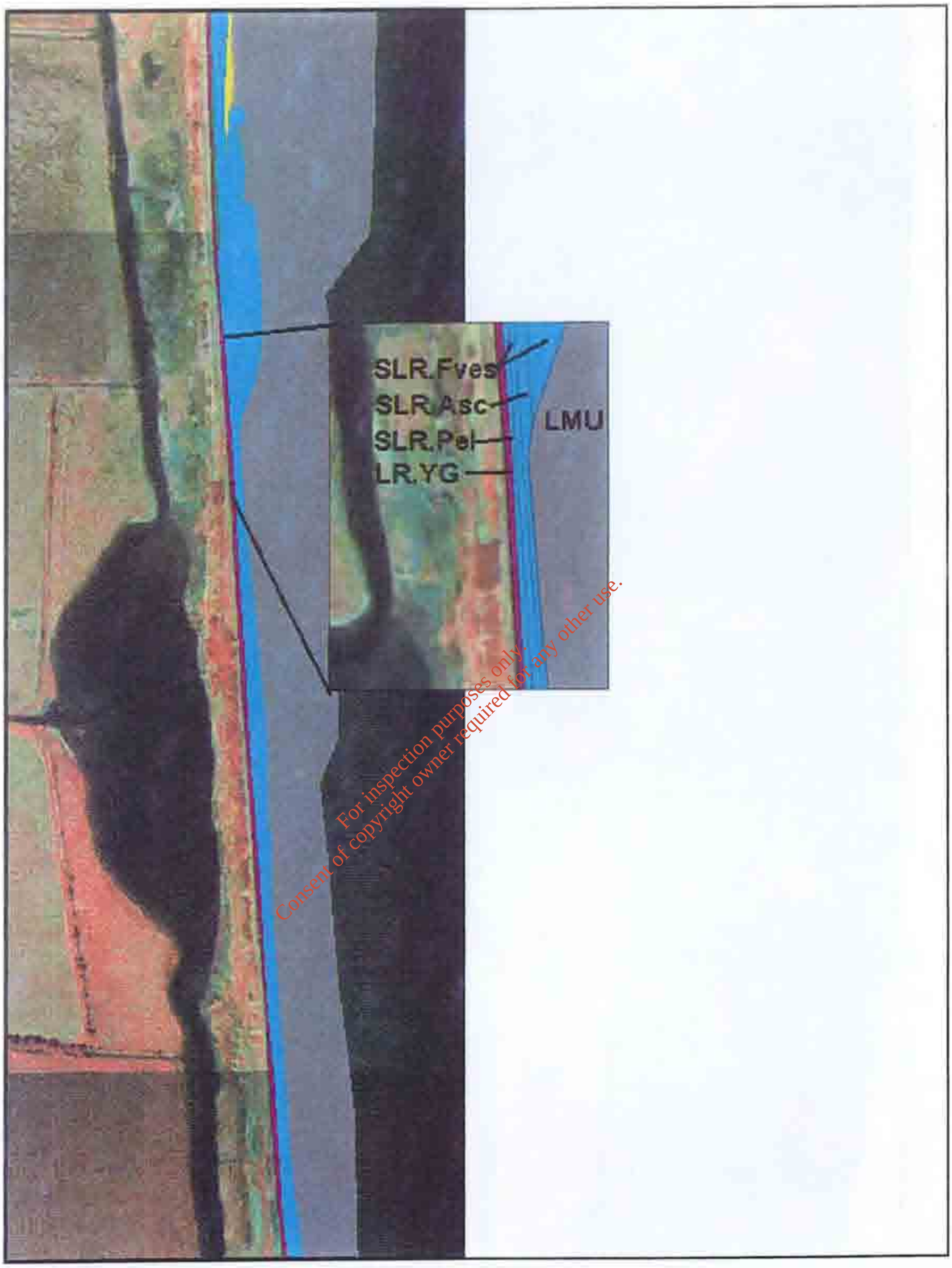


Figure B.2(b). Box 1, showing the biotopes mapped along the upper Youghal Mudlands. This map is approximately 0.75 km in length. The insert is a blown up section of the biotopes typically found along this stretch.



FigureB.2(c). Box 2, showing the biotopes mapped along the mid Youghal Mudlands. This map is approximately 0.75 km in length. The insert is a blown up section of the biotopes typically found along this stretch.

Figure B.2(d). Box 3, showing the biotopes mapped along the lower Youghal Mudlands. This map is approximately 0.75 km in length. The insert is a blown up section of the biotopes found at the site of the proposed outfall Option 3.

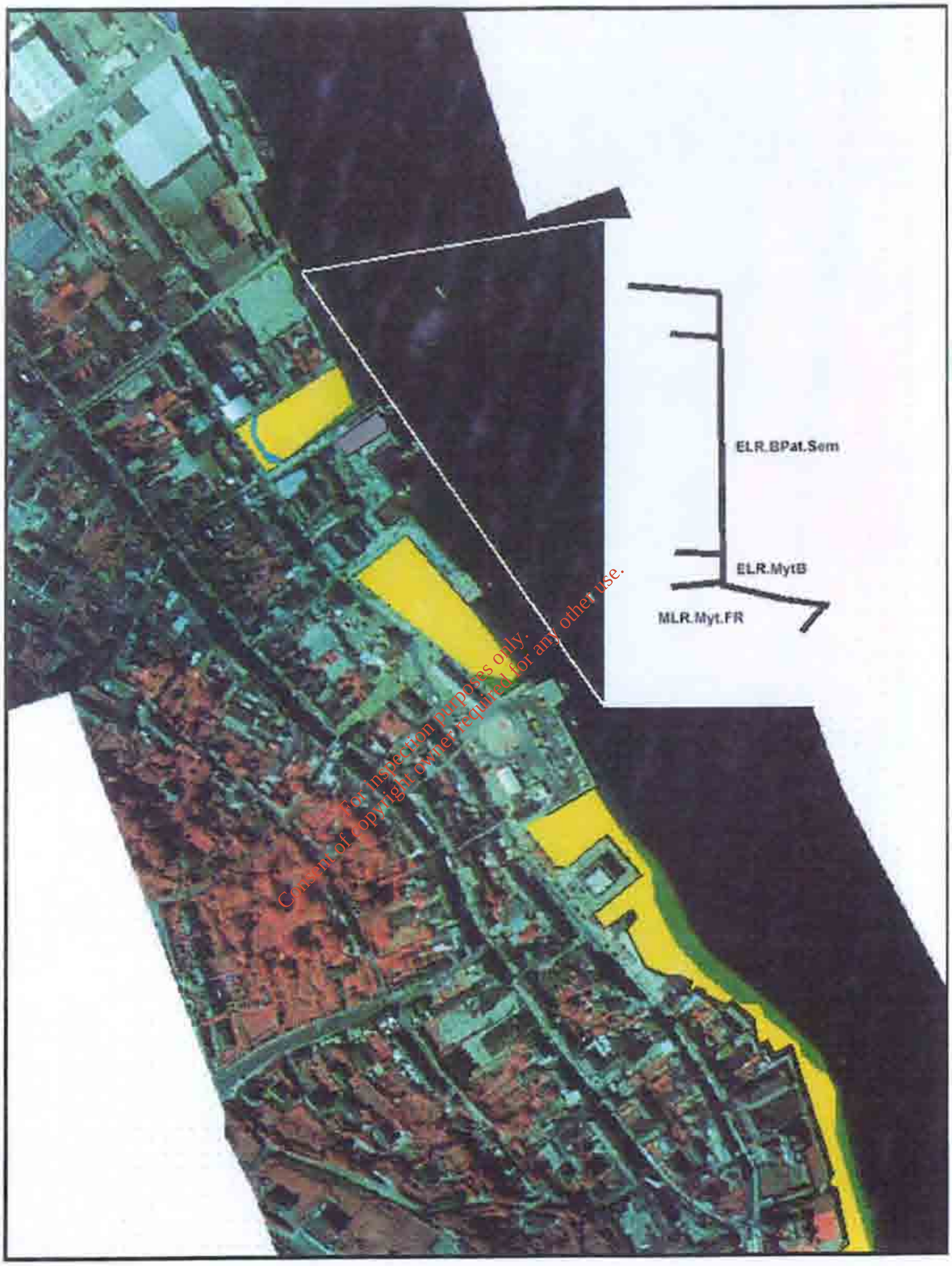


Figure B.2(e). Box 4, showing the biotopes mapped along the harbour walls at Youghal town. This section is approximately 0.75 km in length. The insert is a blown up section of the biotopes found at the location of the proposed outfall Option 1.

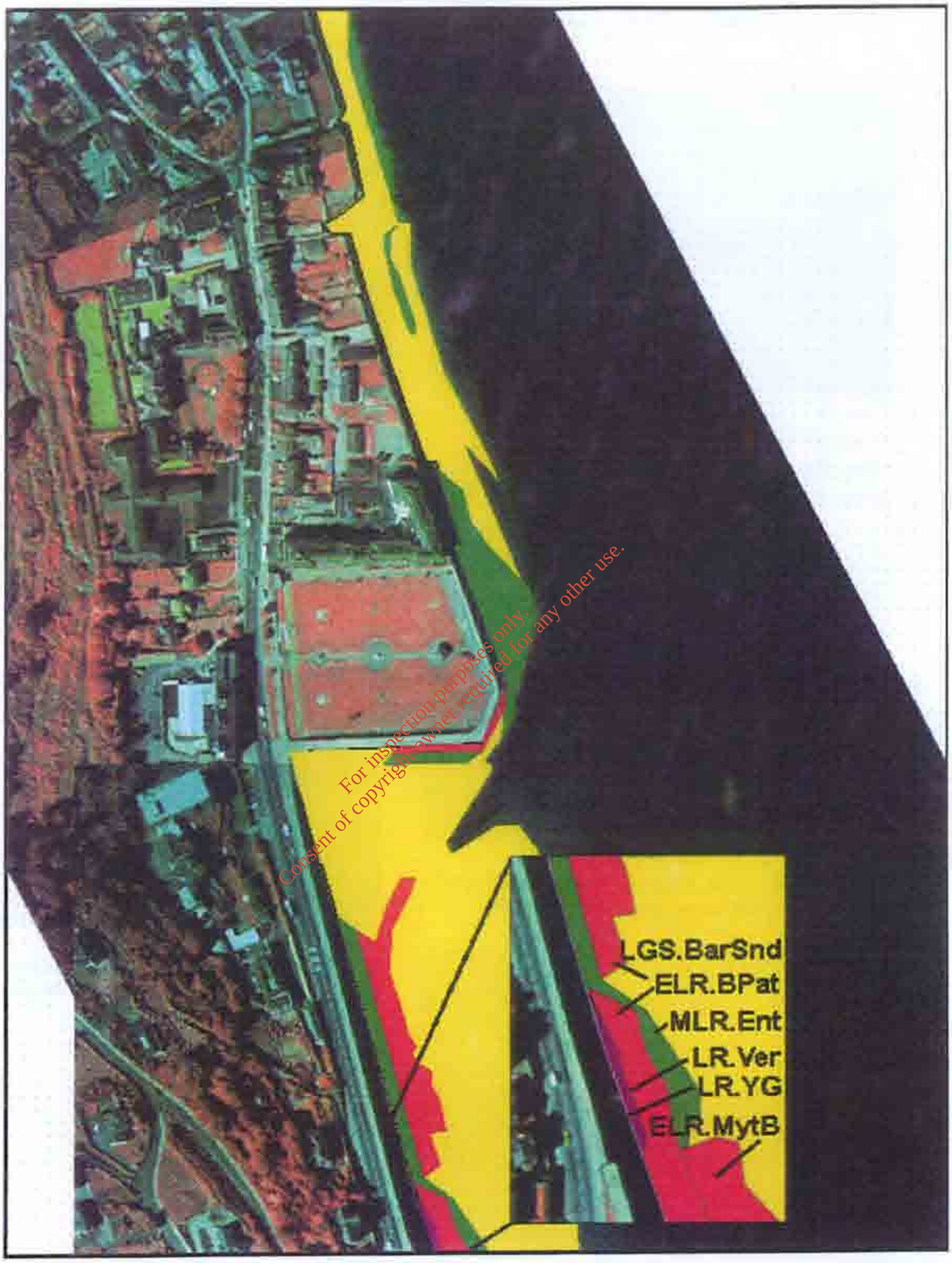


Figure B.2(f). Box 5, showing the biotopes mapped towards the mouth of Youghal Harbour. The stretch is approximately 0.75 km in length. The insert is a blown up section of the biotopes typically found along this stretch.

APPENDIX B.3 PHOTOGRAPHS

Plate B.1. The northern extent of the Youghal Mudlands, showing the biotopes along the wall and extensive mud on the lower shore.

Plate B.2. The northern extent of the Youghal Mudlands.

Plate B.3. The wall along the Youghal mudlands, showing the narrow biotopes along the wall.

Plate B.4. The large extent of *Enteromorpha* sp. on cobbles of the lower shore south of Youghal town.

Plate B.5. The large extent of *Enteromorpha* sp. on cobbles of the lower shore south of Youghal town.

APPENDIX B.2 SUBLITTORAL SAMPLES

Table B.1. Site locations and details of sublittoral dredge sites.

Site no.		Position (Start)	Position (End)	Duration (min.)
D1	11/5/01	51° 58.393 N 07° 50.643 W	51° 58.372 N 07° 50.452 W	4
D2	11/5/01	51° 57.913 N 07° 50.597 W	51° 57.836 N 07° 50.539 W	2
D3	11/5/01	51° 57.540 N 07° 50.607 W	51° 57.510 N 07° 50.589 W	1
D4	11/5/01	51° 57.496 N 07° 50.506 W	51° 57.520 N 07° 50.555 W	2
D5	11/5/01	51° 57.454 N 07° 50.403 W	51° 57.459 N 07° 50.455 W	2
D6	11/5/01	51° 57.136 N 07° 50.499 W	51° 57.012 N 07° 50.411 W	3
D7	11/5/01	51° 57.282 N 07° 50.612 W	51° 57.282 N 07° 50.612 W	3
D8	11/5/01	51° 57.178 N 07° 50.673 W	51° 57.123 N 07° 50.359 W	3
D9	11/5/01	51° 56.548 N 07° 50.282 W	51° 56.429 N 07° 50.232 W	3

Table B.2. Location and description of seabed habitat at each site.

Site no.		Description and notes
D1	Northern extent of Youghal Mudlands	Very soft anoxic mud with some sand, organic matter and shell debris. Very little macrofauna, only polychaetes recorded.
D2	Middle of Youghal Mudlands	Sand with some mud. Substrata anoxic below the surface. Very little macrofauna, tube worms were the dominant species.
D3	Opposite the proposed outfall Option 3	Very coarse shell debris with sand. Large mussels, crabs, hydroids and bryozoans were the dominant species.
D4	Opposite Youghal town	Anoxic mud with coarse shell debris. Very little macrofauna.
D5	North of Ferry Point	Muddy sand with dense *Lanice* casts. Polychaetes were the dominant species.
D6	South west of Ferry Point	Very coarse shell debris and cobbles with anoxic mud. Dominant species were hydroids and bryozoans.
D7	Opposite the proposed outfall Option 1	Coarse sand and shell debris. Dominant species were hydroids, crabs and encrusting bryozoans.
D8	South of Ferry Point	Sandy with coarse shells. Very little macrofauna.
D9	Mouth of Youghal Harbour	Cobbles, pebbles and rocks. Dominant species were starfish and crabs.

Table B.3. Macrofauna recorded at sublittoral sites.

	Station								
Taxonomic Group	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**
Hydrozoa (Hydroids/sea firs)									
Calycella syringa	-	-	-	-	-	-	-	-	P
Hydrallmania falcata	P	-	-	-	-	-	-	-	P
Sertularia cupressina	-	-	-	-	-	P	-	-	P
Obelia dichotoma	-	-	P	P	-	P	P	-	-
Anthoza indet.	-	-	-	-	-	-	P	-	-
Polychaeta (Worms)									
Polychaeta indet.	P	P	P	-	-	-	-	-	-
Glyceridae indet.	P	-	-	-	-	-	-	-	-
Nephtys sp.	-	-	-	-	P	-	-	P	-
Magelona sp.	P	-	-	-	-	-	-	-	-
Terebellida indet.	-	-	-	-	-	-	P	-	-
Lanice conchilega	P	-	-	-	P	-	-	-	-
Pomatoceros triqueter	-	-	P	P	-	P	P	-	P
Crustacea (Crabs, barnacles and amphipods)									
Balanus crenatus	-	-	P	-	-	P	-	-	P
Gastrosaccus spinifer	-	-	-	-	-	-	-	P	-
Pagurus bernhardus	-	-	-	-	-	-	-	-	P
Cancer pagurus	-	-	-	-	-	-	-	-	P
Carcinus maenas	-	-	P	P	P	P	P	-	-
Mollusca (Snails)									
Nucella lapillus	-	-	P	-	-	P	-	-	-
Buccinum undatum	-	-	-	-	-	-	-	-	P
Mytilus edulis	-	-	P	-	-	P	-	-	-
Bryozoa (Sea mats)									
Bryozoa indet.	-	-	P	P	-	P	P	-	P
Echinodermata (Starfish)									
Asterias rubens	-	-	-	-	-	-	-	-	P
Algae (Seaweed)									
Corallinaceae indet.	-	-	-	-	-	-	-	-	P
Laminaria digitata	-	-	-	-	-	-	-	-	P
No. taxa	**5**	**1**	**8**	**4**	**3**	**8**	**6**	**2**	**12**

APPENDIX B. BIOTOPES

List of biotopes recorded during the littoral survey. Descriptions are from Connor *et al.* (1997).

Intertidal

LR.YG Yellow and grey lichens on supralittoral rock

Rock in the supralittoral is typically characterised by a maritime community of yellow and grey lichens, such as *Xanthoria parietina* and *Caloplaca marina*. This band of lichens is usually found immediately above a zone of *Verrucaria maura* (Ver), a black lichen which is also present in this zone, though typically less than common. Damp pits and crevices are occasionally occupied by littorinid molluscs and acarid mites. In sheltered areas the transition from this biotope to *Verrucaria maura* (Ver.Ver) is often indistinct and a mixed zone of YG and Ver.Ver may occur. With increasing wave exposure both zones become wider and more distinct. In estuaries this biotope is often restricted to artificial substrata such as sea defences.

LR.Ver *Verrucaria maura* on littoral fringe rock

Bedrock or stable boulders and cobbles in the sublittoral fringe is typically covered by a band of the black lichen *Verrucaria maura*. It occurs below the yellow and grey lichen zone (YG) and above communities of barnacles and fucoid algae. This biotope occurs in a wide range of wave exposures. Several variants are defined. On exposed shores *Verrucaria* spp. may occur with sparse barnacles (*Chthamalus* spp. or *Semibalanus balanoides*) (Ver.B). Where the ephemeral red alga *Porphyra umbilicalis* occurs this should be recorded as Ver.Por. More sheltered shores tend to lack these species (Ver.Ver).

SLR.Pel *Pelvetia canaliculata* on sheltered littoral fringe rock

Lower littoral fringe bedrock or stable boulders on sheltered shores are characterised by a dense cover of the fucoid *Pelvetia canaliculata*. The fucoid overgrows a crust of black lichens *Verrucaria maura* and *Verrucaria mucosa*, or *Hildenbrandia rubra* on very sheltered shores. This biotope lacks the density of barnacles found amongst the *Pelvetia* on more exposed shores (PelB). The littorinids *Littorina littorea* and *L. saxatilis* occur. The red alga *Catenella caespitosa* is characteristic of this biotope, as is the lichen *Lichina confinis*. Though not typical, this biotope may occur on moderately exposed shores where local topography provides shelter.

SLR.Fves ***Fucus vesiculosus*** **on sheltered mid eulittoral rock**

Moderately exposed to sheltered mid eulittoral rock characterised by a dense canopy of large *Fucus vesiculosus* plants (typically abundant to superabundant). Beneath the algal canopy the rock surface has a sparse covering of barnacles (typically rare-frequent) and limpets, with mussels confined to pits and crevices. *Littorina littorea* and *Nucella lapillus* are also found beneath the algae, whilst *Littorina obtusata* and *Littorina mariae* graze on the fucoid fronds. The fronds may be epiphytised by the filamentous brown alga *Elachista fucicola* and the small calcareous tubeworm *Spirorbis spirorbis*. In areas of localised shelter, *Ascophyllum nodosum* may also occur, though never at high abundance (typically rare to occasional) - (compare with Asc). Damp cracks and crevices often contain patches of the red seaweeds *Osmundea* (*Laurencia*) *pinnatifida*, *Mastocarpus stellatus* and encrusting coralline algae. This biotope usually occurs between the *Fucus spiralis* (Fspi) and the *Fucus serratus* (Fser) zones; both of these fucoids may be present in this biotope, though never at high abundance (typically less than frequent). In some sheltered areas *Fucus vesiculosus* forms a narrow zone above the *A. nodosum* zone (Asc). Where freshwater runoff occurs on more gradually sloping shores *F. vesiculosus* may be replaced by *Fucus ceranoides* (Fcer).

SLR.Asc ***Ascophyllum nodosum*** **on very sheltered mid eulittoral rock**

Sheltered to very sheltered mid eulittoral rock with the knotted wrack *Ascophyllum nodosum*. Several variants of this biotope are described. These are: full salinity (Asc.Asc), tide-swept (Asc.T) and variable salinity (Asc.VS).

SLR.Fserr ***Fucus serratus* on sheltered lower eulittoral rock**

Sheltered lower eulittoral rock with *Fucus serratus*. Several variants of this biotope are described. These are: Dense *Fucus serratus* (Fser.Fser), tide-swept *F. serratus*, sponges and ascidians (Fserr.T) and *F. serratus* and large *Mytilus edulis* in variable salinity (Fserr.VS).

SLR.FvesX ***Fucus vesiculosus* on mid eulittoral mixed substrata**

Sheltered and very sheltered mid eulittoral pebbles and cobbles lying on sediment are typically characterised by *Fucus vesiculosus*. FvesX is usually subject to some variability in salinity from riverine input or, in more marine conditions, the habitat consists predominantly of smaller stones which are too unstable for *Ascophyllum nodosum* to colonise to any great extent (compare with AscX). This biotope typically differs from Fves in having a less dense canopy and reduced richness of epifaunal species, presumably as a result of the increased siltation, variable salinity and lack of stable substrata. In addition, the sediment between patches of hard substrata often contains the lugworm *Arenicola marina*, cockles *Cerastoderma edule* or the ragworm *Hediste diversicolor*. Littorinids, particularly *Littorina littorea*, commonly graze on the algae. Ephemeral algae such as *Enteromorpha* spp. are often present, especially on any more mobile pebbles during the summer. Limpets are less common than in AscX, because of the limited availability of larger rocks.

SLR.EphX **Ephemeral green and red seaweeds on variable salinity or disturbed eulittoral mixed substrata**

Eulittoral mixed substrata (pebbles and cobbles overlying sand or mud) that is subject to variations in salinity and / or siltation are often characterised during the summer months by dense blankets of ephemeral green and red algae. The main species present are *Enteromorpha* spp., *Ulva lactuca* and *Porphyra* spp. Although fucoid algae occur in these areas they are typically rare. Small numbers of other species such as barnacles *Semibalanus balanoides* and *Elminius modestus* and keel worms *Pomatoceros* spp. are confined to any larger cobbles and pebbles. This biotope may be a summer variation of BLlit, in which ephemeral algal growth has exceeded the capacity of the grazing molluscs. In common with the other biotopes found on mixed substrata, patches of sediment are typically characterised by infaunal species including bivalves (*Cerastoderma edule* and *Macoma balthica*) and polychaetes (*Arenicola marina* and *Lanice conchilega*). Occasional clumps of *Mytilus edulis* may also occur, although at considerably lower density than in MytX.

SLR.MytX ***Mytilus edulis*** **beds on eulittoral mixed substrata**

Moderately exposed to very sheltered mid and lower eulittoral mixed substrata (mainly cobbles and pebbles on muddy sediments) with dense aggregations of the mussel *Mytilus edulis*. In high densities the mussels bind the substratum and provide a habitat for many species more commonly found on rocky shores. *Fucus vesiculosus* is often found attached to either the mussels or the cobbles and it frequently occurs at high abundance. The mussels are usually encrusted with the barnacle *Semibalanus balanoides* (and/ or *Elminius modestus* in areas of reduced salinity). *Littorina littorea* and small *Carcinus maenas* are common amongst the mussels, whilst areas of sediment may contain *Arenicola marina*, *Lanice conchilega*, *Cerastoderma edule* and other infaunal species. In contrast with the mussel beds found on rocky shores (MLR.MF) this biotope contains few limpets or red algae. This biotope is also found in lower shore tide-swept areas, such as in the tidal narrows of Scottish sealochs.

MLR.Fser ***Fucus serratus*** **on moderately exposed lower eulittoral rock**

Lower eulittoral bedrock and stable boulders with a canopy of the serrated wrack *Fucus serratus*. Several variants of this biotope are described. These are *Fucus serratus* with red seaweeds (Fser.R), dense *F. serratus* (Fser.Fser), *F. serratus* with under-boulder communities (Fser.Fser.Bo) and *F. serratus* and piddocks on soft rock (Fser.Pid). Dense *Fucus serratus* also occurs on more sheltered shores (Fserr).

MLR.Ent ***Enteromorpha*** **spp. on freshwater-influenced or unstable upper eulittoral rock**

Upper shore hard substrata that is relatively unstable (e.g. soft rock) or subject to considerable freshwater runoff is typically characterised by a dense mat of the green filamentous algae *Enteromorpha intestinalis* and *Enteromorpha prolifera*, often together with the red alga *Porphyra umbilicalis*. This band of *Enteromorpha* spp. is usually found above the *Fucus spiralis* zone (Fspi) and may replace the *Pelvetia canaliculata* zone (PelB).

MLR.Rho ***Rhodothamniella floridula*** **on sand-scoured lower eulittoral rock**

Lower eulittoral and sublittoral fringe sand-scoured bedrock and boulders are often characterised by canopy algae (usually *Fucus serratus*), beneath which a mat of the sand-binding red alga *Rhodothamniella floridula* occurs. These mats can also form distinct areas without *F. serratus*. The small hummocks of *R. floridula* also contain other small red and brown algae and species of worm and amphipod may burrow into the *Rhodothamniella* mat. Other sand-tolerant algae, such as *Polyides rotundus*, *Furcellaria lumbricalis*, *Gracilaria verrucosa* and *Cladostephus spongiosus*, may be present. Ephemeral algae such as *Enteromorpha* spp., *Ulva* spp. and *Porphyra* spp. may occur. Where sand scour is more severe, fucoids and *Rhodothamniella* may be rare or absent and these ephemeral algae dominate the substratum (EntPor).

MLR.MytFR ***Mytilus edulis*, *Fucus serratus*** **and red seaweeds on moderately exposed lower eulittoral rock**

Lower eulittoral moderately exposed bedrock, often with nearby sediment covered by dense, large *Mytilus edulis* with a covering of scattered *Fucus serratus* and red algae. The algae include *Porphyra umbilicalis*, *Rhodothamniella* sp., *Palmaria palmata*, *Mastocarpus stellatus* and *Ceramium nodulosum*. Ephemeral green algae such as *Enteromorpha* spp. and *Ulva lactuca* commonly occur on the shells of the mussels. The barnacle *Semibalanus balanoides* is common on both the mussel valves and on patches of bare rock, where the limpet *Patella vulgata* is also found, often at high abundance. The dog whelk *Nucella lapillus* and a range of littorinids also occur within the mussel bed.

This biotope differs from MytFves which has far fewer red algae present and scattered *Fucus vesiculosus*, indicative of the mid eulittoral zone.

ELR.BPat.Sem *Semibalanus balanoides* on exposed or moderately exposed, or vertical sheltered, eulittoral rock

Exposed to moderately exposed eulittoral bedrock and boulders characterised by dense barnacles *Semibalanus balanoides* and the limpet *Patella vulgata*. In the north-west, where *Chthamalus* spp. also occur, *Semibalanus balanoides* may form a grey band below the distinct white band of *Chthamalus* spp. (BPat.Cht) in which patches of *Lichina pygmaea* may be prominent On some shores, particularly in the south, the *Lichina* may form a distinct zone (see BPat.Lic). On the east coast, where there is no *Chthamalus* spp. *Lichina*, if present, tends to form a band astride the upper limit of the barnacles (i.e. partly in BPat and partly in Ver.B). Cracks and crevices in the rock provide a refuge for small mussels *Mytilus edulis*, winkles *Littorina neglecta* and the dog whelk *Nucella lapillus*. Damp crevices are also frequently occupied by red algae, particularly *Osmundea pinnatifida*, *Mastocarpus stellatus* and encrusting coralline algae. With decreasing wave exposure *Fucus vesiculosus* is able to survive, gradually replacing the barnacles and *Patella* biotope (see FvesB). BPat.Sem may also occur on steep and vertical faces on sheltered shores, while fucoids dominate the flatter areas.

ELR.MytB *Mytilus edulis* and barnacles on very exposed eulittoral rock

The eulittoral zone, particularly mid and lower shore zones, of very exposed rocky shores are typically characterised by patches of small mussels *Mytilus edulis* interspersed with patches of barnacles *Semibalanus balanoides*. Amongst the mussels small red algae including *Ceramium shuttleworthianum*, *Corallina officinalis*, *Mastocarpus stellatus* and *Aglaothamnion* spp. can be found. Two red algae in particular, *Porphyra umbilicalis* and *Palmaria palmata*, are commonly found on the *Mytilus* itself and can form luxuriant growths. The abundance of the red algae generally increases down the shore and in the lower eulittoral they may form a distinct zone in which mussels or barnacles are scarce (R, Him or Coff). Where *Mytilus* occurs on steep rock, red algae are scarce, and restricted to the lower levels. The dog whelk *Nucella lapillus* and a few littorinid molluscs occur where cracks and crevices provide a refuge in the rock. Fucoids are generally absent, although some *Fucus vesiculosus* f. *linearis* may occur where the shore slopes more gently. MytB is generally found above a zone of either mixed turf-forming red algae (R), *Himanthalia elongata* (Him) or above the sublittoral fringe kelp *Alaria esculenta* (Ala). Above MytB there may be a *Porphyra* zone (Ver.Por), a *Verrucaria maura* and sparse barnacle zone (Ver.B) or a denser barnacle and limpet zone (BPat), often with *Porphyra*. In addition, patches of *Lichina pygmaea* with barnacles (BPat.Lic) may also occur above this biotope, particularly on southern shores. This biotope also occurs on steep moderately exposed shores which experience increased wave crash.

ELR.BPat.Cht *Chthamalus* spp. on exposed upper eulittoral rock

Exposed to moderately exposed upper and mid eulittoral bedrock and boulders are characterised by dense barnacles, *Chthamalus* spp. and the limpet *Patella vulgata*. On the west coast *Chthamalus* spp. dominate the upper to mid eulittoral, often forming a distinct white band above a darker *Semibalanus balanoides* zone (BPat.Sem). This is because *Chthamalus montagui* is better adapted to resist desiccation and, therefore, extends further up the shore. There is much regional variation in the distribution and zonation of *Chthamalus* spp. In more northern latitudes, such as north-west Scotland, the abundance of *Chthamalus* is greater on more wave exposed shores. In the south-west *Chthamalus* spp. can be the dominant barnacle throughout the eulittoral zone. Patches of *Lichina pygmaea* may be prominent within the *Chthamalus* zone, especially in the south. Where this forms a distinct *Lichina* zone it should be recorded as BPat.Lic. Cracks and crevices in the rock provide a refuge for small mussels *Mytilus edulis*, winkles *Littorina saxatilis* and the dogwhelk *Nucella lapillus*. Damp crevices are also frequently occupied by red algae, particularly *Osmundea pinnatifida* and encrusting coralline algae. With decreasing wave exposure *Fucus vesiculosus* is able to survive and this alga gradually replaces the barnacles and *Patella* biotope (see FvesB). On such moderately exposed shores BPat.Cht may occur on steep and vertical faces, while fucoids dominate the flatter areas. It should not be confused with more exposed shores characterised by *Fucus vesiculosus f. linearis* and *Chthamalus* spp. (BPat.Fvesl). In areas of soft rock (e.g. shales), the barnacles may be scarce or absent and the rock dominated by *Patella. Chthamalus* spp. are uncommonly abundant in the upper eulittoral zone in very sheltered sealochs in Argyll, West Scotland

LGS.Tal Talitrid amphipods in decomposing seaweed on the strand-line

A community of talitrid amphipods may occur on any shore where decomposing seaweed accumulates on the extreme upper shore strand-line. The community occurs on a wide variety of sediment shores composed of shingle and mixed substrata through to fine sands, but may also occur on mixed and rocky shores in some circumstances. The decaying seaweed provides cover and humidity for *Talitrus saltator* and other components of the community. The amphipods *Orchestia* spp. are also often present, as well as enchytraeid oligochaetes. Polychaetes, molluscs and other crustaceans may be brought in on the tide, but are not necessarily associated with the infaunal community. Further analysis of the data may determine that *Orchestia* spp. are associated with a denser strand and that there are differences in the community dependant upon the substratum-type. *Talitrus saltator* may occur further down the shore, almost invariably accompanied by burrowing amphipods such as *Bathyporeia* spp. (LGS.AEur).

LGS.BarSnd Barren coarse sand shores

Freely-draining coarse sandy beaches, particularly on the upper shore, which lack a macrofaunal community due to their continual mobility. Trial excavations are unlikely to reveal any macrofauna in these typically steep beaches on exposed coasts. Burrowing amphipods *Bathyporeia* spp. or *Pontocrates* spp. and the isopod *Eurydice pulchra* may be found in extremely low abundances, but if present in any quantity should be classed as LGS.AEur. Other species that may be found in low abundance may be left behind by the ebbing tide.

LGS.AP **Burrowing amphipods and polychaetes in clean sand shores**

Mid and lower shore clean sandy shores on wave-exposed or moderately wave-exposed coasts support a community of burrowing amphipods and polychaetes, sometimes with bivalves such as *Angulus tenuis*. The medium to fine-grained sand remains damp throughout the tidal cycle. The community consists of burrowing amphipods (*Pontocrates altamarinus*, *P. arenarius*, *Bathyporeia elegans*, *B. guilliamsoniana*, *B. pelagica*, *B. pilosa* and *B. sarsi*), the isopod *Eurydice pulchra*, the cumacean *Cumopsis goodsiri* and polychaetes (including *Nephtys cirrosa*, *Scolelepis squamata*, *Paraonis fulgens* and *Arenicola marina*). The presence of polychaetes is seen as coloured burrows running down from the surface of the sediment. The sediment is often rippled and typically lacks an anoxic black sub-surface layer. This community differs from the community of burrowing amphipods (LGS.AEur) in its greater variety of polychaete species and the presence of bivalves. The two sub-types are LGS.AP.P and LGS.AP.Pon depending upon the proportion of amphipods and polychaetes and the specific species present in the sand. More stable sediment, such as is found in sandy inlets or extensive coastal sandflats are LMS.PCer or LMS.MacAre.

LMU **Littoral muds**

Shores of fine particulate sediment with a particle size less than 0.063 mm in diameter that typically forms extensive mudflats. Dry compacted mud can form steep and even vertical structures, particularly at the top of the shore adjacent to saltmarshes. Also included in this higher division are sandy muds which have between 20% and 70% sand, the remainder being made up of mud with a particle size less than 0.063 mm. Small amounts of gravel or pebbles may be found within mud, having little effect upon the structure of the associated communities. Littoral muds support communities characterised by polychaetes, certain bivalves and oligochaetes. The ragworm *Hediste* (*Nereis*) *diversicolor*, the Baltic tellin *Macoma balthica* and the furrow shell *Scrobicularia plana* are conspicuous members of muddy shore communities.

APPENDIX B.5. AREAS AND PERCENTAGES OF LITTORAL BIOTOPES

HIGHER_CODE	BIOTOPE_CODE	Total (ha)	% of total
ELR	BPat	0.0	1.71
	MytB	0.0	0.37
ELR		0.0	0.64
ELR Total		0.1	
LGS	BarSh	0.0	0.02
	BarSnd	0.4	16.81
	Tal	0.0	0.01
LGS		0.1	3.61
LGS Total		0.5	
LMU		1.5	61.78
LMU Total		1.5	
LR	Ver	0.0	0.04
	YG	0.0	1.40
LR		0.0	0.17
LR Total		0.0	
MLR	Ent	0.0	0.73
	Eph	0.0	0.65
MLR		0.1	2.38
MLR Total		0.1	
SLR	Asc	0.1	2.07
	EntX	0.0	0.08
	FserX	0.0	1.09
	Fves	0.0	1.71
	FvesX	0.1	2.98
	MytX	0.0	0.02
	Pel	0.0	1.65
SLR		0.0	0.05
SLR Total		0.2	
Grand Total		**2.4**	**100.00**

APPENDIX B.6. GLOSSARY

Term	Definition	Alternative terms
Biotope	After (Hiscock 1996) The physical 'habitat' with its biological 'community'; a term which refers to the combination of physical environment (habitat) and its distinct assemblage of conspicuous species'.	facies
Boulder	stones > 25 cm diameter	
Cobble	stones 64 to 256 mm diameter	
Community	group of different species which occur together	
Gravel	sediment grains 4 to 16 mm diameter	
Infauna	animals living within sediments	
Littoral	Between upper and lower tidemarks, exposed to air at the lowest tides	littoral, seashore
Mud	sediment grains < 0.063 mm diameter	silt, clay
Pebble	sediment grains 16 - 64 mm diameter	
Rock	hard substratum dominated by epifauna or epiflora	hard substrata
Sublittoral	Below the littoral, never exposed to air	sublittoral, seabed
Substrata	surfaces (plural) to which an organism grows on or amongst	
Substratum	surface (singular) to which an organism grows on or amongst	

APPENDIX C

Soils & Geology Assessment

Jeremy Moore, Atkins McCarthy, Dublin Office.

C. GEOTECHNICS SOILS AND SEDIMENTS

C.1 Introduction and Proposed Development

C.1.1 Youghal is situated on the westerly bank of the River Blackwater just downstream of the confluence of the River Tourig.

C.1.2 All three proposed sites for the Waste Water Treatment Works (WWTW) are situated on reclaimed mudflats on the west bank of the River Blackwater to the north of Youghal town. The elevation of the site is currently approximately 1m above Ordnance Datum.

C.1.3 Three options are proposed for the outfall from the WWTW. Options 1 and 3 are planned as short sea outfalls starting from the harbour area and the southerly end of the mudlands respectively. Both these options will discharge into the deep-water channel off Ferry Point and are anticipated to be approximately 300m long. Outfall Option 2 is planned as a long sea outfall discharging into the sea south of Youghal. Pipes linking the WWTW with the outfall are proposed to be constructed either on the foreshore, or along the alignment of existing roads in the case of the long sea outfall (Option 2).

C.1.4 Data on ground conditions in the area of the proposed development was available from two cable percussive boreholes drilled in the area of the WWTW site Option 3, BH1 and BH2. The location of these boreholes is indicated in Figure C.1. Site investigation data was also available from the road embankment crossing the River Tourig (approximately 1km north west of the site) and the proposed landfill site extension approximately 500m north of the site. In addition data was available from aerial photography, topographic maps, Admiralty charts and geological maps.

C.1.5 The mudlands consist of pasture land reclaimed from tidal mudflats. This land has been isolated from the estuarine environment by a sea wall and drained by ditch drainage. No significant quantities of fill have been used to increase the elevation of this land. This is confirmed by the aforementioned borehole data.

C.2 Existing Environment

C.2.2 Geology and Hydrogeology - Mudlands

C.2.2.1 The bedrock geology in the Youghal area consists of Carboniferous and Devonian limestones, sandstones and mudstones.

C.2.2.2 The superficial soil deposits consist primarily of estuarine deposits associated with the rivers Blackwater and Tourig. These deposits consist of normally consolidated estuarine and marine sediments. These sediments consist of soft thinly laminated organic silts and very silty clays with frequent thin (<10mm) sand layers and layers of partially decomposed organic material overlying dense gravel. In the BH2 3m of stiff clay was encountered between the silt and gravel. The dense gravels were encountered at 9.2m in BH1 and 14m in BH2 indicating the depth of this stratum increases in depth towards the river.

C.2.2.3 The ground profile encountered in both boreholes is similar to that encountered during the site investigations for the proposed landfill site and road embankment. These site investigations show lateral continuity of the silt across the flood plain with the silts underlain by gravel towards the river and stiff clay towards the land.

C.2.2.4 The thickness of the estuarine deposits can be expected to vary over the mudlands with the deeper deposits being located adjacent to the river.

C.2.2.5 Groundwater was encountered in the gravel deposits underlying the soft silts. The piezometric head of the groundwater in the gravels was found to be slightly above ground level and piezometers were installed to allow monitoring of ground water levels.

C.2.3 Geology – Estuary Sediments

C.2.3.1 Soil conditions under the estuary are anticipated to be similar to those encountered beneath the mudflats, with the addition of a layer of loose unconsolidated estuarine soils. Site investigation data is not available in the vicinity of the proposed short sea outfalls. The thickness and nature of the upper layers of estuarine sediments are dependant on the hydrological regime of the river. The bathymetric survey and topographic data show that the channel narrows and deepens in the area of the proposed short sea outfalls. This indicates a significant increase in current velocity in this area with the possibility of the scouring of superficial sediments.

C.2.3.2 Grab samples from Youghal Harbour were analysed for metal concentrations and grain size. These indicated that the sediments comprise slightly organic sands and silts with low concentration of metals. These are characteristic of low energy estuarine environments.

Table C.1 Concentrations of metals in marine sediment in Youghal Harbour.

mg/kg (ppm)	Site 3	Site 4	Site 5	Sewage Sludge Directive limits*	Dumping at Sea Act** limits
Arsenic	<1	<1	4	None	None
Cadmium	<1.0	<1.0	<1.0	20-40	10
Copper	<5	6	9	1000-1750	300
Lead	10	10	19	750-1200	400
Mercury	<0.10	<0.10	<0.10	16-25	5
Nickel	12	11	25	300-400	250
Tri-butyl tin	<0.02	<0.02	<0.02	None	None
Zinc	32	49	70	2500-4000	1000

*EC limits for disposal of sewage sludge to agricultural land (98/278/EEC).

**Licensed limits set under Dumping at Sea Act, 1981 (before dumping of sewage sludge at sea ceased in 1998).

C.2.4 Geology – Marine Sediments

C.2.4.1 No site investigation data is available for marine soil conditions in the vicinity of the proposed long sea outfall.

C.2.4.2 The proposed long sea outfall is however located at the northerly extremity of the beaches running along Youghal Bay. The orientation of the beach as well as the presence of groins perpendicular to the beach indicates that this area is susceptible to longshore drift with sediments being transported from north to south.

C.2.4.3 The seabed is shown on the Admiralty Chart of the area to shelve shallowly with water depths of less than 2m below chart datum extending a considerable distance off shore. The Admiralty chart indicates the sea floor to comprise of sands and gravels.

C.2.4.4 The ground conditions can therefore be expected to comprise several metres of loose unconsolidated granular soils. The presence of longshore drift conditions indicates that the seafloor is vulnerable to scouring by tidal currents with the presence of mobile sandbars likely.

C.3 Impacts

C.3.1 Mudlands – Waste Water Treatment Works

C.3.1.1 The proposed waste water treatment works will involved the construction of several reinforced concrete treatment and settling tanks with associated infrastructure.

C.3.1.2 The soft nature of the superficial deposits in the mudlands will necessitate piled foundations for structures on all three options. Combined end bearing / friction piles will be required with the extremely soft nature of the silts necessitating a large end bearing component to the pile design. Pile toes will probably be situated in the gravels encountered during site investigation drilling. To provide an adequate lateral support to piles the pile toe will be required to be seated an adequate depth into the founding stratum. If the gravel deposits represent weathered rockhead this may necessitate the drilling of rock sockets into bedrock.

C.3.1.3 For Option 3 pile lengths are likely to 10-15m. The pile length is dependant on depth to a suitable bearing stratum which is likely to be deeper for Options 1 and 2 than for Option 3, due to the proximity to the river of these sites.

C.3.1.4 The required construction method of the piles is dependent on economic considerations. However it is likely that bored or augered piles will be necessary if rock sockets are required. The low bearing capacity of the surface soils also has an affect on the trafficability of the ground by heavy pile driving plant. It is likely that a substantial piling mat will be required for driven piles.

C.3.1.5 The main impacts caused by piling are noise and spoil generation. The significance of these impacts is dependent on the selection of pile type. Bored or augered piles will generate spoil.

C.3.2 Estuary Environment – Short Sea Outfalls

C.3.2.1 The short sea outfall pipes are proposed to be approximately 300m long. These pipes will have to be trenched into the riverbed to prevent damage from ships anchors etc.

C.3.2.2 The major impact of these works is the increased turbidity caused by the disturbance of sediments by trenching.

C.3.2.3 Scour may occur within the river system causing the trench backfill to be eroded.

C.3.3 Marine Environment – Long sea outfall

C.3.3.1 The long sea outfalls will necessitate the laying of an 2.5km long pipe which will be partially trenched in the nearshore area.

C.3.3.2 The trenching of this pipe will also cause disturbance to the sea floor with an increase in the turbidity of the water. The currents will however quickly disperse suspended sediment and this impact is expected to short term.

C.3.3.3 The currents present in this area are likely to cause scour which may have the affect of uncovering trenched pipe and eroding material from beneath sections of pipe causing 'spans' to be formed.

C.4 Mitigation

C.4.1 Mudlands – Waste Water Treatment Works

C.4.1.1 Spoil generation from construction of bored piles can be mitigated by reuse of the excavated materials on site for landscaping.

C.4.1.2 If driven piles are selected noise can be reduced by specifying appropriate pile driving equipment to keep noise to within allowable tolerances as stated in Appendix F on Noise.

C.4.2 Estuary – Short Sea Outfalls

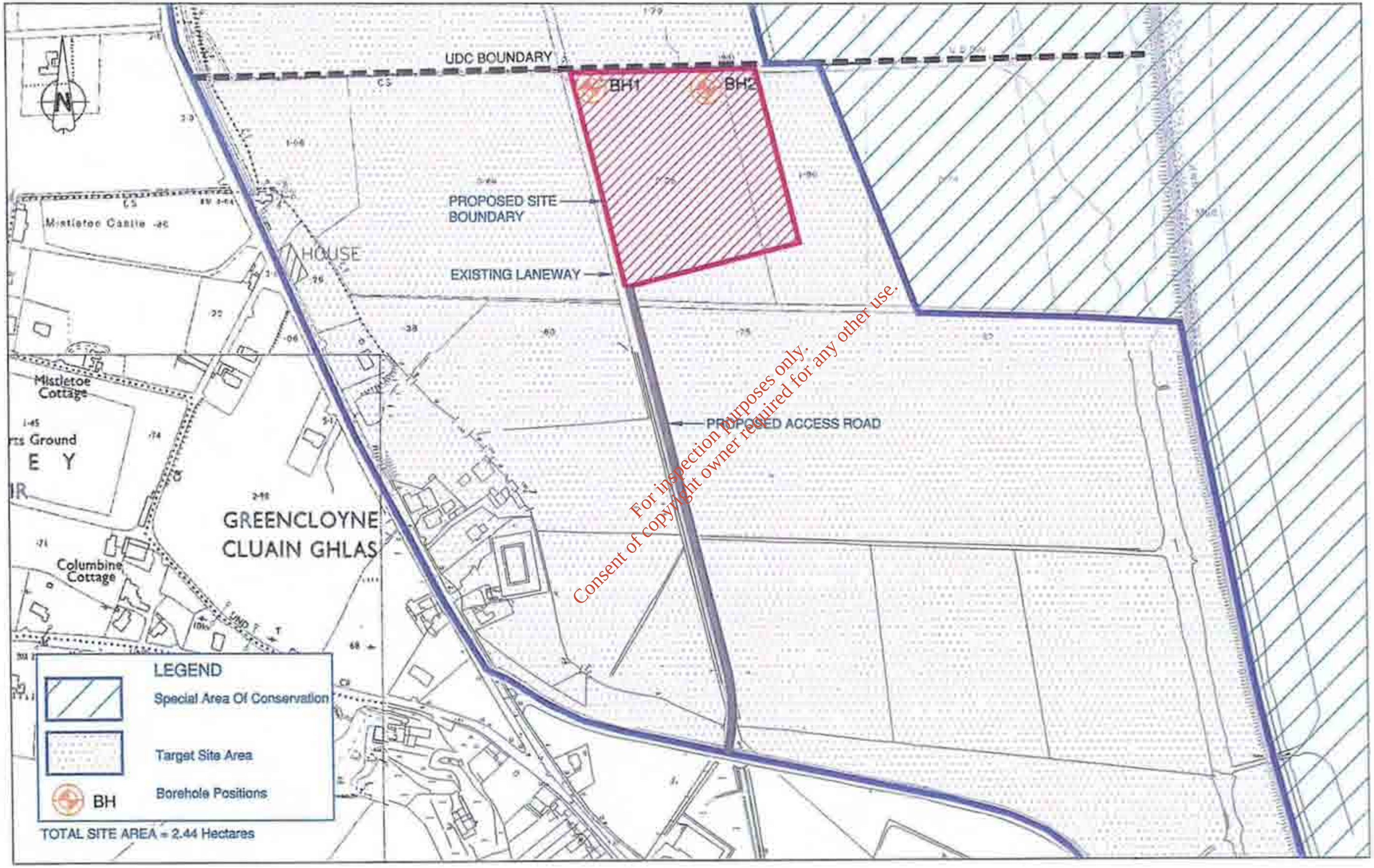
C.4.2.1 Excavating trenches at low tide can mitigate the increase in turbidity of river water by sediment washout from excavations. This will reduce the amount of sediment washed into the river. Where the trench is to be situated in non-drying areas the trenching technique should be such as to cause as little disturbance as possible to the riverbed.

C.4.2.2 If scour is likely to occur over the alignment of the proposed outfall consideration should be given to rock armour protection of the riverbed in the area of the outfall.

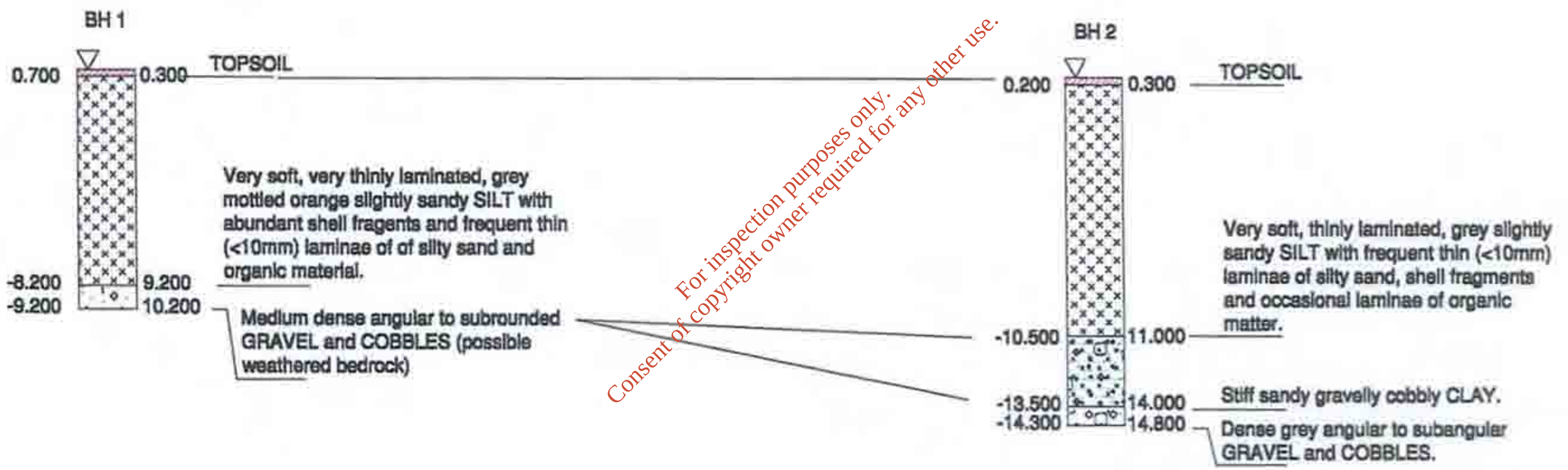
C.4.3 Marine Environment – Long Sea Outfalls

C.4.3.1 The open water nature of this site indicates that the impact of increased turbidity due to trenching works is likely to be minimal.

C.4.3.2 Where current scouring of sea floor sediments beneath the outfall is assessed as likely rock armour should be placed to protect the pipeline.



PROPOSED WASTEWATER TREATMENT PLANT SITE LOCATION FIGURE C.1



BOREHOLE DETAILS FIGURE C.2

APPENDIX D

Water Quality Modelling

Part A :Dye Trace and Drogue Study

Hydrographic Surveys Ltd, The Cobbles, Crosshaven, Co. Cork

Part B : Cormix Effluent Plume Modelling

Robert Leslie, Atkins McCarthy, Dublin Office and

George Mitchell, WS Atkins ,Epsom Office

APPENDIX D PART A

Youghal Main Drainage

Dye Trace and Drogue Study

April-May 2001

Prepared for:

Youghal Urban District Council

Prepared by:

Hydrographic Surveys Ltd
The Cobbles
Crosshaven
Co. Cork
Rep. of Ireland

Contents

1: Introduction

A Dye trace and Drogue tracking study was conducted on the Blackwater estuary, in order to determine the suitability of a proposed sewage outfall location. Dye and Drogue releases were conducted at the following states of the tide:

Table 1: Dye release description

Date	Release Time	Tidal State
25/04/01	Low Water	Springs
26/04/01	High Water	Springs
03/05/01	High Water	Neaps
04/05/01	Low Water	Neaps

Table 2: Drogue release description

Date	Release Time	Tidal State
01/05/01	High Water	Neaps
02/05/01	Low Water	Neaps

The release point for the study was mid channel off Ferry Point at 211466 east and 73834 north. Dye tracing was undertaken in light to moderate winds and good sea conditions.

The dye study consisted of the batch release of 7.5 Kilograms Rhodamine BNG dye, this dye was tracked until the concentration was reduced to a level where accurate tracking was not possible. Dye units are displayed as micrograms per litre.

A streamline drogue study was carried out over a full flood and ebb tidal cycle.

Times for tides, drogue tracks and dye patches are in GMT. Release times were calculated from the predicted tide tables of the area as computed by the Proudman Oceanographic Laboratory. Water current directions are quoted as the bearing to which the currents flow.

2: Navigation

During the dye tracing part of the study the position of the survey vessel was determined using a Trimble Ag-DGPS unit. This unit was interfaced with Coastal Oceanographics Hypack software providing navigation information, recording the dye track lines in Irish National Grid.

For the drogue tracking, a Northstar 921XD DGPS system was used.

3: Dye Tracing

3.1 Dye Release

A drogue was deployed at the proposed outfall location prior to release of the dye. Drogue positions are used as a reference point for the dye patch and as a basis for current corrections. A tabulated list of drogue velocities and directions are contained in Appendix B.

A nominal 40% solution of Rhodamine BNG liquid was supplied. Prior to release, 7.5 kg of the Rhodamine BNG liquid was diluted with fresh water, in order to simulate the density of seawater. Fluorimetric tracing was carried out using a Chelsea Instruments Aquatracka. The instrument was mounted on a pole, which was deployed over the side of the vessel at 1 metre below the sea surface. The concentration of dye is measured by irradiating the water in the vicinity of the sensor head with ultra violet light, then measuring the emitted fluorescence of the Rhodamine at the appropriate wavelength, values were recorded in Volts.

A batch release method was employed, this entails pouring 10 litres of density adjusted dye into the wake of the survey vessel, thus aiding mixing and distribution of the dye over a wide area. A batch release simulates the early stages of secondary dispersion. This reduces the time required before accurate flourimetric tracking could commence. The survey specifications required four releases at the high and low water stages of a spring and neap tide. The survey vessel circled the initial patch approximately 10 minutes after release, in order to determine its size. A zigzag pattern was employed for subsequent patches, with a number of lines crossing the patch perpendicular to the main concentration. A line was then run lengthways through the patch, providing an indication of the distance the patch would have travelled during the survey time. The dye slick was monitored until it was no longer possible to distinguish the dye from the background fluorescence. A background value for clear water was obtained before and after each patch.

3.2 Dye Processing

The instrument was calibrated prior to post processing of the data, calibration was carried out against a known concentration of dye used for the study. The background values as determined during the survey were removed from the raw voltage readings. A formula derived from the calibration was applied to these adjusted readings in order to provide values in micrograms/litre (μg/l). The upper range of dye concentration which may be measured by this instrument was 167 μg/l, any values above this are recorded as maximum value (167 μg/l).

Each patch was adjusted to a central time in order to provide a quasi-synoptic view of the dye. Information regarding wind and water current speed and direction were considered when adjusting a patch. Contours were drawn for each patch using AutoCAD LT 2000. The results of the dye trace study are summarised in Figures 1 to 4, detailed drawings of each patch and supplementary information are contained in Appendix A. A straight red line on drawings 5A, 6A, 7A and 8A indicates the patch generated during the release of the dye.

4: Drogue Tracking

4.1 Streamline Drogue Release

A surface (surface –1 metre) cruciform drogue and a mid-depth cruciform drogue were deployed at hourly intervals over a flood and ebb tidal period. The drogues were deployed from the survey vessel, intermediate positions were recorded and when the drogues were recovered over an hourly period. The vessel then returned to the release position and repeated the exercise. The release position relates to the proposed sewage outfall location. Flood tide monitoring was carried out on 1 May 2001, the wind was from a northeast direction throughout the survey and of moderate strength i.e. 8-5 m/sec. The ebb flow was surveyed on the 2 May 2001, light airs prevailed.

5: Discussion

5.1 Overview

The Blackwater estuary is orientated north to south and is approximately 4.5 Km long from Youghal Bridge to the lighthouse at the mouth, the survey was undertaken halfway along the estuary at the proposed outfall location. The fresh water catchment area for the Blackwater estuary is estimated at 3324 sq. Km (Marine Institute, 1999), as such the effect of fresh water flow on the current regime within the estuary would be significant. Rainfall quantities and seasonal variations in soil moisture content would influence the overall effect.

The main channel is approximately 250 metres wide at Ferry Point, expanding to between 500-750 metres south of this point to the mouth of the estuary and Youghal Bay. The width of the estuary north of Ferry Point varies between 1.5 and 1 Km, however the navigable part is approximately half this width. There are large sandbanks to the northeast of Ferry Point, a small channel runs between this bank and the shore. The presence of this bank influenced the course of the flood dye releases.

A combination of fresh water input, topography, wind direction and strength had an influence on the general trend for all the dye releases. Rainfall levels were low for the 2 weeks prior to the surveys, thus reducing the rate of flow from the river. Dispersion and dilution characteristics appeared to be good, low concentrations were recorded before the dye reached the estuary mouth on the ebb releases and Youghal Bridge on the flood releases. Higher background levels were recorded in the north section of the estuary compared to the southern section, reflecting greater interference of the signal to the fluorimeter due to riverine input. There appears to be an east to west flowing current at high and low water slack periods, causing the dye to migrate towards the west shore at this time. It was not possible to survey outside the estuary mouth on the 26 April due to rough seas. A visual estimate was made of the extent of the dye patch in shallow waters, as it was not possible to survey these areas with the boat.

Values recorded during the streamline drogue tracking exercise indicated that water currents within the Blackwater estuary are predominantly rectilinear and moderate flowing. Recorded currents were south-southeast for the ebb tide and north-northeast for the flood tide. Higher velocities were recorded for the ebb tide compared to the flood. This was due to a combination of wind (NE) and fresh water flow augmenting the current generated by the outgoing tide.

5.2 Low Water Spring Dye Release

The direction and strength of the wind had a major influence on the track of the dye patch. A moderate wind (6-7 m/s) from the south veering later in the day to the southwest prevailed during the survey.

The dye was released approximately 25 minutes after predicted LW. It was observed that the tide appeared to have turned at this time, whereby the residual south flowing current was counteracted by the southerly breeze. This effect resulted in an elongated patch centred around the Ferry Point spit, 20 minutes after the release. The dye proceeded to move northeast of the spit towards the sandbanks on the Waterford side of the estuary, probably influenced by the incoming flood current and the wind direction. Due to the lack of water over these sandbanks it was not possible for the survey vessel to navigate safely over the dye patch. However a visual inspection of the patch, noted high concentrations of dye being pushed up against the shore.

As the tide increased the dye spread north into a narrow channel between sandbanks (see patch 3, Fig. 1). Yet again it was impossible to estimate the full extent of the patch, but it could be seen that the dye extended to the shore. The dye continued to move northwards along the east shoreline towards Youghal Bridge, concentrations 2.5 hours after the release time were reduced to 35 $\mu g/l$. There was no evidence of dye in the estuary 03:30 hours after release time. The high input of fresh water in the vicinity of Youghal Bridge combined with a denser incoming saltwater may have encouraged mixing and possibly some subduction of the dye below the less dense fresh water layer.

5.3 High Water, Spring Dye Release

This release was carried out under calm conditions with little or no wind to influence the dispersion of the dye. The dye was released approx.30 minutes after high water when it had been established that the tide had turned. The patch very rapidly headed westwards and stretched southwards forming an elongated patch along the quay walls, harbour and docks areas.

The main concentration of dye continued to move southwards along the western shore until it reached the area in the vicinity of Youghal lighthouse where it began to spread southeast across the mouth of the estuary. At 02:30 hours after the release the main body of dye had disappeared from the estuary and travelled out to sea where it could not be tracked due to deteriorating sea conditions.

The only dye detectable in the estuary at this stage was that which remained trapped in the harbour. Strong dye concentrations were observed within the harbour where a clockwise circulation pattern appeared to have prevented this dye from re-entering the channel. By

03:30 hours after release time most of the dye had settled out of the water column with the silt.

5.4 High Water, Neap Dye Release

The time for release of the dye was delayed until there was a definite ebb current flowing south. This was due to the track noted for the corresponding Spring tide release, where the dye backed up within the harbour confines soon after deployment. Release time was 30 minutes after predicted high water. The wind strength on the survey day (3 May 2001) averaged 5 m/sec from the NE.

The track and speed of the dye patch was influenced by the combined influence of the wind strength and direction and the ebb current. The mid-ebb current was measured at 0.25 m/sec setting in a southerly direction.

Patch 1 as may be seen from Figure 3, tracked along the Youghal shoreline. This patch quickly spread into the centre of the estuary, clearing East Point 01:45 hours after high water. There was a greater than ten-fold dilution of the dye at this time, a maximum concentration of 7-8 μg/l was recorded for Patch 3. The patch progressed in a south-southeast direction in Youghal Bay, continuing to be diluted and dispersed. Due to high levels of variation in the background levels it was not possible to track the dye 03:45 hours after high water. A drogue was monitored until 05:15 hours after high water, it was noted that the surface current remained at 0.25 m/sec in a southerly direction.

Good dispersion and dilution characteristics were shown during the survey period. This situation was aided by slightly choppy sea conditions, which assisted mixing of the dye and the seawater.

5.5 Low Water, Neap Dye Release

Similar to the Spring low water release, there appeared to be a residual south flowing current, due to a combination of fresh water flow and wind influence. This survey took place on 4 May 2001, wind strength was 5 m/sec on average, from a north-northeast direction. Release time was 25 minutes after low water, the initial patch moved southwards along the town shoreline.

A change in current direction was noted at 01:15 hours after low water from the drogue information and the orientation of vessels at anchor. The dye patch started to alter direction heading northwards at a rate of 0.4 m/sec, (see Patch 3, Figure 4). There was a significant reduction in dye concentration; a maximum value of 49 μg/l was measured for this patch compared to the maximum concentrations (167 μg/l) measured for Patch 2. There was visual evidence of a wind against tide effect at this time (HW- 04:24 hours), this was particularly true for the narrow stretch of water between the spit at Ferry Point and Youghal Town. This effect would result in a high-energy area, thus aiding mixing.

The dye continued in a northeast direction, moving quickly along the channel. The north-northeast wind direction kept the patch from entering the shallow area immediately north of Ferry Point, as occurred with the corresponding Spring tide release. The concentration of dye measured 03:19 hours before high water was 3 μg/l, indicating good dilution and dispersion characteristics for this part of the estuary. However due to density differences between the dye and fresh water, there is a possibility that some of the dye may have been subducted below the fresh water layer.

Monitoring of the area downriver and upriver of Youghal Bridge indicated that there was no dye present 02:15 hours before high water (03:30 hours after release time).

5.6 Ebb Streamline Drogue Study

The initial stage of the study indicated a current favouring the Youghal side of the channel, flowing south (see HS 65-01/01). The directions moved towards the centre of the channel by mid-tide, velocities of approximately 0.6-0.8 m/sec were recorded at this time. The wind changed direction 5 hours after HW, this coincided with reduced velocities measured for the drogues i.e. approximately 0.45m/sec.

Measured velocities and direction were similar for the surface and mid-depth drogues, indicating very little stratification of the water column.

5.7 Flood Streamline Drogue Study

The initial deployment shows moderate southerly movement for the drogues until 00:45 hours after low water, at this time the drogues changed direction, heading north-northwest (see HS 65-02/01). The drogues maintained this direction for each release until 30 minutes before high water, attaining a maximum velocity of 0.64 m/sec. The pick-up point for the drogues was approximately halfway between the release point and Youghal Bridge. A southeast wind began to blow 02:00 hours before high water, this direction assisted the northwest movement of the drogues.

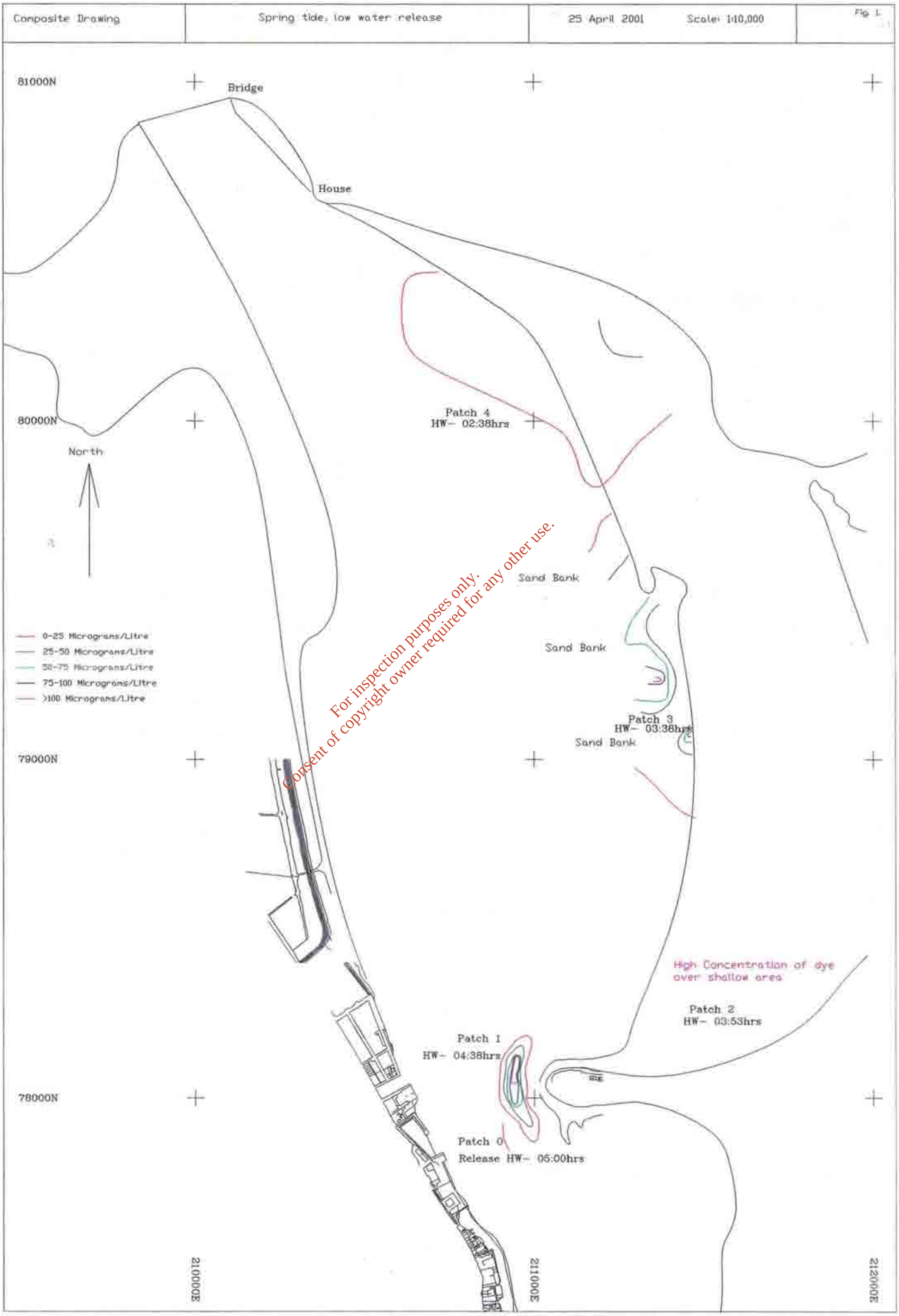
6: Summary

The general trend for the dye was as expected, north for the flood and south for the ebb tide, there was some variation during slack periods of the tide. Similarly the streamline drogue study indicated a rectilinear water current regime. Weather conditions would have an impact on dispersion and dilution of any effluent plume. Similarly a large freshwater input may cause some stratification within the estuary, resulting in density differences through the water column, thus impeding mixing. However the streamline drogue study indicated that there was very little stratification at the time of the study.

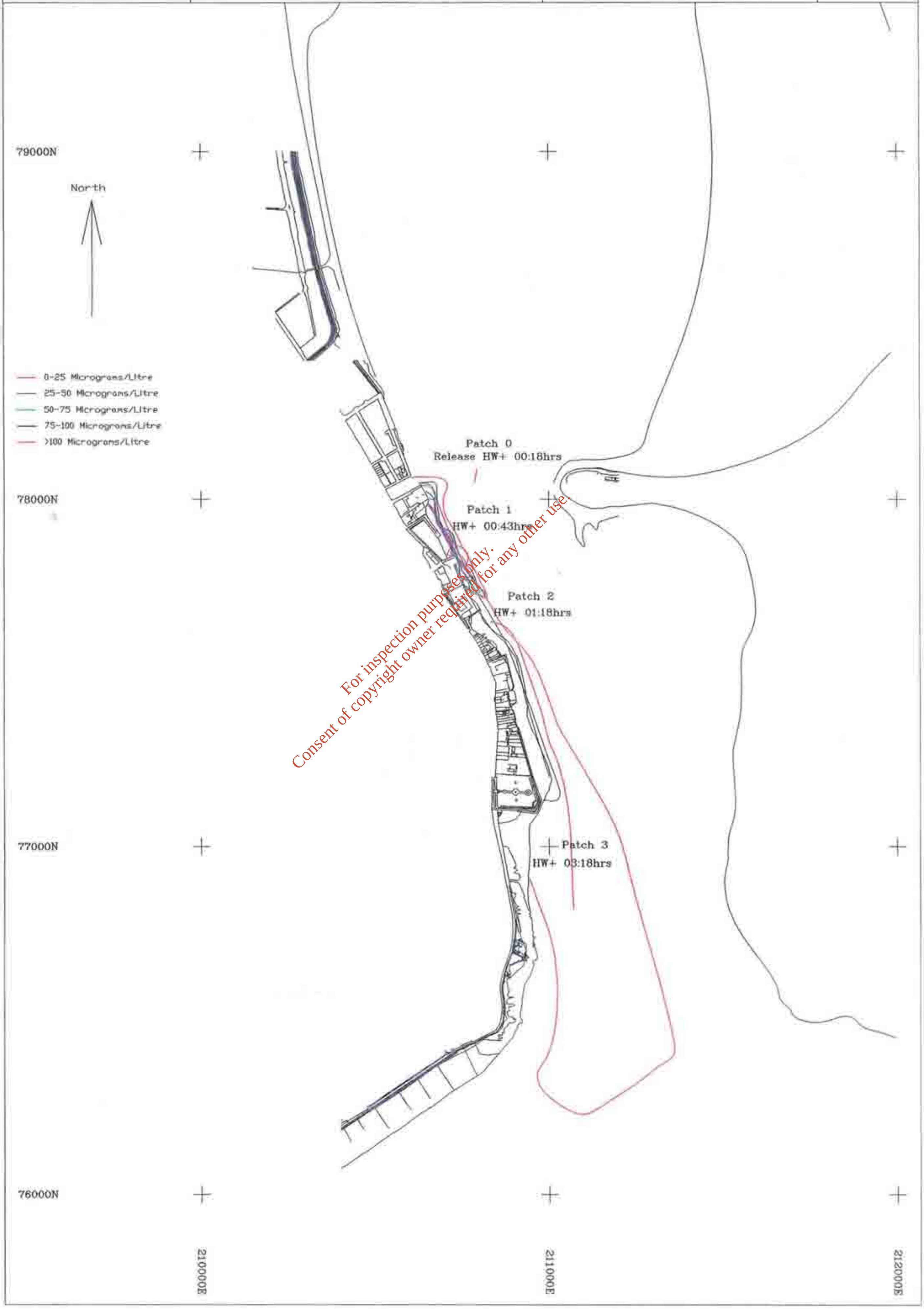
The study indicated that the dilution and dispersion characteristics of the Blackwater Estuary are good. Dye concentrations were reduced to background levels by mid-tide in all cases, while the streamline drogues indicated moderate currents following the main channel, north to south.

Reference

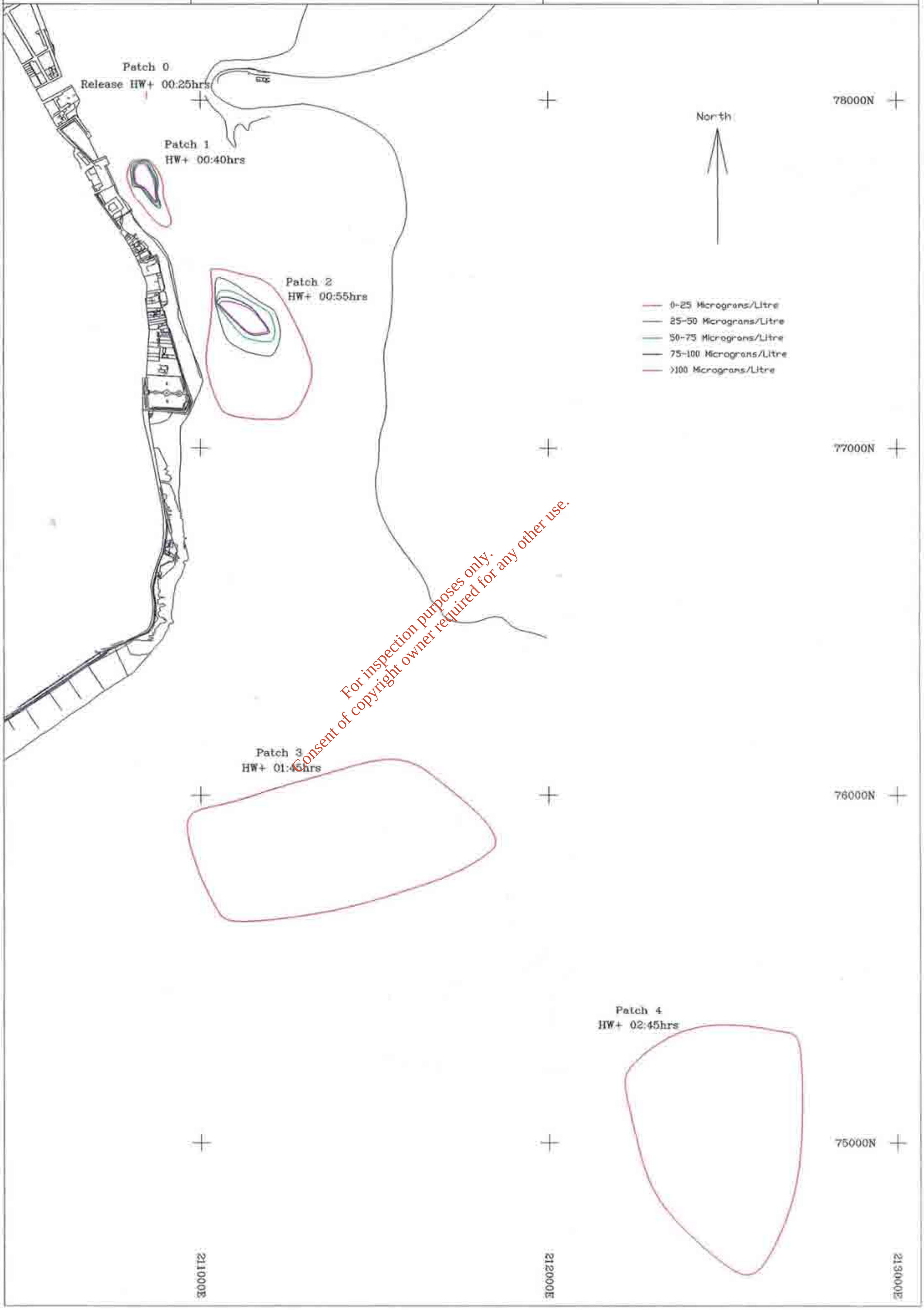
Marine Institute, 1999, Irelands Marine and Coastal Areas and Adjacent Seas – An Environmental Assessment.


Composite Drawing
Spring tide, low water release
25 April 2001
Scale: 1:10,000
Fig 1
81000N
80000N
79000N
78000N
210000E
211000E
212000E
Bridge
House
North
Patch 4
HW- 02:38hrs
Sand Bank
Sand Bank
Patch 3
HW- 03:38hrs
Sand Bank
0-25 Micrograms/Litre
25-50 Micrograms/Litre
50-75 Micrograms/Litre
75-100 Micrograms/Litre
>100 Micrograms/Litre
High Concentration of dye over shallow area
Patch 2
HW- 03:53hrs
Patch 1
HW- 04:38hrs
Patch 0
Release HW- 05:00hrs

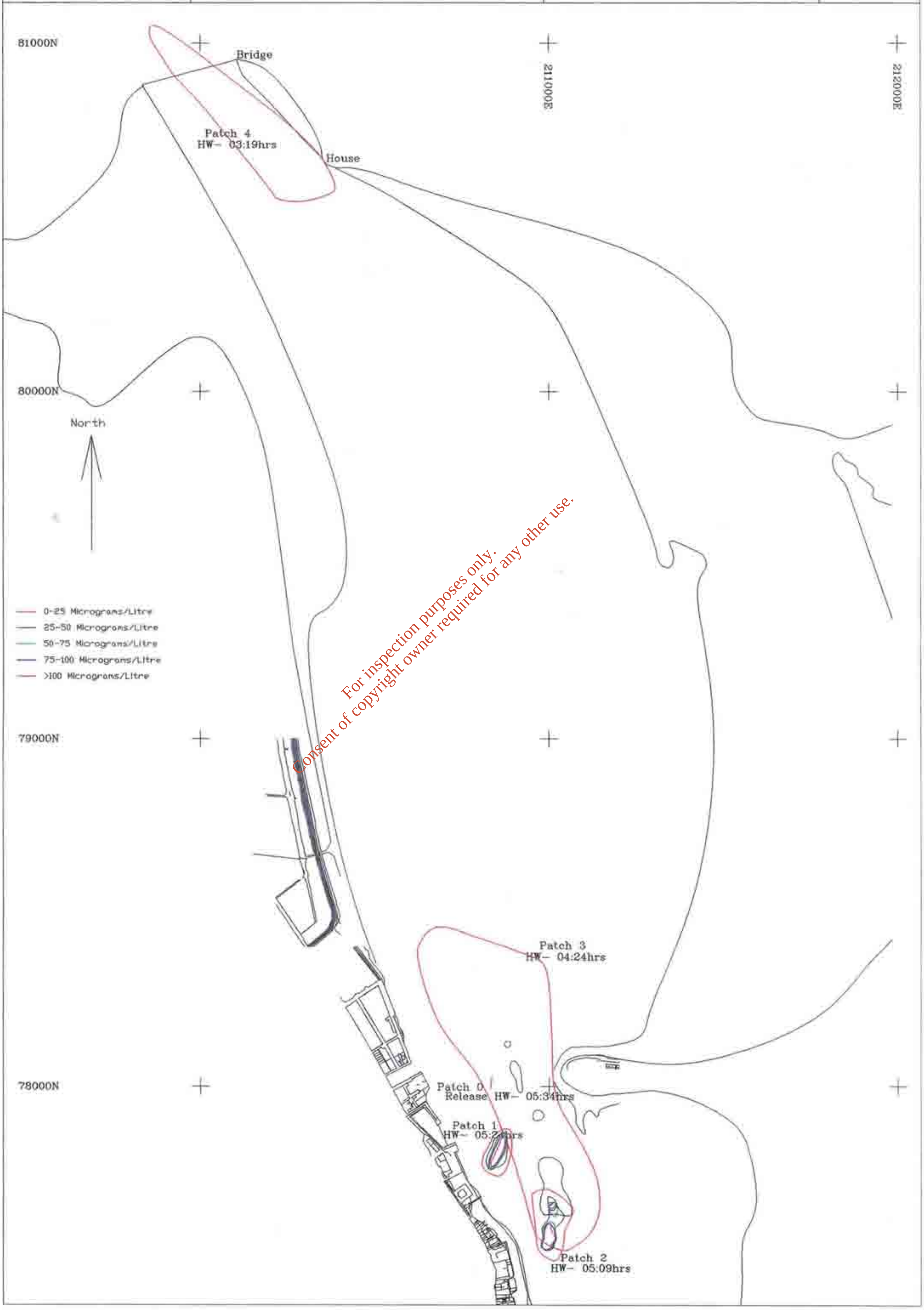
Composite Drawing	Spring tide, high water release	26 April 2001 Scale: 1:10,000	Fig. 2



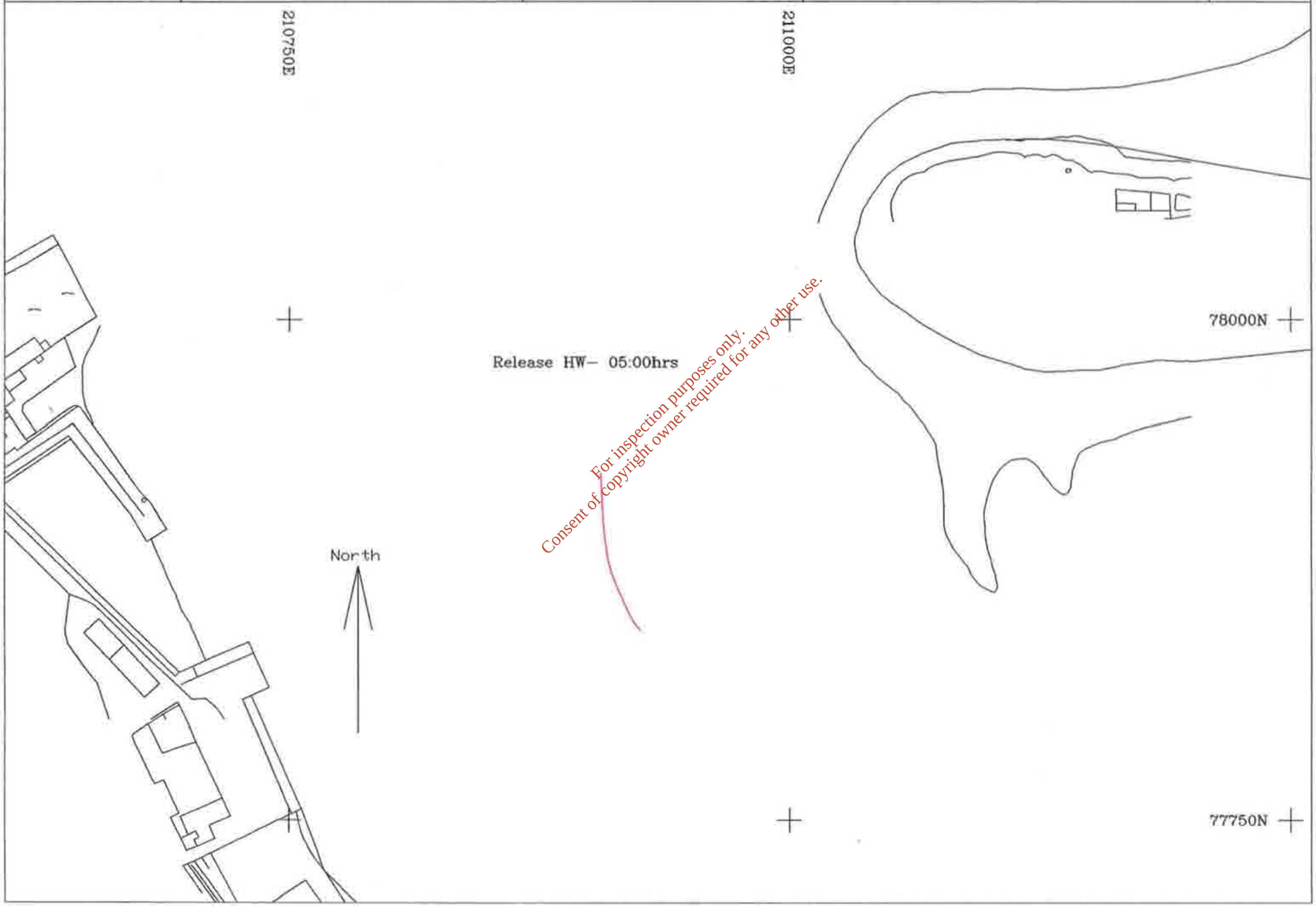
Composite Drawing	Neap tide, high water release	03 May 2001 Scale: 1:10,000	Fig. 3



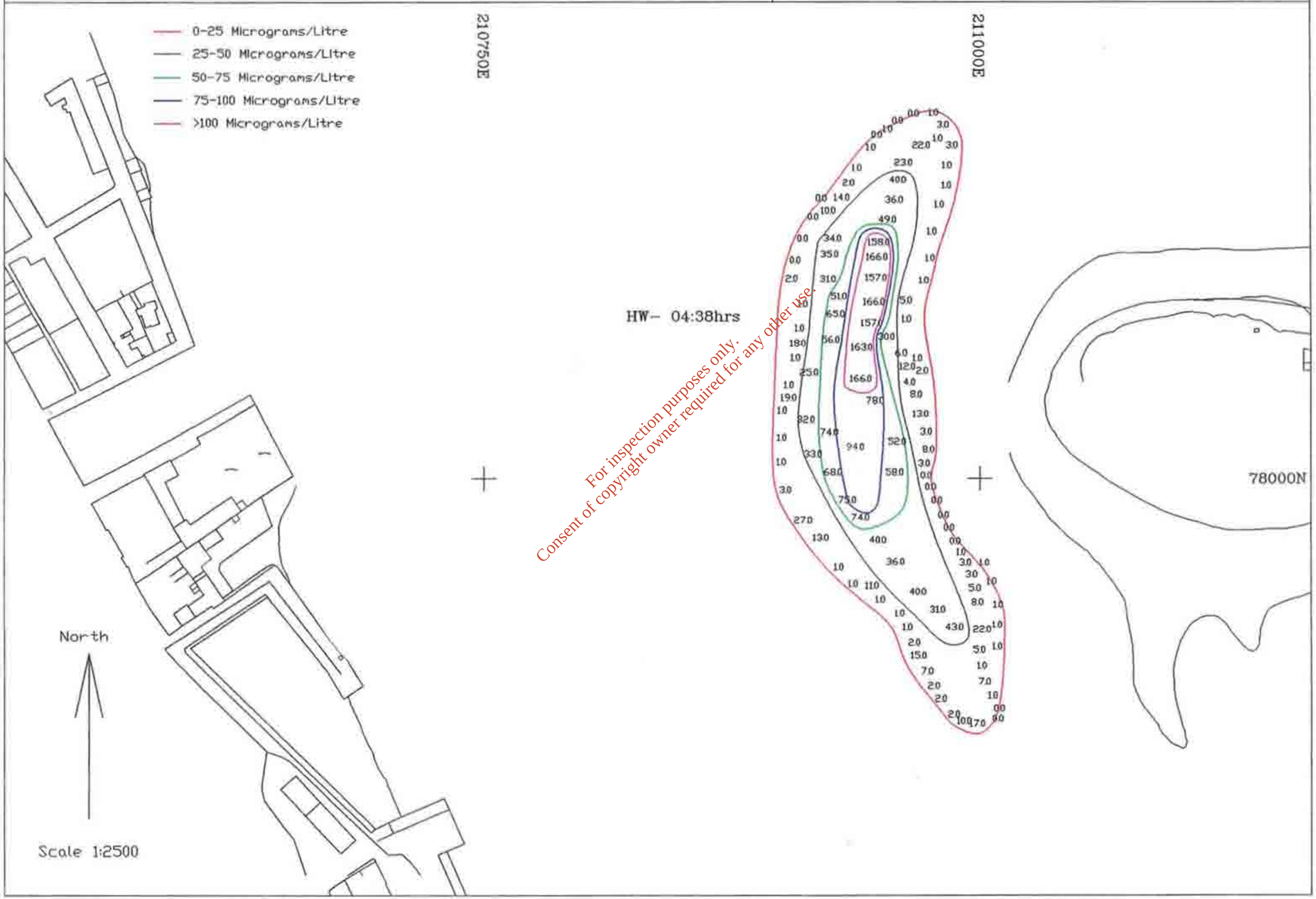
Composite Drawing	Neap tide, low water release	04 May 2001 Scale: 1:10,000	Fig. 4



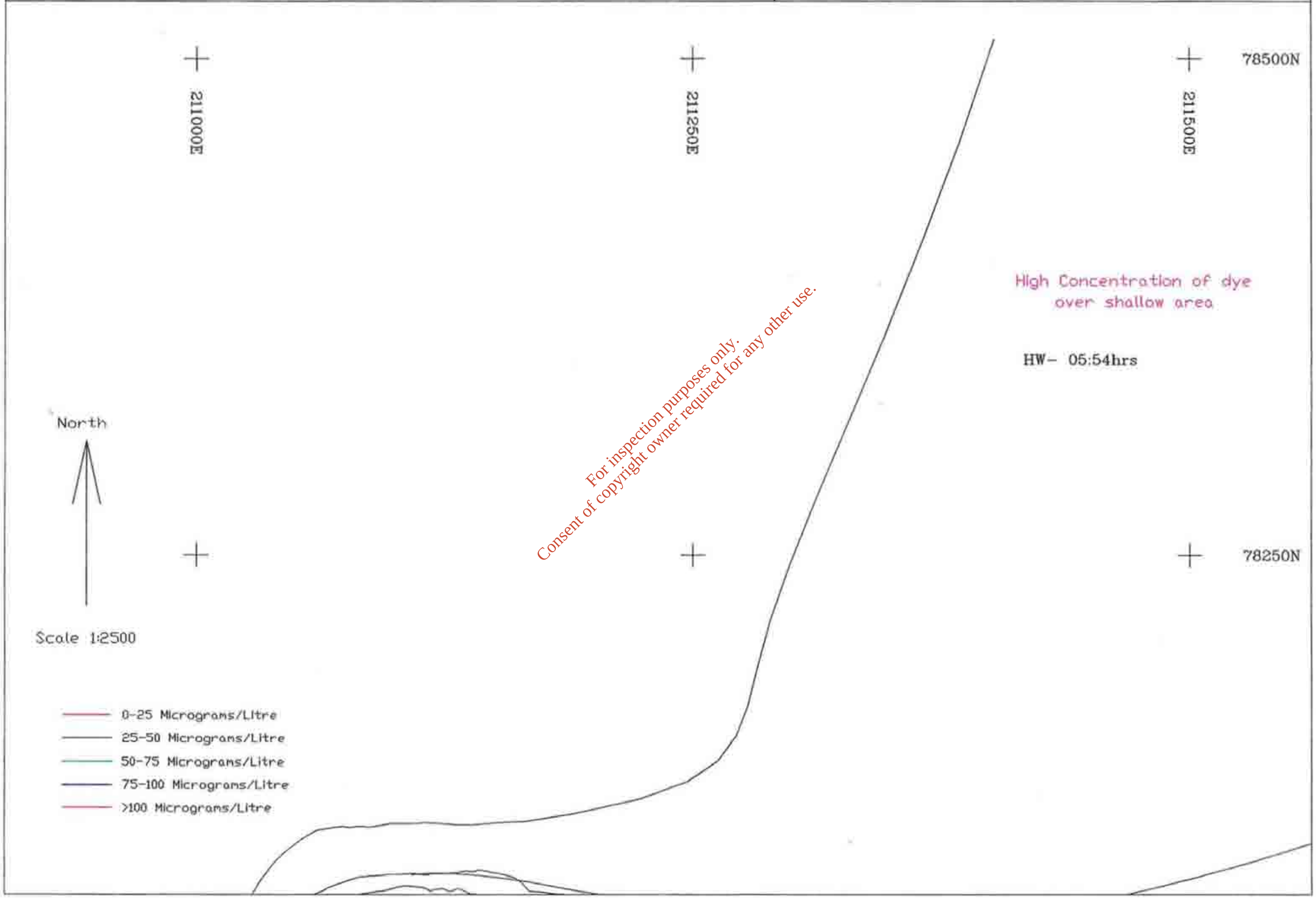
Patch 0	Spring Tide, Low Water Release	25/April/01 Scale 1:2500	Youghal Sewage Outfall Study Dye Release Point	Fig. 5.A



Patch	Spring tide, Low Water Rele. .e	25 April 2001	Central Tim 4:00 GMT Maximum Conc.: 167 micrograms/litre Current Correction Applied: 0.2 m/sec at 340 deg. grid



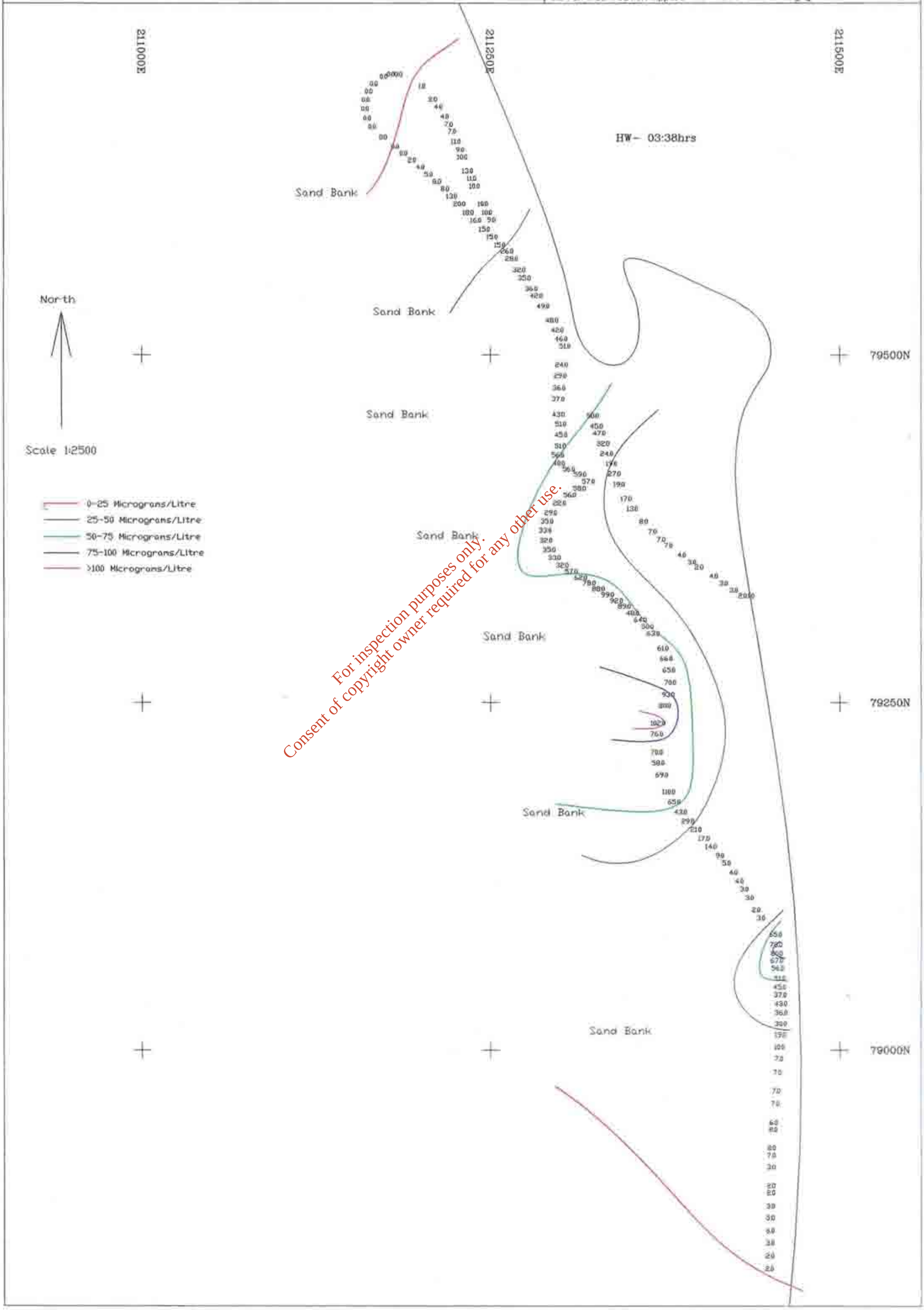
Patch	Spring Tide, Low Water Rele. .e	25 April 2001	Central Tim 4:45 GMT	Fi



Patch 3 | Spring Tide, Low Water Release | 25 April 2001

Central Time 15:00 GMT
Maximum Conc. 102 micrograms/litre
Current Correction Applied 0.2 m/sec at 340 deg grid

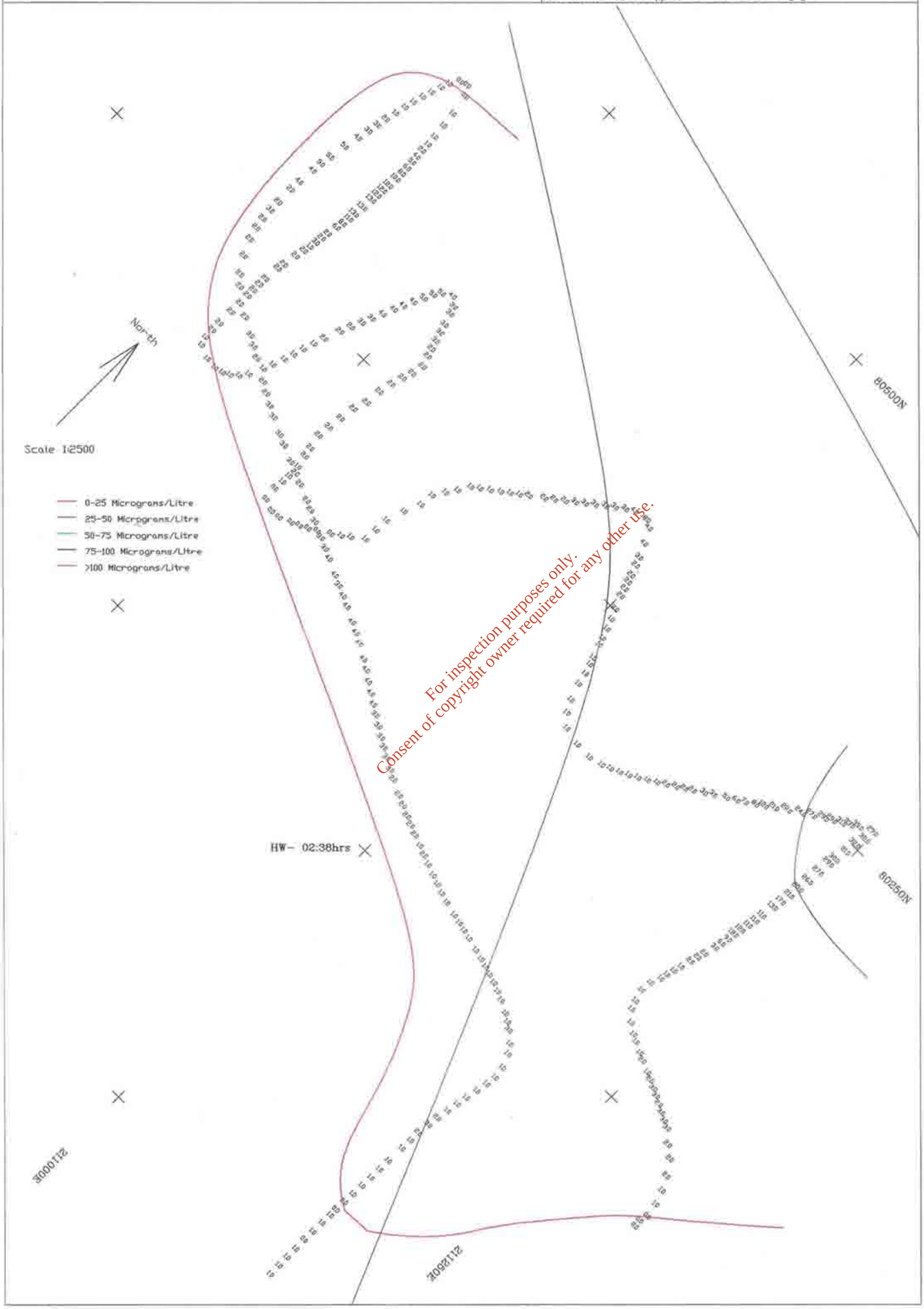
Fig. 5D



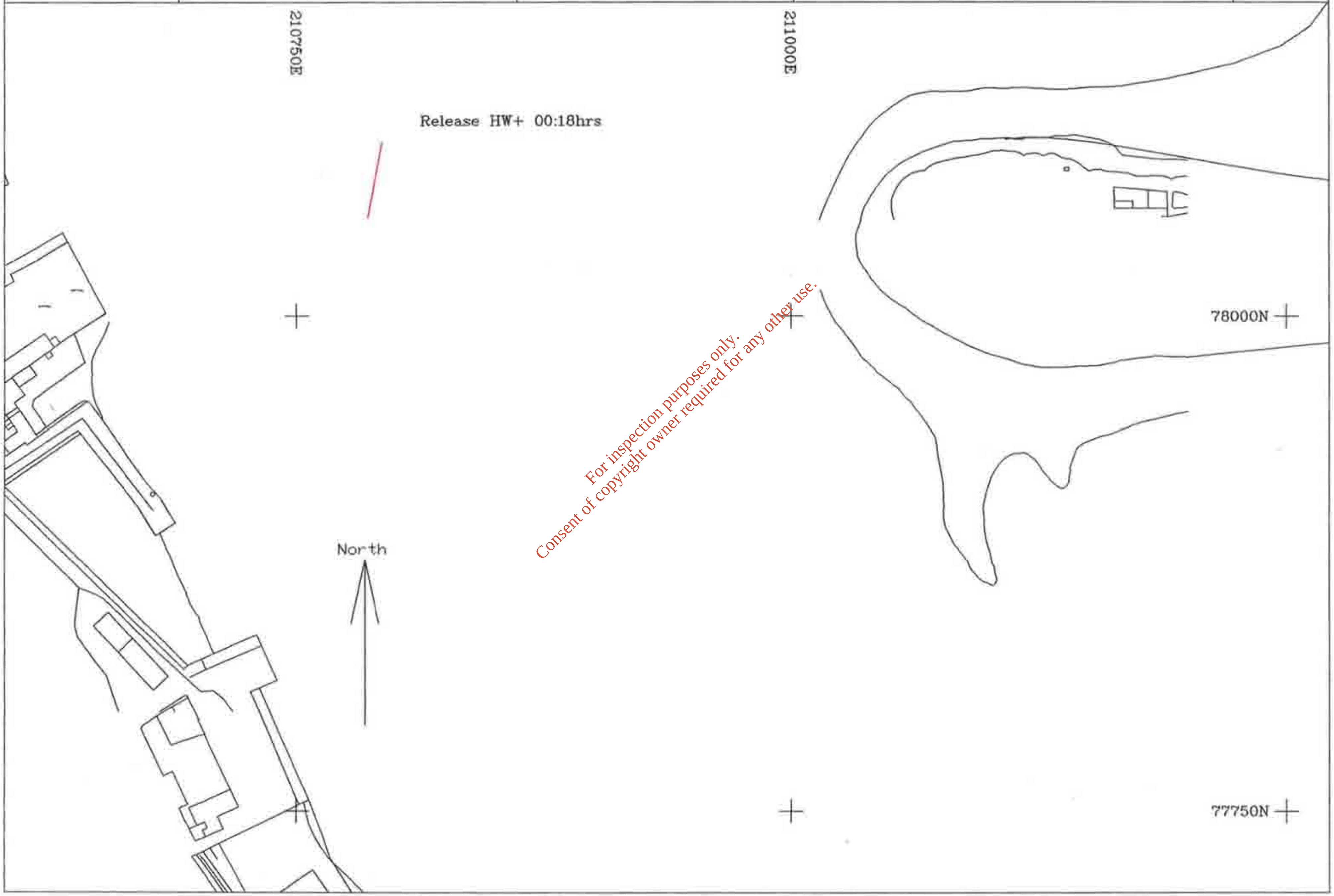
Patch 4 | Spring Tide, Low Water Release | 25 April 2001

Central Time: 16:00 GMT
Maximum Conc: 35 micrograms/litre
Current Correction Applied: 0.1 m/sec at 330 deg grid

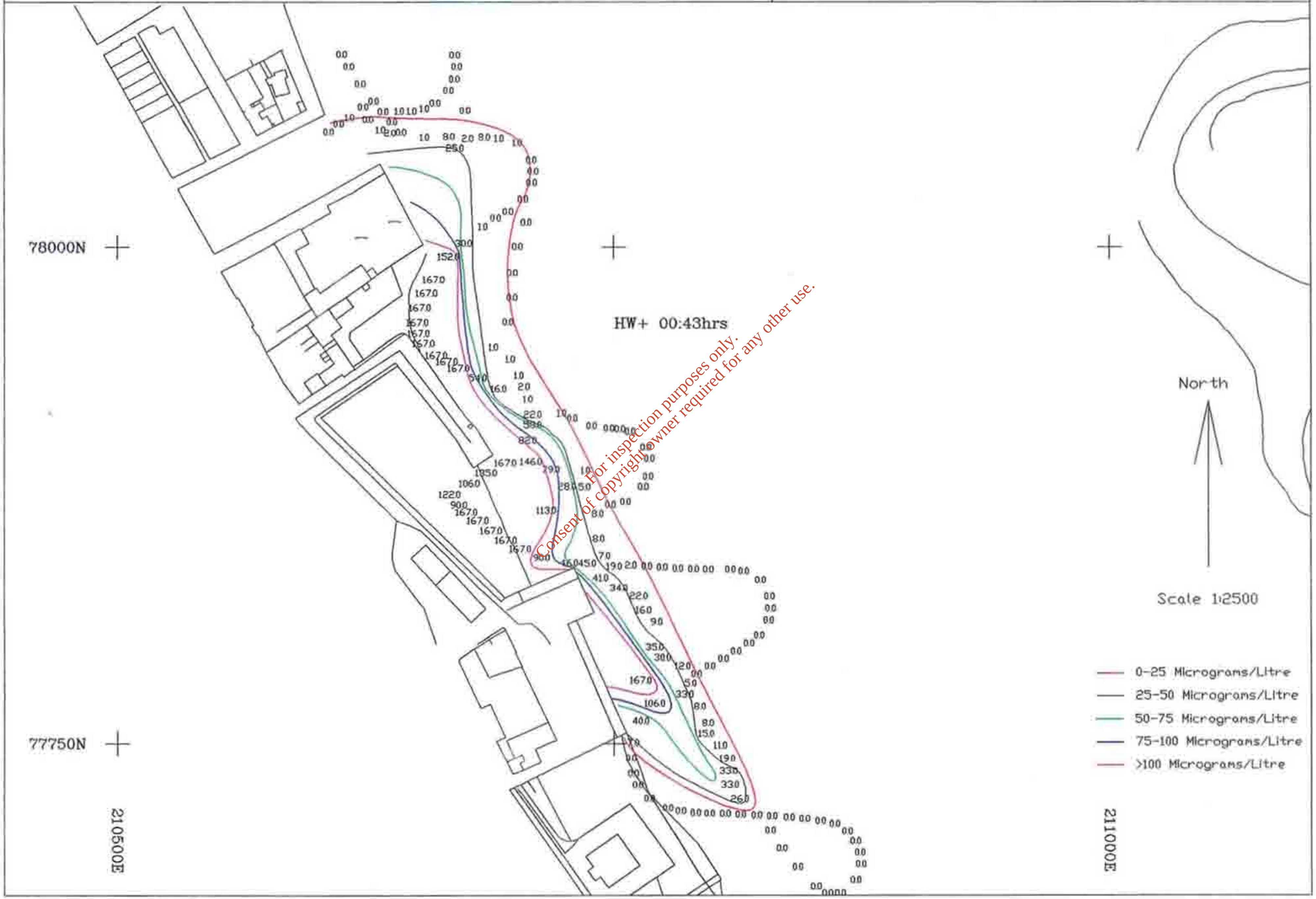
Fig. 5E



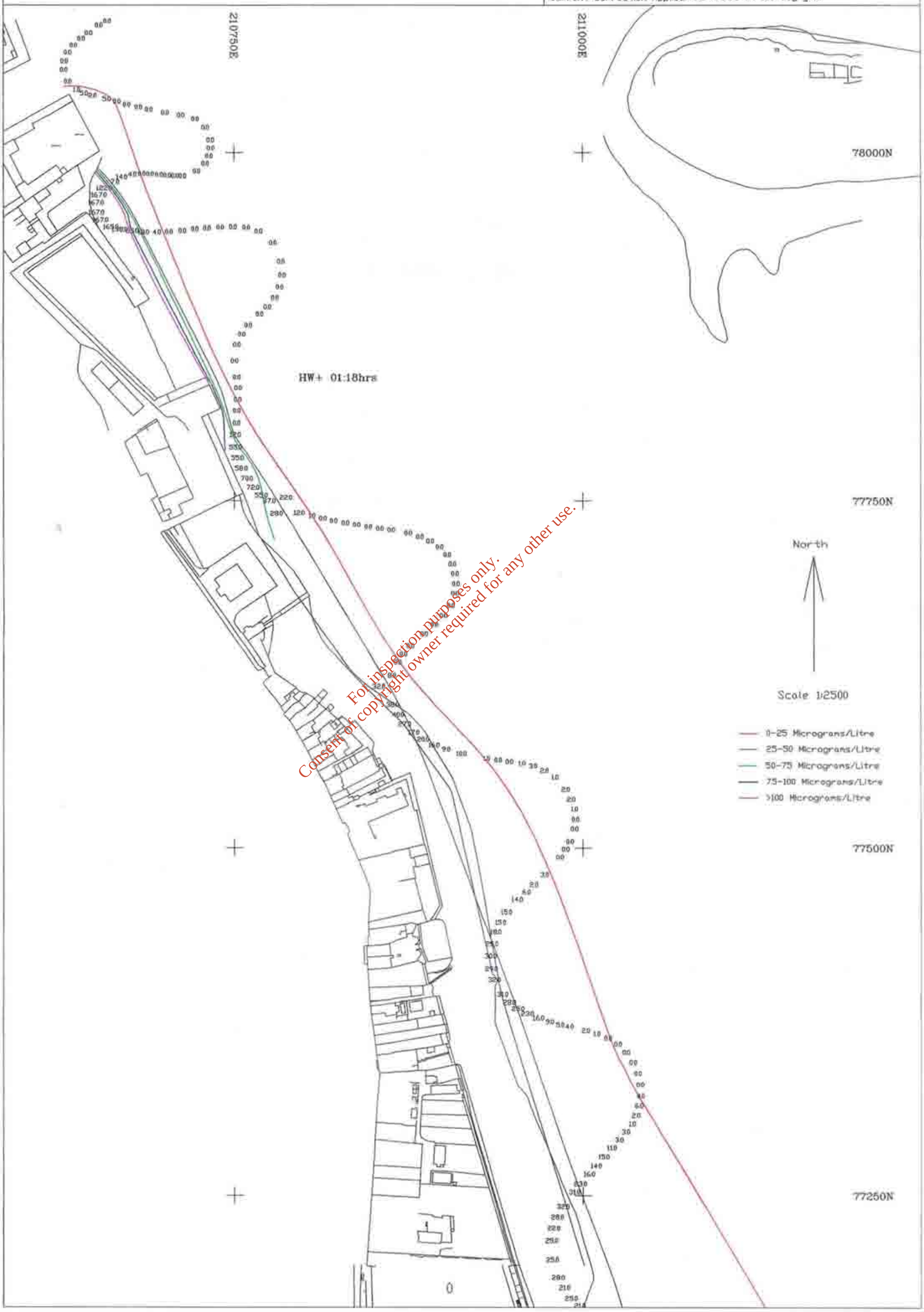
Patch 0	Spring Tide, High Water Release	26/April/01 Scale 1:2500	ɔughal Sewage Outfall Study Dye Release Point	Fig. 6.A



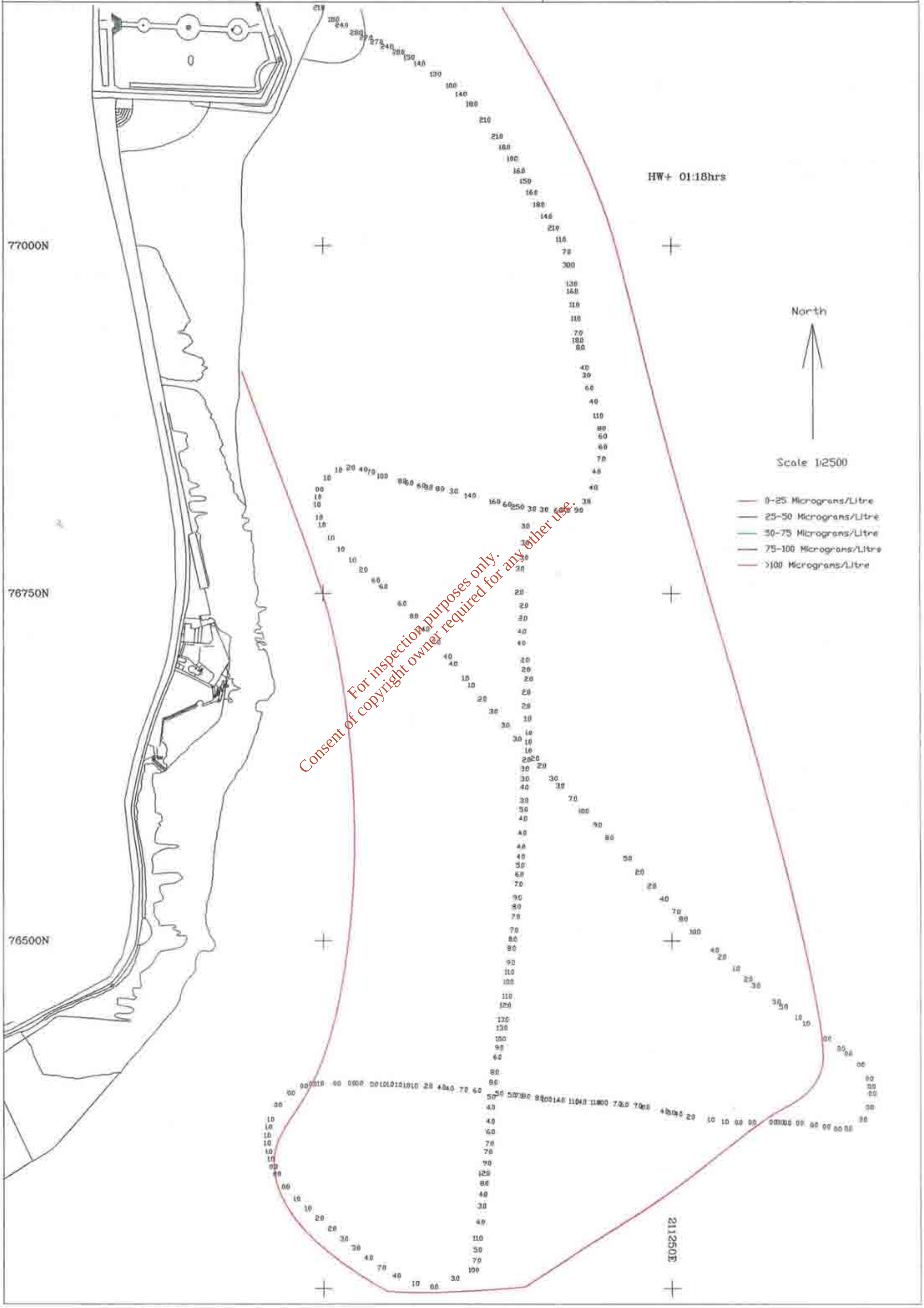
Patch 1	Spring Tide, High Water release	26 April 2001	Central Tim 7:40 GMT Maximum Conc: 167 micrograms/litre Current Correction Applied: 0.02 m/sec at 220 deg grid



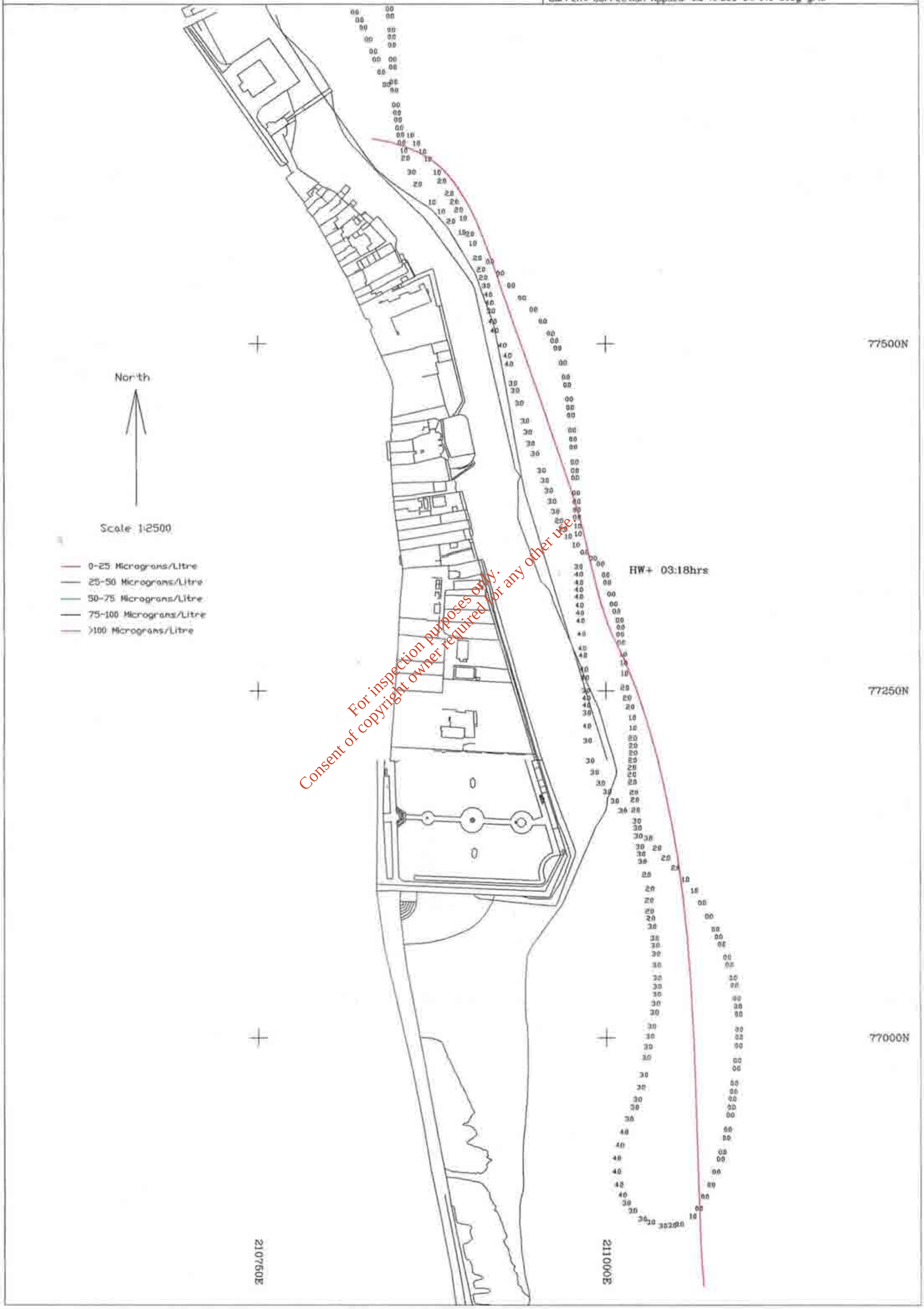
Patch 2 | Spring tide, high water release | 26 April 2001 | Central Time: 0815 GMT
Maximum Conc: 167 micrograms/litre
Current Correction Applied: 0.2 m/sec at 130 deg grid | Fig 6.C-1



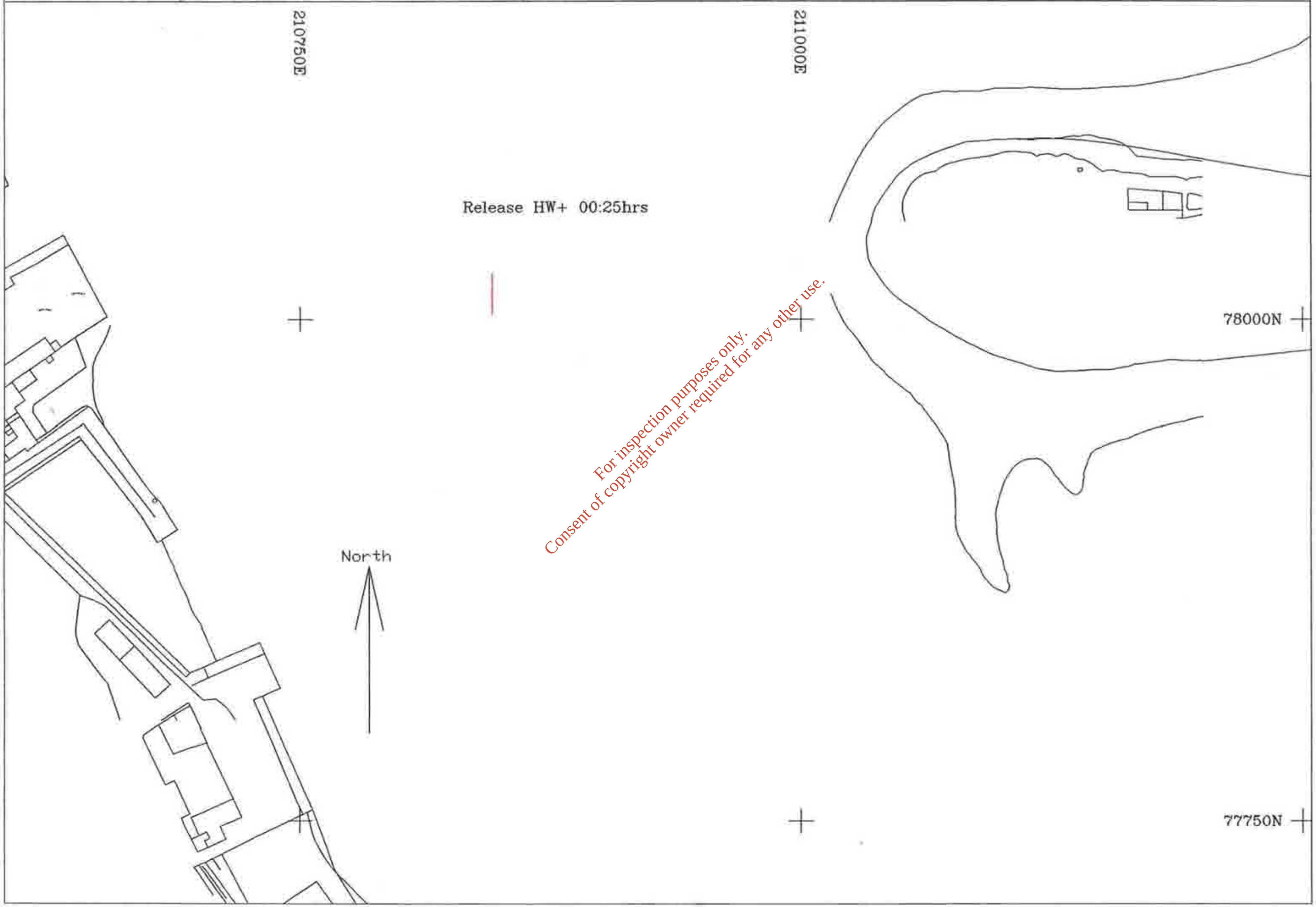
Patch 2	Spring tide, high water release	26 April 2001	Central Time: 08:15 GMT Maximum Conc.: 167 micrograms/litre Current Correction Applied: 0.2 m/sec at 130 deg grid	Fig. 6C-2



Patch 3 | Spring tide, high water release | 26 April 2001 | Central Time 0945 GMT
Maximum Conc.: 4 Micrograms/Litre
Current Correction Applied: 0.2 m/sec at 140 deeg grid | Fig. 6.8



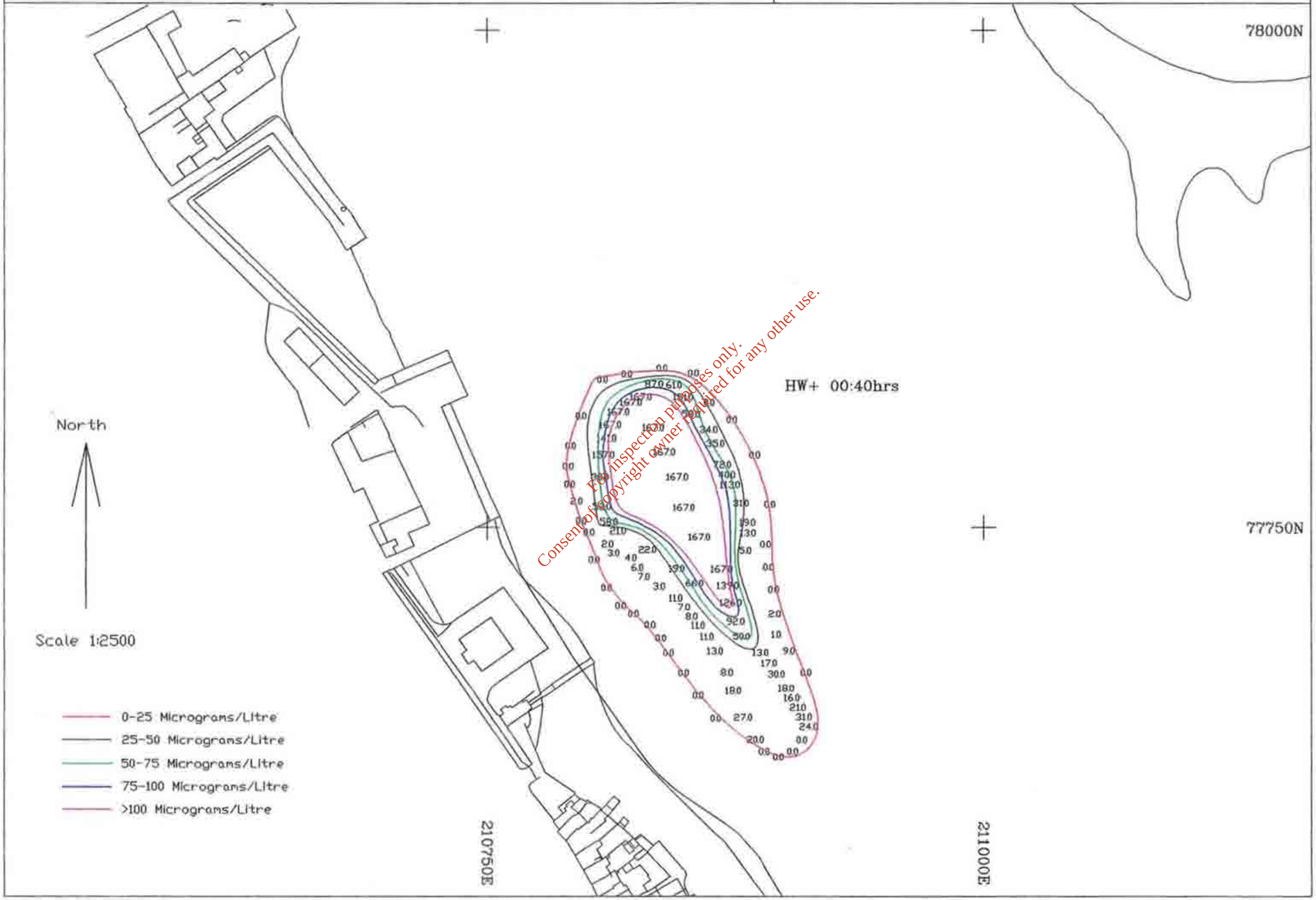
Patch 0	Neap Tide, High Water Release	03/May/01 Scale 1:2500	.oughal Sewage Outfall Study Dye Release Point	Fig. 7.A



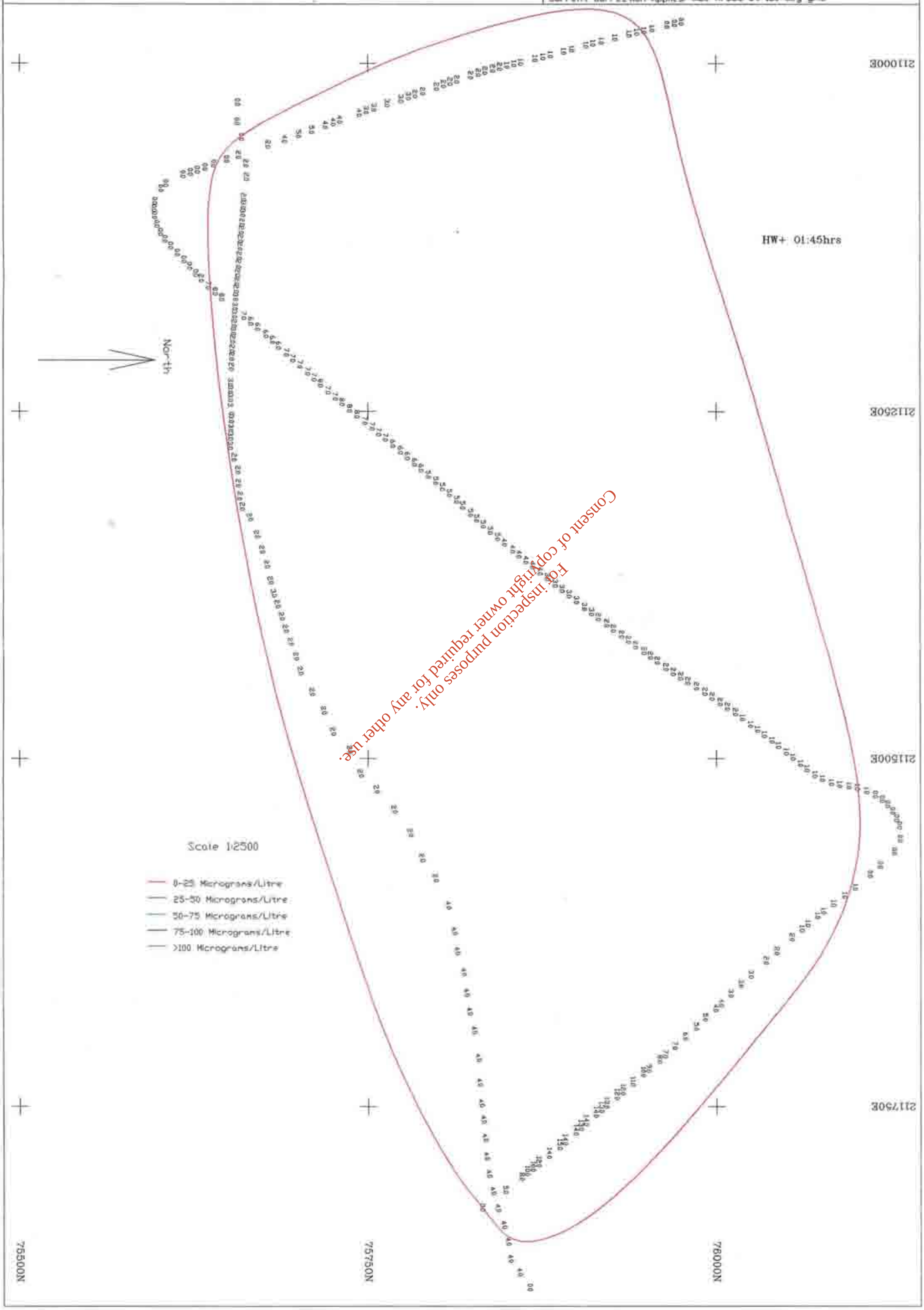
Patch 1 — Neap Tide, High Water Relea. — 03 May 2001

Central Time 1:45 GMT
Maximum Conc.: 167 micrograms/litre
Current Correction Applied: 0.44 m/sec at 165 deg.grid

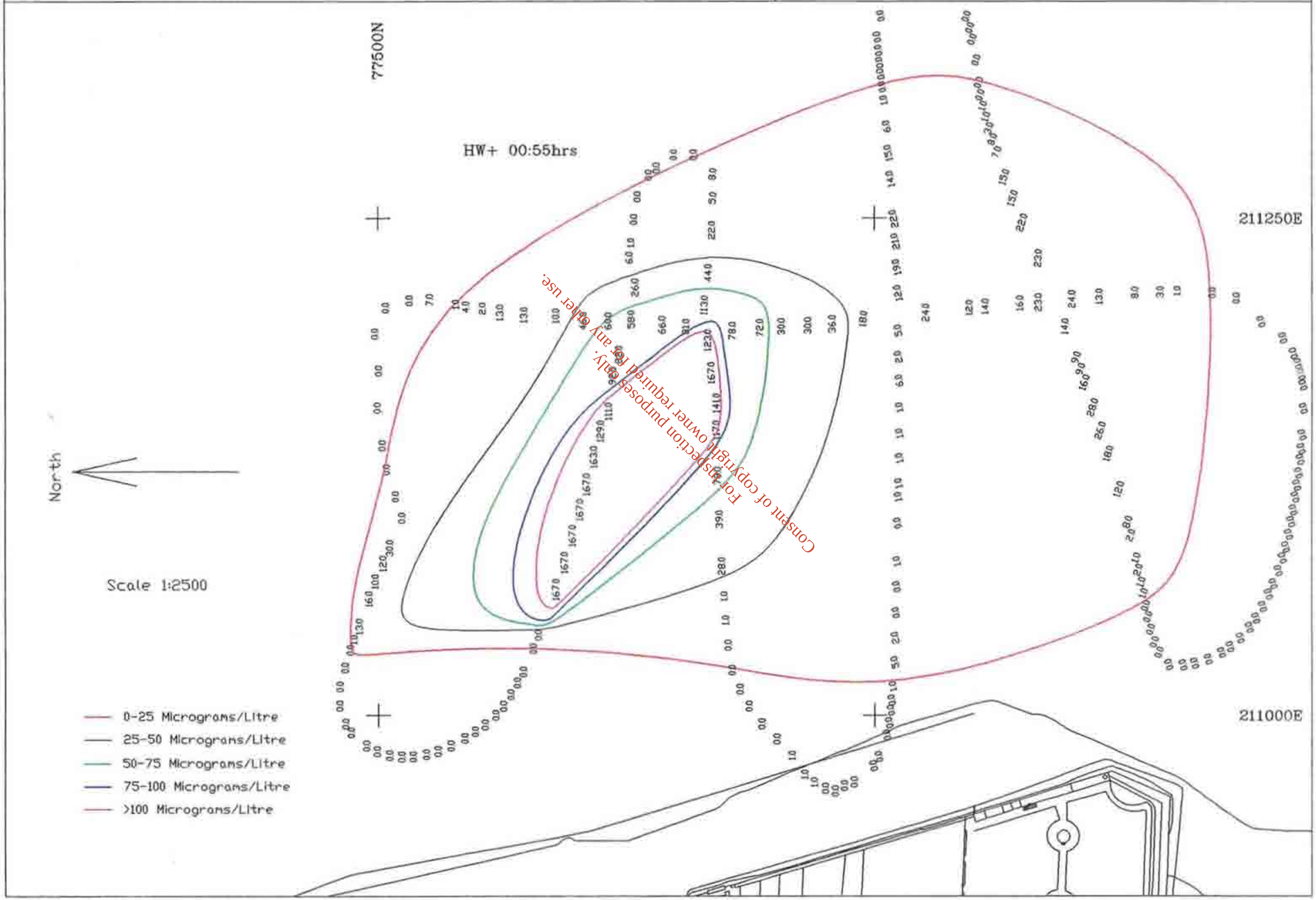
Fi 8



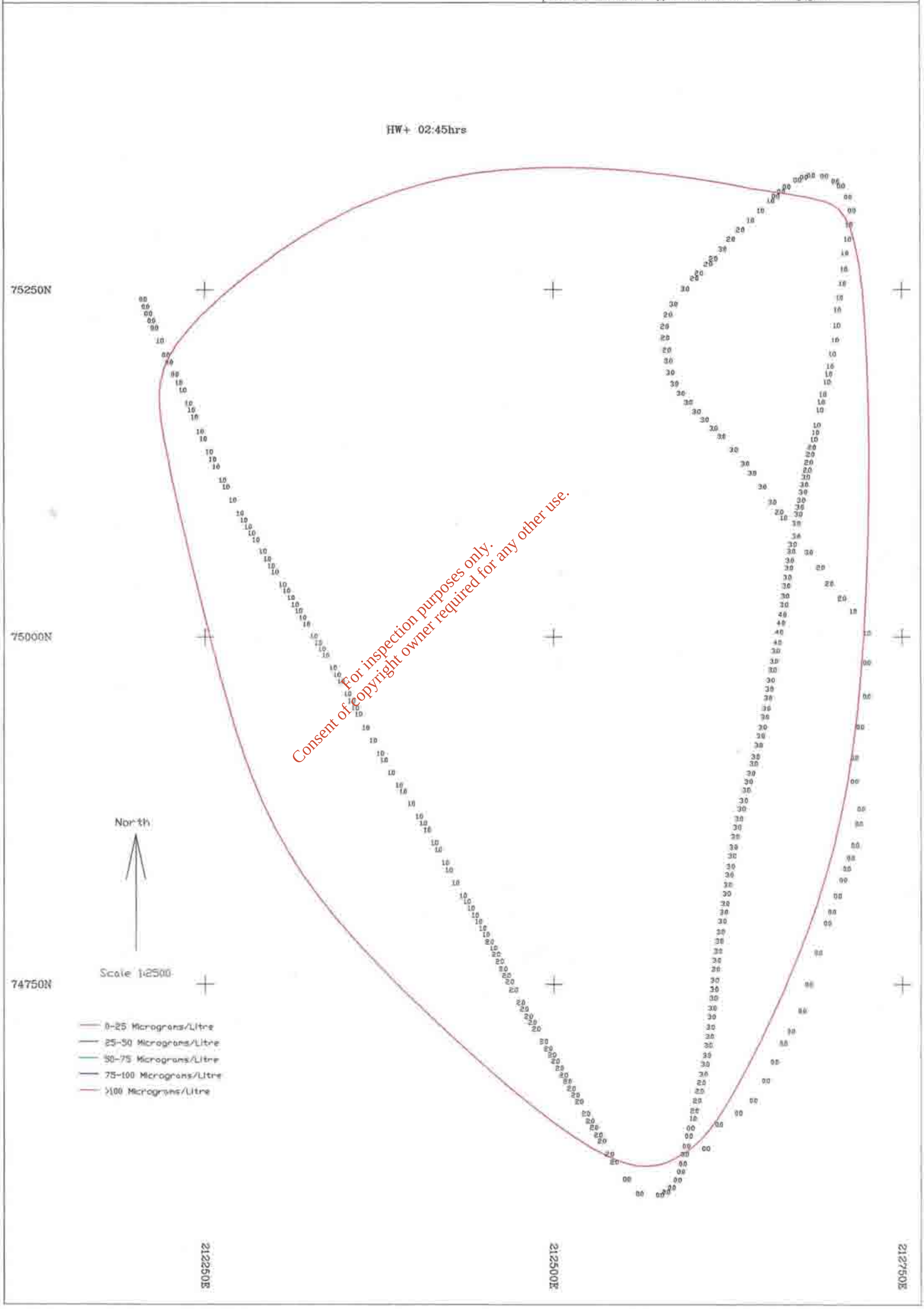
Patch 3	Neap Tide, High Water Release	03 May 2001	Central Time: 15:50 GMT Maximum Conc: 8 micrograms/litre Current Correction Applied: 0.25 n/sec at 150 deg grid	Fig. 7.D



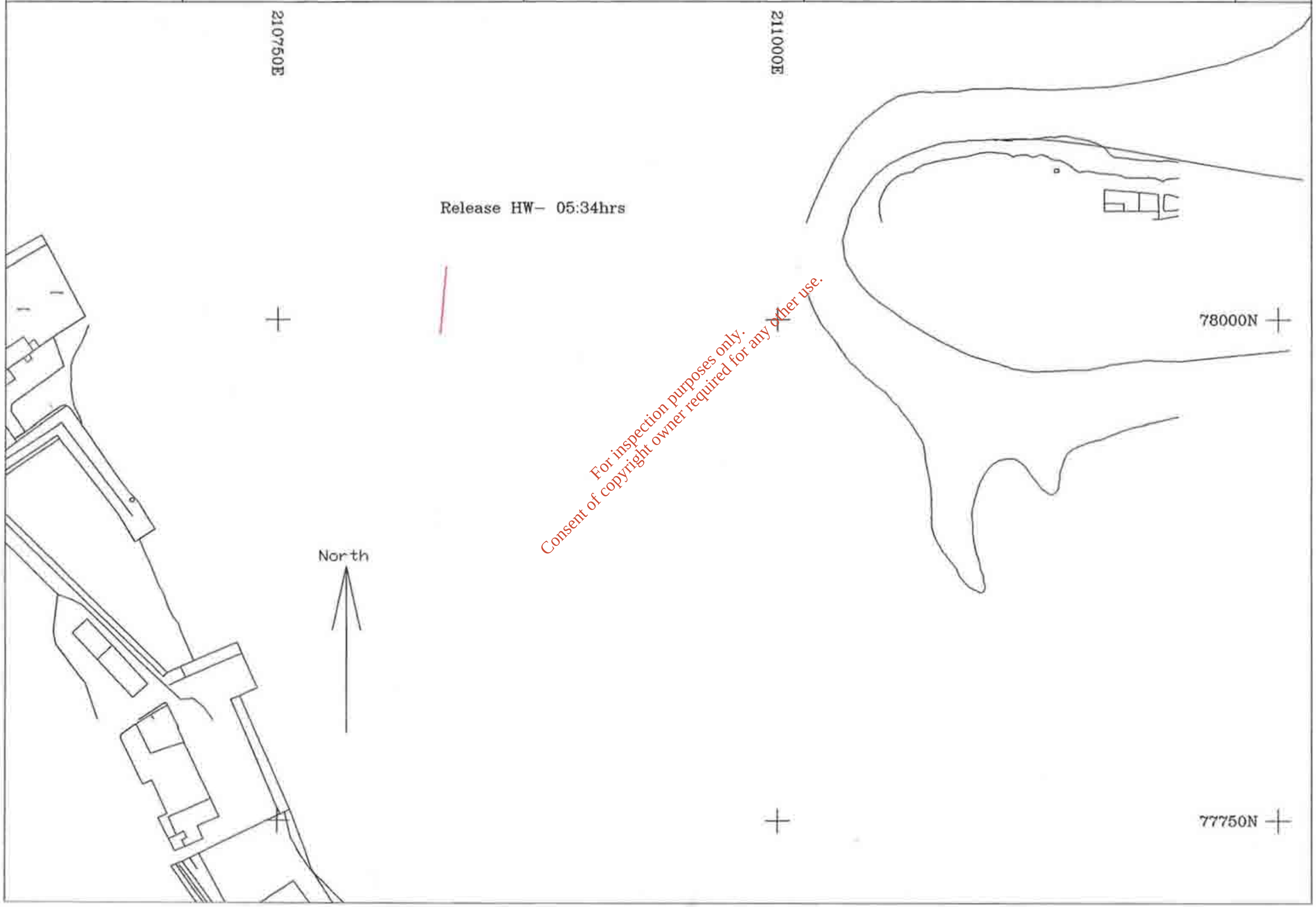
Patch _	Neap Tide, High Water Relea	03 May 2001	Central Tir 5:00 GMT Maximum Conc: 167 micrograms/litre Current Correction Applied: 0.35 m/sec at 190 deg grid



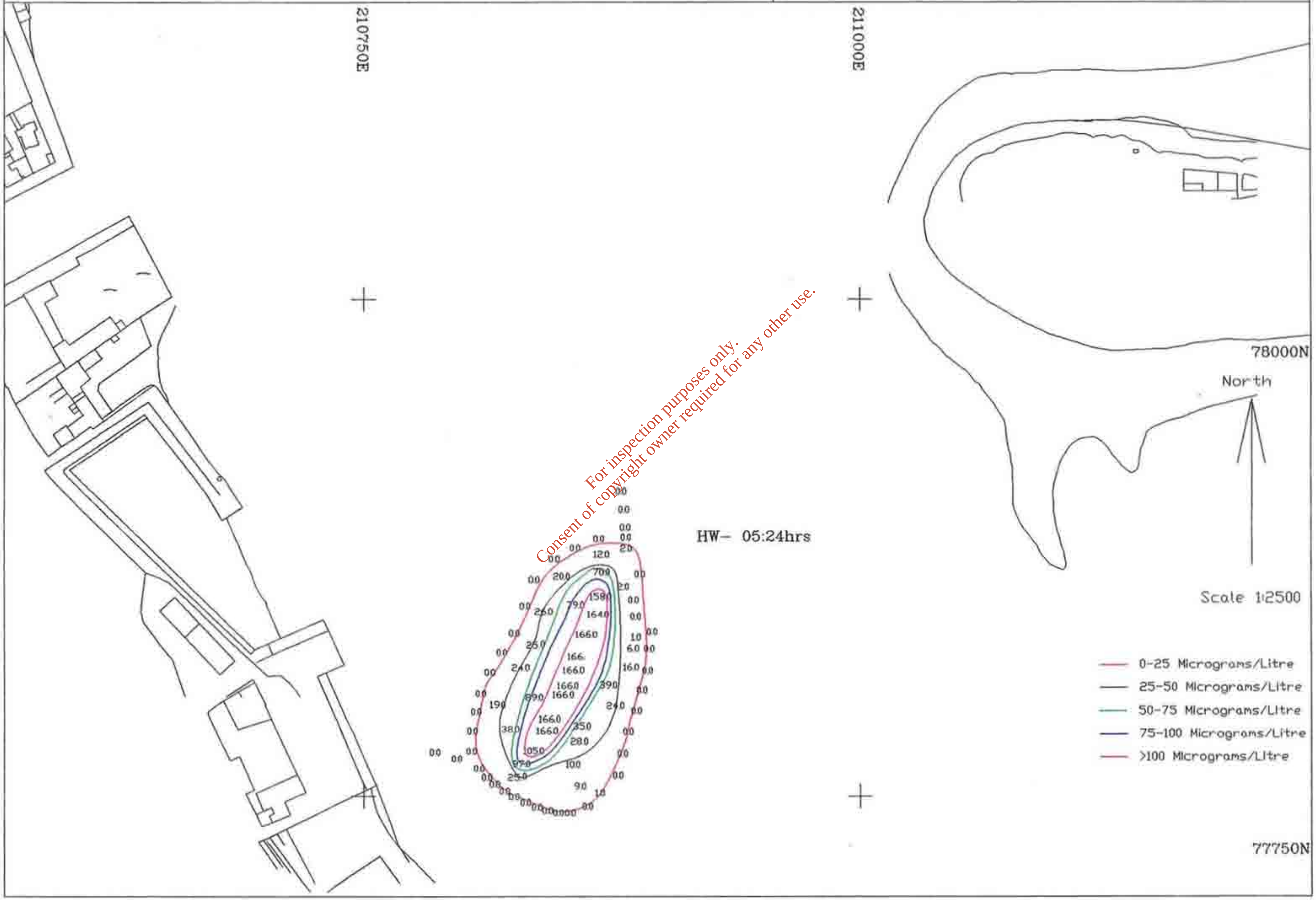
Patch 4 | Neap Tide, High Water Release | 03 May 2001 | Central Time: 16:50 GMT | Maximum Conc: 3 micrograms/Litre | Current Correction Applied: 0.25 m/sec at 160 deg grid | Fig. 7.E



Patch 0	Neap Tide, High Water Release	04/May/01 Scale 1:2500	.oughal Sewage Outfall Study Dye Release Point	Fig. 8.A

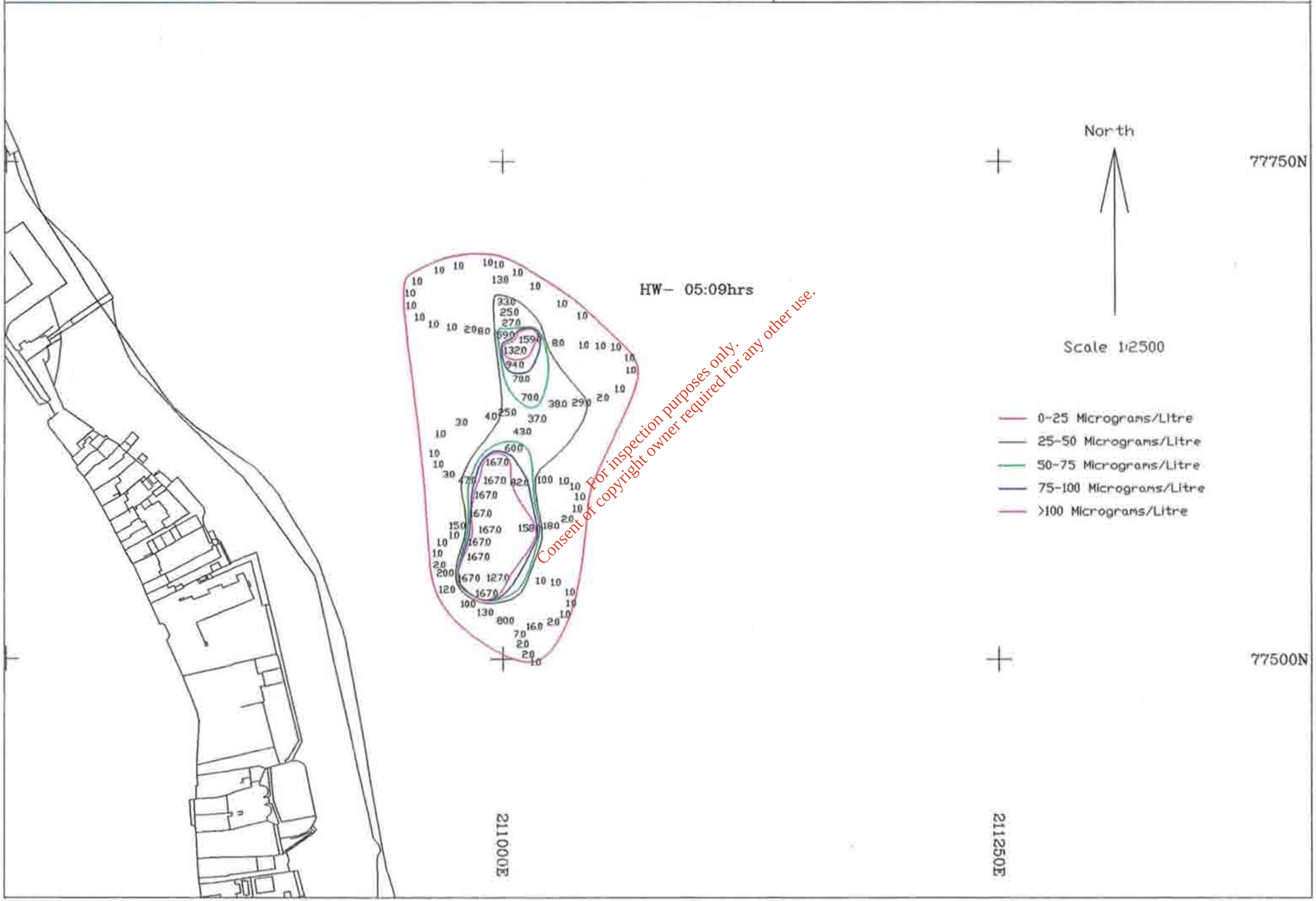


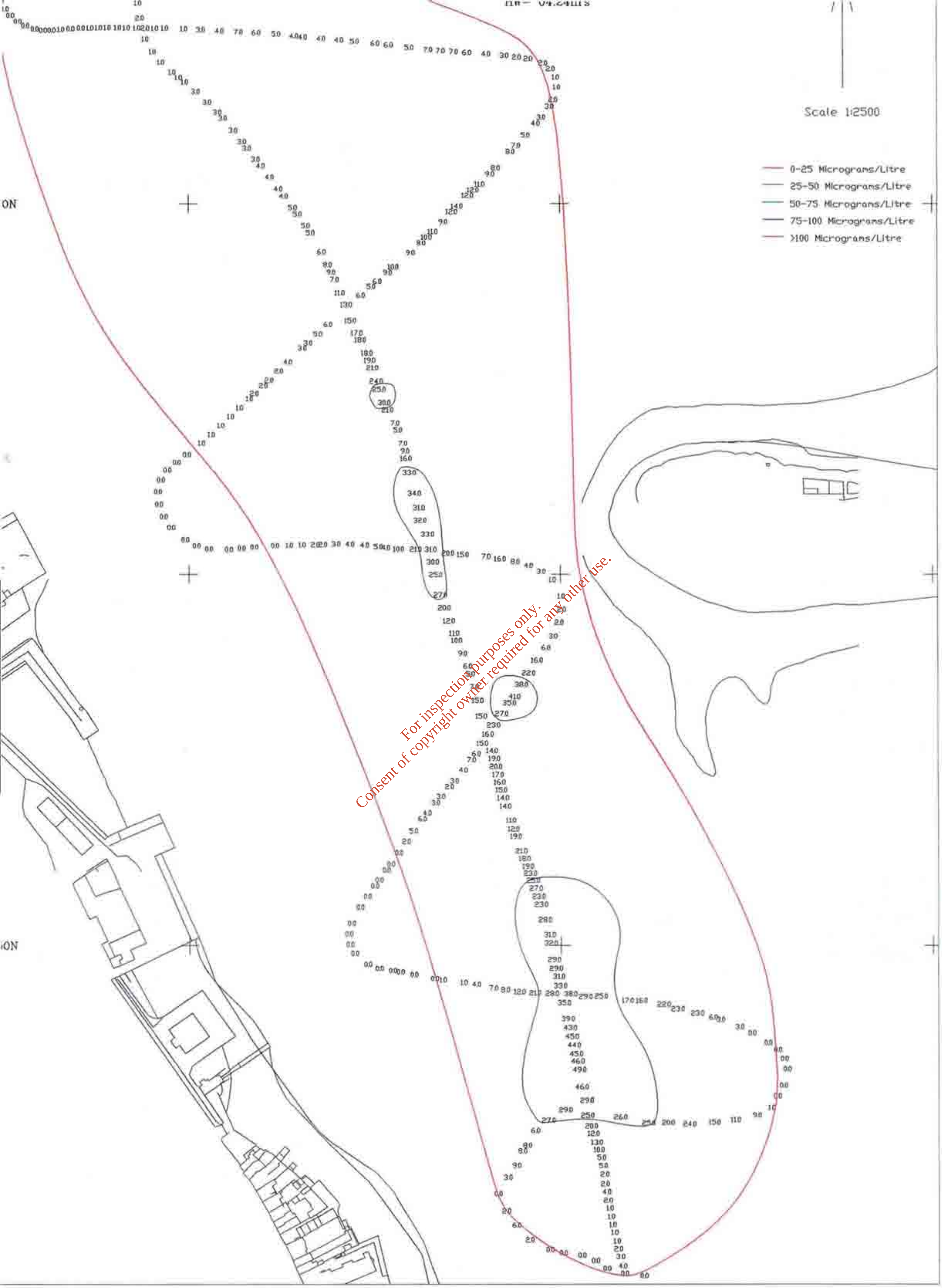
Patch .	Neap Tide, Low Water Relea.	04 May 2001	Central Tir 19:45 GMT Maximum Conc.: 166 micrograms/litre Current Correction Applied: 0.2 m/sec at 140 deg grid



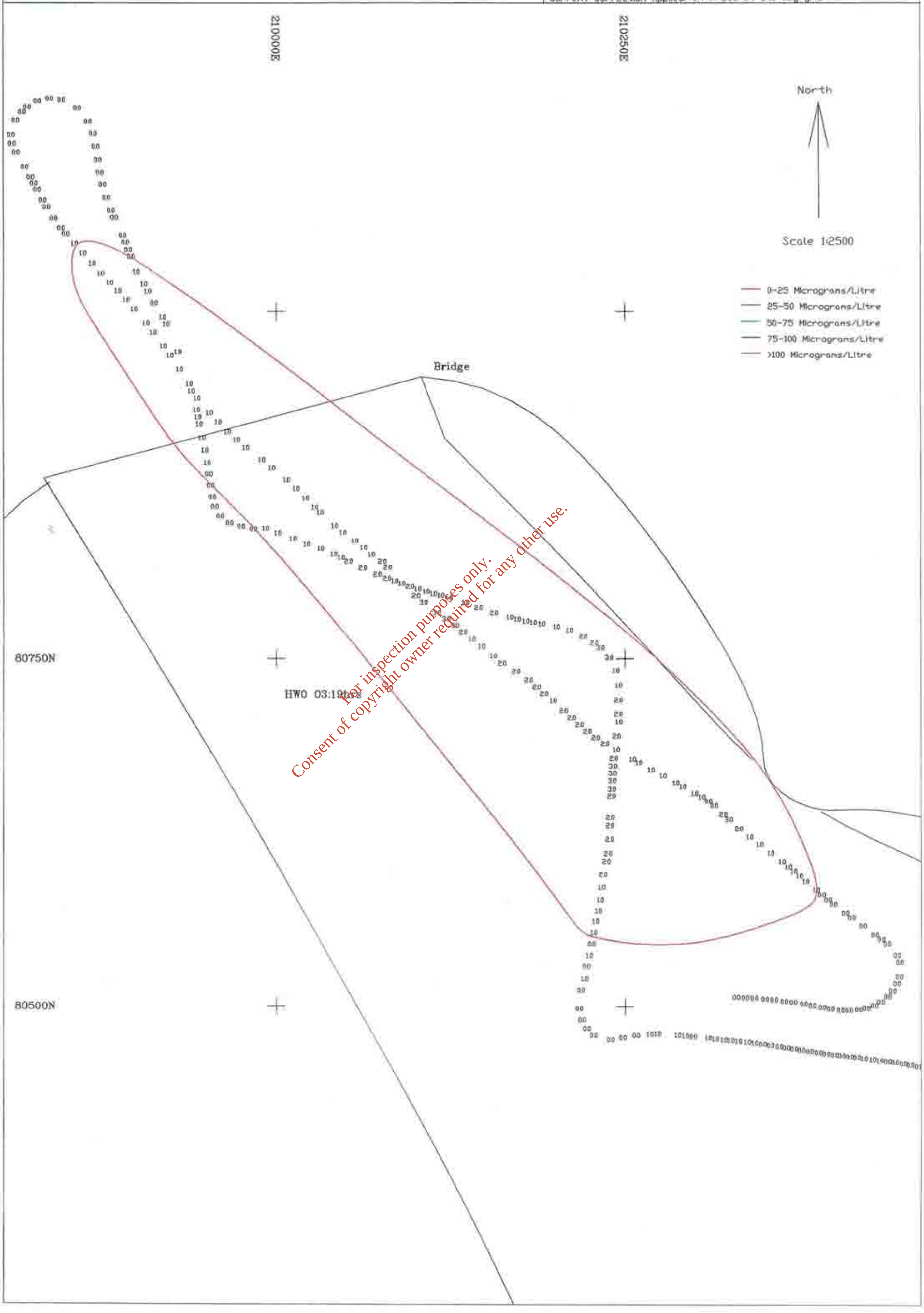
Patch _ Neap Tide, Low Water Relea 04 May 2001

Central Tir 0:00 GMT
Maximum Conc.: 167 micrograms/litre
Current Correction Applied: No Adjustment




Scale 1:2500
0-25 Micrograms/Litre
25-50 Micrograms/Litre
50-75 Micrograms/Litre
75-100 Micrograms/Litre
>100 Micrograms/Litre
ON

Patch 4	Neap Tide, Low Water Release	04 May 2001	Central Time: 11:50 GMT Maximum Conc: 3 micrograms/litre Current Correction Applied: 0.4 m/sec at 340 deg grid	Fig. 8E



Appendix A:2

Maximum Dye Concentration: Springs

Dye Tracing Survey Low Water Spring 7.5Kg Rhodamine BNG
Survey Date 25/04/01
Release Time (GMT) 13:39

Dye Patch	Central Patch Time	Elapsed Time	Max Dye Conc	Current Correction applied	
No.	(GMT)	from Release	(micrograms/litre)	Speed (m/s)	Dir'n (Deg G)
1	14:00	00:21	166	0.20	340
2	14:45	01:06	166	no	adjustment
3	15:00	01:21	102	0.20	270
4	16:00	02:21	35	0.10	265

Dye Tracing Survey High Water Spring 7.5Kg Rhodamine BNG
Survey Date 26/04/01
Release Time (GMT) 07:15

Dye Patch	Central Patch Time	Elapsed Time	Max Dye Conc	Current Correction applied	
No.	(GMT)	from Release	(micrograms/litre)	Speed (m/s)	Dir'n (Deg G)
1	07:40	00:25	167	0.02	220
2	08:15	01:00	167	0.20	130
3	09:15	02:00	4	0.20	140

Maximum Dye Concentration: Neaps

Dye Tracing Survey High Water Neap 7.5Kg Rhodamine BNG
Survey Date 03/05/01
Release Time (GMT) 14:30

Dye Patch	Central Patch Time	Elapsed Time	Max Dye Conc	Current Correction applied	
No.	(GMT)	from Release	(micrograms/litre)	Speed (m/s)	Dir'n (Deg G)
1	14:45	00:15	167	0.44	165
2	15:00	00:30	167	0.35	190
3	15:50	01:20	8	0.25	150
4	16:50	02:20	3	0.25	160

Dye Tracing Survey Low Water Neap 7.5Kg Rhodamine BNG
Survey Date 04/05/01
Release Time (GMT) 09:35

Dye Patch	Central Patch Time	Elapsed Time	Max Dye Conc	Current Correction applied	
No.	(GMT)	from Release	(micrograms/litre)	Speed (m/s)	Dir'n (Deg G)
1	09:45	00:10	166	0.20	140
2	10:00	00:25	167	no	adjustment
3	10:45	01:10	49	0.35	350
4	11:50	02:15	3	0.40	340

Appendix A.3 Meteorological Data

Location: Youghal

Job: Dye Tracing/ Drogue Tracking

Date: 25 April '01
High Water: 18:38 (G.M.T)

Time			Wind		Comment
Re High Water		(G.M.T)	Direction	Speed m s^{-1}	
H.W -	5:30:00	13:08	South	6	
H.W -	4:31:00	14:07	South	5.3	
H.W -	3:23:00	15:15	South West	6	
H.W -	2:23:00	16:15	South West	6	
H.W -	17:30:00	17:30	South West	7.8	

Date: 26 April '01
High Water: 6:57 (G.M.T)

Time			Wind		Comment
Re High Water		(G.M.T)	Direction	Speed m s^{-1}	
H.W +	0:03:00	7:00		Light Airs	
H.W +	1:03:00	8:00		Light Airs	
H.W +	2:03:00	9:00		Light Airs	
H.W +	3:03:00	10:00		Light Airs	
H.W +	4:03:00	11:00		Light Airs	

Date:01 May'01
High Water: 11:30 (G.M.T)

Time			Wind		Comment
Re High Water		(G.M.T)	Direction	Speed m s^{-1}	
H.W +	11:30:00	11:30	North East	7.9	
H.W +	11:46:00	11:46	North East	6.0	Slight Chop
H.W +	12:34:00	12:34	North East	5.6	
H.W +	12:49:00	12:49	North East	6.3	
H.W +	13:09:00	13:09	North East	6.3	
H.W +	13:39:00	13:39	North East	7.0	
H.W +	14:34:00	14:34	North East	6.3	
H.W +	15:05:00	15:05	North East	4.5	
H.W +	15:36:00	15:36	North East	5.7	
H.W +	16:25:00	16:25	East	4.0	
H.W +	16:35:00	16:35	South East	4.3	
H.W +	16:57:00	16:57	South East	4.0	

Date: 02 May'01
High Water: 12:42 (G.M.T)

Time			Wind		Comment
Re High Water		(G.M.T)	Direction	Speed m s^{-1}	
H.W -	7:04:00	7:04		Light Airs	
H.W -	8:20:00	8:20		Light Airs	
H.W -	8:40:00	8:40		Light Airs	
H.W -	9:08:00	9:08		Light Airs	
H.W -	9:20:00	9:20		Light Airs	
H.W -	9:34:00	9:34		Light Airs	
H.W -	10:00:00	10:00		Light Airs	
H.W -	10:20:00	10:20	South East	3.2	Calm
H.W -	11:20:00	11:20		Light Airs	Calm
H.W -	12:00:00	12:00	South East	4.3	
H.W -	12:23:00	12:23	South East	3.8	

Date: 03 May '01
High Water: 14:05 (G.M.T)

Time			Wind		Comment
Re High Water		(G.M.T)	Direction	Speed m s^{-1}	
H.W +	0:03:00	14:08	North East	7.2	
H.W +	0:35:00	14:40	North/North East	4	
H.W +	1:32:00	15:37	North/North East	4.5	
H.W +	2:44:00	16:49	North East	5	
H.W +	3:36:00	17:41	North East	5	
H.W +	4:45:00	18:50	North East	3	
H.W +	5:13:00	19:18	North/North East	3	

Date: 04 May '01
High Water: 15:09 (G.M.T)

Time			Wind		Comment
Re High Water		(G.M.T)	Direction	Speed m s^{-1}	
H.W +	5:49:00	9:20	North East	7	
H.W +	4:50:00	10:19	North/North East	5	
H.W +	4:13:00	10:56	North/North East	5	
H.W +	3:43:00	11:26	North/North East	5	
H.W +	3:09:00	12:00	North/North East	4.6	

Appendix B – Calibration information.

1) **Drogue Tables**
   1.1 Streamline drogue study
   1.2 Drogue tracking for dye patch adjustment

2) **Dye Calibration Information**

Appendix B.1.1: Streamline Drogue Study

Location: Youghal
Date: 01.05.01
High Water: 11:30:00

Drogue Depth: Mid- depth

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW+	0:00:00	11:30:00		210797	77997.45				Released
HW+	0:16:33	11:46:33	0:16:33	210877.7	77752.86	258	0.26	160	
HW+	0:36:43	12:06:43	0:36:43	211050.4	77367.54	422	0.35	153	
HW+	0:54:07	12:24:07	0:54:07	211132.7	76961.64	414	0.40	166	
HW+	1:12:13	12:42:13	1:12:13	211141.9	76429.48	532	0.49	178	Recovered

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW+	0:00:00	11:30:00		210797	77997.45				Released
HW+	0:18:00	11:48:00	0:18:00	210808.9	77793.5	204	0.19	177	
HW+	0:34:13	12:04:13	0:34:13	210916	77543.41	272	0.28	154	
HW+	0:56:43	12:26:43	0:56:43	211019.9	77193.17	365	0.27	162	
HW+	0:59:30	12:29:30	0:59:30	211029.2	77132	62	0.37	164	Recovered

Drogue Depth: Mid- depth

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW+	1:04:35	12:34:35		210810.8	77973.37				Released
HW+	1:18:37	12:48:37	0:14:02	210998.5	77563.98	450	0.53	152	
HW+	1:39:19	13:09:19	0:34:44	211180.1	76791.15	794	0.64	165	
HW+	1:54:27	13:24:27	0:49:52	211201.7	76336.9	455	0.50	176	Recovered

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW+	1:04:35	12:34:35		210810.8	77973.37				Released
HW+	1:19:49	12:49:49	0:15:14	211109.7	77495.62	564	0.62	145	
HW+	1:37:40	13:07:40	0:33:05	211327.8	76815.59	714	0.67	160	
HW+	1:57:55	13:27:55	0:53:20	211509.6	76001.97	834	0.69	166	Recovered

Location: Youghal
Date: 01.05.01
High Water: 11:30:00

Drogue Depth: Mid- depth

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW+	2:09:09	13:39:09		210797.0	77997.45				Released
HW+	2:19:33	13:49:33	0:10:24	210959.5	77545.36	480	0.77	158	
HW+	2:38:14	14:08:14	0:29:05	211150.5	76676.12	890	0.79	166	
HW+	2:55:30	14:25:30	0:46:21	211117.5	76086.38	591	0.57	183	Recovered

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW+	2:09:09	13:39:09		210797	77997.45				Released
HW+	2:18:52	13:48:52	0:09:43	210967.6	77513.85	513	0.88	159	
HW+	2:36:59	14:06:59	0:27:50	211213.8	76581.69	964	0.89	162	
HW+	2:53:44	14:23:44	0:44:35	211212.8	75997.59	584	0.58	180	Recovered

Drogue Depth: Mid- depth

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW+	3:04:43	14:34:43		210817.6	77997.49				Released
HW+	3:18:51	14:48:51	0:14:08	211060.5	77493.66	559	0.66	151	
HW+	3:33:58	15:03:58	0:29:15	211261.2	76908.15	619	0.68	159	
HW+	3:57:34	15:27:34	0:52:51	211275.2	76264.75	644	0.45	179	Recovered

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW+	3:04:43	14:34:43		210817.6	77997.49				Released
HW+	3:19:33	14:49:33	0:14:50	211072.1	77399.12	650	0.73	155	
HW+	3:35:24	15:05:24	0:30:41	211228.5	76654.04	761	0.80	167	
HW+	3:55:08	15:25:08	0:50:25	211271.5	75903.16	752	0.64	176	Recovered

Drogue Depth: Mid- depth

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW+	4:06:03	15:36:03		210823.4	77995.65				Released
HW+	4:23:58	15:53:58	0:17:55	211135.1	77421.51	653	0.61	148	
HW+	4:58:23	16:28:23	0:52:20	211201	76642.85	781	0.38	154	Recovered

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW+	4:06:03	15:36:03		210823.4	77995.65				Released
HW+	4:24:30	15:54:30	0:18:27	211183.4	77347.44	741	0.67	148	
HW+	4:55:26	16:25:26	0:49:23	211499.7	76319.03	1076	0.58	160	Recovered

Drogue Depth: Mid- depth

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW+	5:05:46	16:35:46		210836	77999.39				Released
HW+	5:27:01	16:57:01	0:21:15	211086.6	77597.56	474	0.37	144	
HW+	5:56:18	17:26:18	0:50:32	211316	77512.77	245	0.14	108	Recovered

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW+	5:05:46	16:35:46		210836	77999.39				Released
HW+	5:27:52	16:57:52	0:22:06	211160.2	77499.44	596	0.45	144	
HW+	5:52:00	17:22:00	0:46:14	211317.3	76913.84	606	0.42	163	Recovered

Location: Youghal
Date: 02.05.01
High Water: 12:42:00

Drogue Depth: Mid- depth

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW-	5:37:22	7:04:38		210787.9	77984.45				Released
HW-	5:17:43	7:24:17	0:19:39	210887.9	77797.38	212	0.18	149	
HW-	5:00:58	7:41:02	0:36:24	210892.7	77713.95	84	0.08	176	
HW-	4:45:57	7:56:03	0:51:25	210845.6	77797.29	96	0.11	327	Recovered

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW-	5:37:22	7:04:38		210787.9	77984.45				Released
HW-	5:16:34	7:25:26	0:20:48	210883.4	77771.41	233	0.19	153	
HW-	5:01:21	7:40:39	0:36:01	210899.6	77688	85	0.09	167	
HW-	4:47:02	7:54:58	0:50:20	210872	77756.55	74	0.09	335	Recovered

Location: Youghal
Date: 02.05.01
High Water: 12:42:00

Drogue Depth: Mid- depth

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW-	4:43:47	7:58:13		210800.4	78004.87				Released
HW-	4:21:54	8:20:06	1:15:28	210717.1	78381.11	385	0.29	347	
HW-	4:00:57	8:41:03	1:36:25	210530.7	78794.22	453	0.36	332	
HW-	3:44:53	8:57:07	1:52:29	210460.1	79133.41	346	0.36	346	Recovered

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW-	4:43:47	7:58:13		210800.4	78004.87				Released
HW-	4:21:31	8:20:29	0:55:03	210704.4	78416.32	422	0.32	325	
HW-	4:02:16	8:39:44	1:14:18	210611.7	78916.78	509	0.44	348	
HW-	3:42:08	8:59:52	1:34:26	210570.4	79485.96	571	0.47	355	Recovered

Location: Youghal
Date: 02.05.01
High Water: 12:42:00

Drogue Depth: Mid- depth

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW-	3:33:35	9:08:25		210787.8	78002.99				Released
HW-	3:20:47	9:21:13	2:16:35	210673.4	78490.42	501	0.64	345	
HW-	3:06:51	9:35:09	2:30:31	210570.5	78922.25	444	0.53	345	
HW-	2:50:16	9:51:44	2:47:06	210509.8	79441.32	523	0.53	352	Recovered

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW-	3:33:35	9:08:25		210787.8	78002.99				Released
HW-	3:21:32	9:20:28	2:15:50	210634.6	78416.17	441	0.61	345	
HW-	3:07:23	9:34:37	2:29:59	210538.4	78933.31	526	0.62	349	
HW-	2:48:55	9:53:05	2:48:27	210453.6	79507.96	581	0.52	357	Recovered

Location: Youghal
Date: 02.05.01
High Water: 12:42:00

Drogue Depth: Mid- depth

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW-	2:41:57	10:00:03		210761.4	78058.56				Released
HW-	2:20:39	10:21:21	3:16:43	210581.2	78714.59	680	0.53	343	
HW-	1:47:47	10:54:13	3:49:35	210491.7	79354.14	646	0.33	341	Recovered

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW-	2:41:57	10:00:03		210761.4	78058.56				Released
HW-	2:21:41	10:20:19	10:20:19	210563.9	78788.73	756	0.62	343	
HW-	1:50:33	10:51:27	10:51:27	210445	79786.09	###	0.54	352	Recovered

Location: Youghal
Date: 02.05.01
High Water: 12:42:00

Drogue Depth: Mid- depth

Time Re High Water		Time (G.M.T)	Elapsed time min/sec	Easting x	Northing y	Dist. (m)	Vel. m s-1	Dir (° mag)	Comment
HW-	1:40:36	11:01:24		210780.9	78006.68				Released
HW-	1:21:12	11:20:48	4:16:10	210565.4	78632.97	662	0.57	339	
HW-	0:47:56	11:54:04	4:49:26	210378	79500.39	887	0.44	349	Recovered

Drogue Depth: 1m

Time Re High Water		Time (G.M.T)	Elapsed time min/sec	Easting x	Northing y	Dist. (m)	Vel. m s-1	Dir (° mag)	Comment
HW-	1:40:36	11:01:24		210780.9	78006.68				Released
HW-	1:20:06	11:21:54	11:21:54	210541.2	78673.72	709	0.58	338	
HW-	0:49:23	11:52:37	11:52:37	210378	79500.39	843	0.46	347	Recovered

High Water: 12:42:00

Drogue Depth: Mid- depth

Time Re High Water		Time (G.M.T)	Elapsed time min/sec	Easting x	Northing y	Dist. (m)	Vel. m s-1	Dir (° mag)	Comment
HW-	0:41:21	12:00:39		210797	77986.32				Released
HW-	0:16:55	12:25:05	5:20:27	210575.9	78540.28	596	0.41	335	
HW-	0:08:03	12:50:03	5:45:25	210523.5	78955.53	419	0.28	352	
HW-	0:23:22	13:05:22	6:00:44	210520.8	79114.99	159	0.17	359	Recovered

Drogue Depth: 1m

Time Re High Water		Time (G.M.T)	Elapsed time min/sec	Easting x	Northing y	Dist. (m)	Vel. m s-1	Dir (° mag)	Comment
HW-	0:41:21	12:00:39		210797	77986.32				Released
HW-	0:18:22	12:23:38	4:58:12	210575.9	78540.28	596	0.43	324	
HW-	0:09:33	12:51:33	5:26:07	210428.6	78836.66	331	0.20	349	
HW-	0:25:12	13:07:12	5:41:46	210449	78944.25	110	0.12	13	Recovered

Appendix B.1.2: Drouge tracking for dye patch adjustment

Location: Youghal
Date: 25.04.01
High Water: 18:38:00

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	min/sec	x	y	(m)	m s-1	(° mag)	
HW-	5:30:00	13:08		210822	77870				Released
HW-	5:12:00	13:26	0:18:00	210971	77622	293	0.27	145	Recovered
HW-	5:08:00	13:30	0:22:00	210877	77844				Released
HW-	4:50:00	13:48	0:40:00	210963	77758	121	0.50	130	
HW-	4:23:00	14:15	1:07:00	210886	78062	315	0.19	344	Recovered

Location: Youghal
Date: 26.04.01
High Water: 6:57:00

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	(seconds)	x	y	(m)	m s-1	(° mag)	
HW+	0:25:00	7:22		210768	77994				Released
HW+	1:39:00	8:36	1:14:00	210715	77919	91	0.02	220	
HW+	2:41:00	9:38	2:16:00	211411	77584	774	0.21	118	Recovered

Location: Youghal
Date: 03.05.01
High Water: 14:05:00

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	(seconds)	x	y	(m)	m s-1	(° mag)	
HW+	0:25:00	14:30		210811	77997				Released
HW+	1:06:00	15:11	0:41:00	211069	76947	1080	0.44	165	
HW+	1:53:00	15:58	1:28:00	210903	75899	1077	0.38	189	
HW+	3:04:00	17:09	2:39:00	210629	75625	403	0.09	229	Recovered

Location: Youghal
Date: 03.05.01
High Water: 14:05:00

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	(seconds)	x	y	(m)	m s-1	(° mag)	
HW+	2:00:00	16:05		212240	75372				Released
HW+	2:44:00	16:49	0:44:00	212613	74720	721	0.27	148	
HW+	3:28:00	17:33	1:28:00	212769	74060	648	0.25	168	
HW+	3:53:00	17:58	1:53:00	212764	73703	351	0.23	181	
HW+	4:15:00	18:20	2:15:00	212754	73399	323	0.24	182	
HW+	4:42:00	18:47	2:42:00	212734	72984	415	0.26	182	
HW+	5:09:00	19:14	3:09:00	212724	72544	435	0.27	180	
HW+	5:19:00	19:24	3:19:00	212728	72406	147	0.25	180	Recovered

Location: Youghal
Date: 04.05.01
High Water: 15:09:00

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	(seconds)	x	y	(m)	m s-1	(° mag)	
HW-	5:38:00	9:31		210804	78017				Released
HW-	5:29:00	9:40	0:09:00	210878	77910	130	0.24	141	
HW-	5:03:00	10:06	0:35:00	210963	77800	140	0.09	137	
HW-	4:21:00	10:48	1:17:00	210993	78321	529	0.21	003	
HW-	3:54:00	11:15	1:44:00	211043	78717	400	0.25	008	Aground

Location: Youghal
Date: 04.05.01
High Water: 15:09:00

Drogue Depth: 1m

Time Re High Water		Time	Elapsed time	Easting	Northing	Dist.	Vel.	Dir	Comment
		(G.M.T)	(seconds)	x	y	(m)	m s-1	(° mag)	
HW-	4:53:00	10:16		211106	77448				Released
HW-	4:31:00	10:38	1:07:00	211071	77553	112	0.08	338	
HW-	4:13:00	10:56	1:25:00	210971	77816	281	0.47	340	
HW-	3:20:00	11:49	2:18:00	210549	79896	1651	0.45	342	
HW-	3:00:00	12:09	2:38:00	210177	80486	726	0.61	325	
HW-	2:36:00	12:33	3:02:00	209879	80988	610	0.42	326	
HW-	2:18:00	12:51	3:20:00	209208	81158	692	0.64	282	Recovered

Appendix B.2

Dye calibration information

Readings have been taken from the fluorimeter for 100 micrograms/litre concentration of Rhodamine dissolved in pure water and for pure water. The following formula is derived from these readings and relates to instrument output to Rhodamine in water concentration

Conc. = (Vsample – 0.081) x 30.186

Where: conc. = Rhodamine concentration in micrograms/litre

Vsample = minitracka output in volts when exposed to Rhodamine sample in water

Hydrographic Surveys Ltd.
The Cobbles, Crosshaven, Co. Cork.
Tel.: + 353 21 4831184
Fax: + 353 21 4831193

Atkins McCarthy,
Villa Franca,
Douglas Road,
Cork.

15th June 2001

Attn: Louise Collier.

Re: Youghal Study.

Dear Louise,
I enclose the results of the survey at Youghal, carried out on the following dates:

Bathymetric survey, 12th and 13th June 2001. Charts HS 85-1 and 85-2/-1
DRCM observations, 6th and 13th June, 2001 – see attached tables.

Results of the bathymetric survey indicate that the extensive drying bank located north east of Youghal dries to 0.9m and has a channel of approximately 140m width on the Waterford side. The main harbour to the north of the town is quite shallow.

The direct reading current meter observations were carried out on the 6th June 2001, on a good Spring tide and on the 13th June 2001, on a very good Neap tide. On both occasions conditions for observing were very good with, apart from a period of about two hours on the 6th, mostly light winds.

Results of the DRCM observations show that the tidal flow is generally north – south in direction with a maximum velocity of over 2 knots measured on the surface on several occasions, (i.e. in excess of $1.0 msec^{-1}$), during Spring Observations.
As would be expected, bearing in mind the range of the tide during Neaps, velocities recorded were less than this, nevertheless surface velocities were frequently of the order of 1.5 knots. In both cases maximum velocities occur at about half-tide.

It was intended that two stations would be observed, however, the constant presence of drift-net fishermen made this impossible, except for the part of the tide on the 6th.

Depths are shown in metres and decimetres on the bathymetric charts, reduced to Chart Datum which is +0.48m O.D. Poolbeg.

See dwgs folder for attachments.
Diskettes - Dwg. Office.

Horizontal control for the survey was provided by DGPS interfaced to Hypack survey software. Depths were obtained by ODOM digital echo sounder, calibrated by the bar-check method. Tides were measured by the Valeport T.G. model 740 at Youghal harbour.

The following is attached or accompanies this letter:

Diagram showing DRCM locations
Table showing Spring DRCM observations
Table showing Neap DRCM observations
Disk with DRCM data, .xyz data and .dwgs.

If you have any queries please contact me.

Yours sincerely,

M. J. Haberlin

M. J. Haberlin.

Location:Youghal
Area: Site A
Date:06/06/01
Spring Tide

Tide 06/06/01	Time BST
HW	06:26:00
LW	12:57:00
HW	18:36:00

Range of tide 3.3 metres

Time			Surface				Middle				Bottom			
Re HW		BST	Vel ms^{-1}	Brg °mag	Sal ppt	Temp °C	Vel ms^{-1}	Brg °mag	Sal ppt	Temp °C	Vel ms^{-1}	Brg °mag	Sal ppt	Temp °C
HW+	01:29	07:55	0.78	185	33.3	12.2	0.78	197	34.0	12.1	0.77	191	34.0	12.0
HW+	02:06	08:32	0.97	198	34.1	11.9	0.94	199	34.2	11.9	0.94	209	34.2	11.8
HW+	02:39	09:05	1.31	171	34.0	12.0	0.95	178	34.0	12.0	0.94	190	34.0	12.0
HW+	03:09	09:35	0.83	196	33.5	12.2	0.92	155	33.4	12.2	0.91	152	33.4	12.2
HW+	03:39	10:05	1.05	190	32.5	12.5	0.88	146	32.4	12.5	1.02	172	32.4	12.5
HW+	04:09	10:35	0.95	193	31.1	12.8	0.83	190	31.2	12.7	0.71	188	31.2	12.7
HW+	04:39	11:05	1.00	175	28.7	13.2	0.85	170	29.0	13.1	0.55	182	29.0	13.1
HW+	05:09	11:35	0.85	168	26.9	13.5					0.34	173	28.7	13.2
HW+	05:39	12:05	0.83	167	25.0	13.7					0.51	171	26.3	13.5
HW-	06:01	12:35	0.49	167	23.1	13.9					0.34	204	25.7	13.6
HW-	05:31	13:05	0.32	188	21.1	14.2					0.21	204	23.8	13.9
HW-	05:01	13:35	0.14	015	21.4	14.1	0.19	130	22.9	13.9	0.22	139	24.6	13.9
HW-	04:31	14:05	0.27	195	24.4	13.8	0.26	279	25.8	13.5	0.30	251	27.2	13.4
HW-	04:01	14:35	0.86	308	26.8	13.6	0.83	323	27.4	13.5	0.66	009	30.0	13.0
HW-	03:31	15:05	0.60	346	34.1	12.5	0.90	017	34.1	12.5	0.80	345	34.1	12.5
HW-	03:01	15:35	1.10	026	34.5	12.3	0.95	316	34.5	12.3	0.84	267	34.5	12.3
HW-	02:16	16:20	1.01	272	34.6	12.0	0.87	008	34.4	12.0	0.63	060	34.5	12.0
HW-	01:46	16:50	0.89	280	34.6	11.9	0.73	338	34.6	11.9	0.71	322	34.8	11.9
HW-	01:16	17:20	0.63	359	34.6	11.9	0.44	016	34.7	11.9	0.37	013	34.8	11.8
HW-	00:46	17:50	0.35	015	34.7	11.8	0.36	013	34.7	11.8	0.47	045	34.8	11.8
HW-	00:16	18:20	0.48	343	34.5	11.8	0.51	344	34.5	11.8	0.67	357	34.5	11.8
HW+	00:14	18:50	0.25	317	33.7	12.5	0.11	299	33.7	12.2	0.25	330	34.1	12.3
HW+	00:44	19:20	0.15	260	32.4	12.8	0.15	215	33.1	12.5	0.06	028	33.3	11.9
HW+	01:14	19:50	0.27	148	33.0	12.8	0.24	213	33.3	12.3	0.19	189	33.4	12.2

Location: Youghal
Area: Site B
Date:06/06/01.
Spring Tide

Tide 06/06/01	Time BST
HW	06:26:00
LW	12:57:00
HW	18:36:00

Range of tide 3.3 metres

	Time		Surface				Middle				Bottom			
Re	HW	BST	Vel ms-1	Brg °mag	Sal ppt	Temp °C	Vel ms^{-1}	Brg °mag	Sal ppt	Temp °C	Vel ms^{-1}	Brg °mag	Sal ppt	Temp °C
HW+	01:54	08:20	1.03	178	33.3	12.2	1.0	173	33.4	12.1	0.83	198	33.3	12.2
HW+	02:24	08:50	1.27	163	33.4	12.1	0.94	193	33.6	12.1	1.10	207	33.7	12.1
HW+	02:54	09:20	1.16	177	33.1	12.2	0.93	158	33.6	12.2	0.92	172	0.3	12.1
HW+	03:24	09:50	0.86	167	33.4	12.2	0.84	124	33.3	12.2	0.81	162	33.3	12.2
HW+	03:54	10:20	0.59	208	32.7	12.5	0.88	173	32.7	12.5	0.98	168	32.7	12.5
HW+	04:24	10:50	0.91	180	30.5	12.8	0.87	174	30.9	12.8	0.52	185	31.0	12.8
HW+	04:54	11:20	0.86	186	28.5	13.1	0.61	166	29.4	13.0				
HW-	02:31	16:05	1.00	275	34.7	12.2	0.73	299	34.8	12.1	1.05	058	34.7	11.9

Measurements taken at one metre below surface, one metre above bottom and mid way through water column.
At low tide the channel was too shallow for three measurements only surface and bottom readings were taken.
Sampling at Site B was suspended for a period before and after low water as it interfered with drift net fishing. Sampling was resumed at approx.16:00hrs however due to deteriorating sea conditions, sampling at the area had to be abandoned.

Location: Youghal
Area: Site A
Date:13/06/01
Neap Tide

Tide 13/06/01	Time BST
HW	10:56:00
LW	17:39:00
HW	23:28:00

Range of tide 1.1 metrers

Time			Surface				Middle				Bottom			
Re	HW	BST	Vel ms-1	Brg °mag	Sal ppt	Temp °C	Vel ms^{-1}	Brg °mag	Sal ppt	Temp °C	Vel ms^{-1}	Brg °mag	Sal ppt	Temp °C
HW-	03:11	07:45	0.71	079	33.4	12.4	0.56	010	34	12.3	0.16	010	34	12.3
HW-	02:41	08:15	0.72	024	34	12.4	0.68	351	34	12.3	0.29	357	34.1	12.3
HW-	02:11	08:45	0.78	332	33.8	12.3	0.68	355	34.2	12.2	0.70	353	34.2	12.2
HW-	01:41	09:15	0.66	341	34.1	12.3	0.65	356	34.3	12.2	0.58	353	34.3	12.2
HW-	01:11	09:45	0.60	341	34.1	12.3	0.46	350	34.3	12.2	0.37	357	34.3	12.2
HW-	00:41	10:15	0.42	351	34.1	12.2	0.36	353	34.2	12.2	0.25	357	34.2	12.2
HW-	00:11	10:45	0.25	326	33	12.8	0.21	328	33.2	12.8	0.23	018	34.3	12.2
HW+	00:19	11:15	0.13	258	33.5	12.7	0.07	311	33.7	12.5	0.11	026	34.2	12.2
HW+	00:49	11:45	0.19	220	33.3	13	0.17	183	33.7	12.6	0.15	166	33.7	12.5
HW+	01:19	12:15	0.32	184	32.8	13.2	0.48	168	33	13.1	0.42	168	34.1	12.2
HW+	01:49	12:45	0.53	188	32.5	13.3	0.55	174	33.5	12.7	0.39	181	34.1	12.3
HW+	02:19	13:15	0.66	183	32.3	13.3	0.56	175	33.8	12.6	0.49	171	33.9	12.5
HW+	02:49	13:45	0.77	174	30.1	13.5	0.50	167	32.8	12.8	0.46	172	33.4	12.7
HW+	03:19	14:15	0.78	184	29.1	13.9	0.66	183	30.7	13.2	0.37	165	32.5	12.8
HW+	03:49	14:45	0.71	183	28.4	13.9	0.71	179	29	13.7	0.62	165	30.9	13.2
HW+	04:19	15:15	0.74	197	27.1	14.2	0.64	188	27.7	14	0.19	143	29.9	13.3
HW+	04:49	15:45	0.49	187	25.7	14.4	0.42	183	27.5	14	0.51	155	28.2	13.9
HW+	05:19	16:15	0.58	190	22.9	15	0.50	182	25.5	14.4	0.47	163	27	14.2
HW-	06:13	17:15	0.27	194	20.60	15.20	0.28	187	23.00	14.90	0.18	174	23.30	15
HW-	05:43	17:45	0.38	148	20.90	15.20					0.26	152	26.60	14.5
HW-	05:13	18:15	0.19	190	19.8	15.20					0.04	260	27.50	14.9
HW-	04:43	18:45	0.40	286	23.80	14.90	0.24	281	27.10	14.8	0.02	289	29.20	14.2
HW-	04:13	19:15	0.54	341	21.80	15.60	0.44	354	25.10	15.20	0.76	027	28.90	14.4

Meteorological data: Youghal

Date: 06/06/01

Tides 06/06/01

HW	06:26
HW	18:36

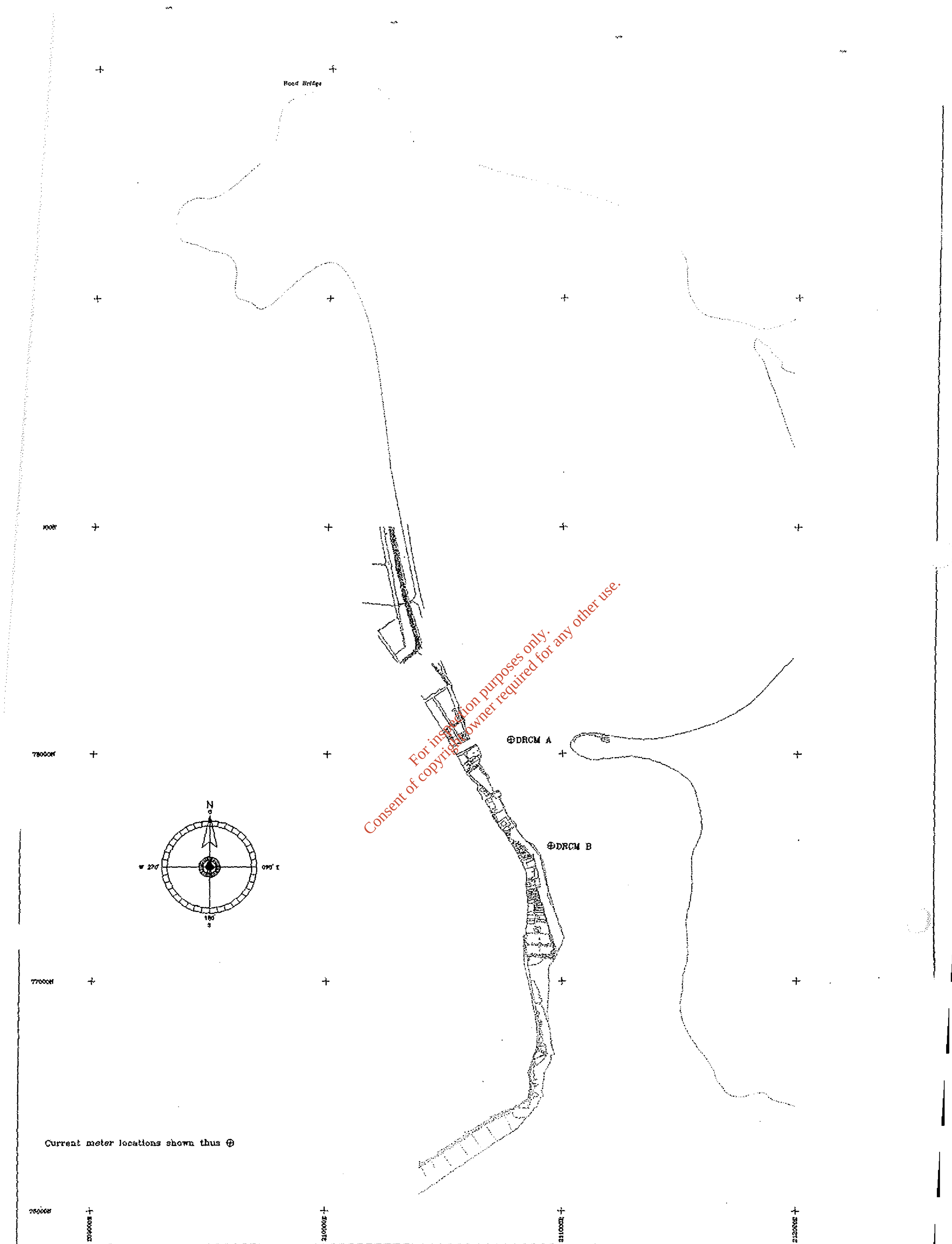
Time			Wind	
Re	HW	BST	Vel m/s	Direction
HW+	01:34	08:00	1.5	North West
HW+	02:04	08:30	5.5	West
HW+	03:04	09:30	3.5	West
HW+	03:29	09:55	2.5	West
HW+	03:49	10:15	3.3	West
HW+	04:04	10:30	4.4	West
HW+	04:34	11:00	2.2	West
HW+	06:04	12:30	5.0	West
HW-	04:31	14:05	3.5	West
HW-	03:06	15:30	8.9	West
HW-	02:16	16:20	11.5	North West
HW-	01:36	17:00	10.0	North West
HW-	00:36	18:00	7.6	North West
HW-	00:44	19:20	6.0	North West
HW-	01:24	20:00	7.5	North West

Date: 13/06/01

Tides 13/06/01

HW	10:56
HW	23:28

Time			Wind	
Re	HW	BST	Vel m/s	Direction
HW-	03:11	07:45	2.2	South
HW+	01:11	09:45	1.9	South
HW+	00:19	11:15	Light airs	
HW+	01:19	12:15	3.5	South
HW+	01:49	12:45	3.5	South
HW+	02:19	13:15	3.5	South
HW+	03:19	14:15	3.5	South
HW+	04:19	15:15	3.5	South
HW-	05:19	16:15	3.5	South
HW-	06:49	17:45	2.3	South



YOUGHAL HARBOUR *Co. Cork.* *CURRENT METER LOCATIONS*	Drwg No. HS 85A/01 Date June 2001 Scale 1:20000	CLIENT *Atkins McCarthy Consulting Engineers.* *SURVEYED BY HYDROGRAPHIC SURVEYS LTD.* *The Cobbles, Crosshaven, Co. Cork. Tel. 353-21-4831184*	*Produced by* *HYDROGRAPHIC SURVEYS L*

APPENDIX D PART B

ESTUARY RECEIVING WATERS MODELLING

INTRODUCTION

1.1 The site selection process indicates that the preferred option for the location of the treatment works is at the mudlands. Secondary treatment is proposed with a proposed discharge of treated effluent to the estuary. This section of the report describes the results of a water quality modelling analysis undertaken to examine the effects on the receiving waters of the current and proposed discharge situations to the estuary.

1.2 The model applied is an industry-standard near field model which is capable of providing a reliable and robust analysis of discharge plumes from outfalls

1.3 The legislative requirements for water quality in the estuary / harbour and bay area is dealt with in detail in Chapter 6 of the report. BOD, COD , TSS , have specified emission limit values in accordance with the legislation are independent of the receiving waters. The levels are considered to be sufficiently low not to have av n impact on the estuary. Nitrogen and phosphorus have also emission limit values as the waters are designated a sensitive area. Nitrogen is considered to be the limiting nutrient and the 15 mg/l in the effluent will apply. No reduction in Phosphorus is proposed. It is therefore not proposed to model these parameters. However inferences can be drawn from the parameters being modelled. The impact of the nutrients on the estuary from the proposed plant is very minor as the load is very small percentage of the total nutrients in the harbour which are mainly due to catchment and riverine loads.

1.4 The main use of the model is to determine if the effluent will impact on the designated beaches at Youghal Main Beach and Claycastle beach and the previously designated Shellfish production areas in Youghal bay which are all located outside the harbour / estuary area.. Faecal coliform concentration is the limiting water quality parameter for both these designations and the modelling is based on this situation.

STUDY AREA

Introduction

1.5 Youghal Harbour / Blackwater Estuary lies approximately 30 km east of Cork Harbour and forms part of the lower estuary of the Blackwater River. The harbour and outer bay are popular tourist destinations, particularly during the summer months, and have a high level of recreational fishing, sailing and bathing activity.

Inflowing Rivers

1.6 The Blackwater has a total channel length of 140 km and passes through the towns of Millstreet, Banteer, Mallow, Fermoy, Lismore, Cappoquin and Youghal before entering Youghal Bay. All of these towns discharge effluent to the river. The most recent EPA survey of river water quality[3] found 41.5 km of the river to be slightly polluted/eutrophic and 0.5 km to be moderately polluted, with the remainder being unpolluted. The portion of the river making up the estuary and approaching the estuary is classed as unpolluted.

1.7 The flow in the Blackwater is monitored at a gauging station near a dogleg bend in the river at Cappoquin, approximately 22 km upstream of Youghal Bridge. The EPA have estimated the following parameters for the river at this point[5]:

- Average Flow = 58.6 m^3/s
- 95-percentile Flow = 10.7 m^3/s

- Dry Weather Flow = 5.2 m^3/s

1.8 The River Bride flows into the estuary at a point approximately 13 km upstream of Youghal Bridge. The EPA water quality survey found 53.0 km of the river to be unpolluted and the remaining 2.0 km to be slightly polluted/eutrophic. The portion of the river entering the estuary is classed as unpolluted.

1.9 The EPA have estimated the following flows for the Bride upstream of the confluence of river and the estuary[5]:

- Average Flow not estimated
- 95-percentile Flow = 0.9 m^3/s
- Dry Weather Flow = 0.5 m^3/s

1.10 The Womanagh River discharges into the western side of Youghal Bay. The EPA water quality survey found 10.5 km of the river to be unpolluted and the remaining 10.5 km to be slightly polluted/eutrophic. The portion of the river entering the bay is classed as slightly polluted/eutrophic. No information is currently available for the flow in the Womanagh. However, the river is quite small and is not likely to affect the tidal circulation patterns in the Bay.

1.11 In general, the water quality of the inflowing rivers is good and the flow in the main Blackwater channel is relatively high, ensuring a good level of circulation and mixing in the estuary and outer bay.

Bathymetry and tidal Current Data

1.12 Admiralty Chart 2071 gives the bathymetry of Youghal Harbour and Bay and extends approximately 2 km upstream of Youghal Bridge. The 2 and 5 metre depth contours lie approximately 1 and 1.5 km respectively off the western shore of

Youghal Bay but lie close to the shore on the eastern side. The depth reaches 15 to 20 metres approximately 4 km from the entrance to the harbour.

1.13 Apart from a narrow 6-10 metre deep trench at the mouth, Youghal Harbour is relatively shallow with large expanses of mud flats at low water (see Figure 5). Upstream of Youghal Bridge the depth of water increases to approximately 10 metres along the main channel of the Blackwater. Strong southerly winds are known to cause significant swell inside the harbour.

1.14 The Admiralty Chart gives the following tidal levels for Youghal Harbour:

Table 1 – Tidal Elevations at Youghal Harbour

Place	Lat	Long	Height (metres)			
	N	W	MHWS	MHWN	MLWN	MLWS
Youghal	51° 57′	7° 51′	4.0	3.1	1.2	0.3

1.15 Thus, the spring and neap tidal ranges at Youghal are 3.7 and 1.9 metres respectively.

1.16 Imray Chart C57 shows the generalised tidal streams along the entire southern Irish coast. Off the coast of Cork, the prevailing current direction is from the south west on the flood and from the north east on the ebb, i.e. following the line of the coast.

1.17 Tidal stream data are also given on the Admiralty Chart at the 2 locations shown in Figure 1.

1.18 At point 1, which is located in the middle of the deep trench in 8 metres of water just inside the mouth of the harbour, the spring tidal currents exceed 1.3 m/s on the flooding tide and 1.5 m/s on the ebb tide. The neap currents reach 0.7 m/s on the flood and 0.8 m/s on the ebb. The current directions show that the prevailing tides enter and leave the harbour along its longitudinal axis, following the line of the trench.

1.19 . The data were plotted and the resulting charts are as follows:

Point 1 (51° 57.0′ N, 7° 50.4′ W)

Figure 1 – Tidal Stream Magnitudes at Point 1

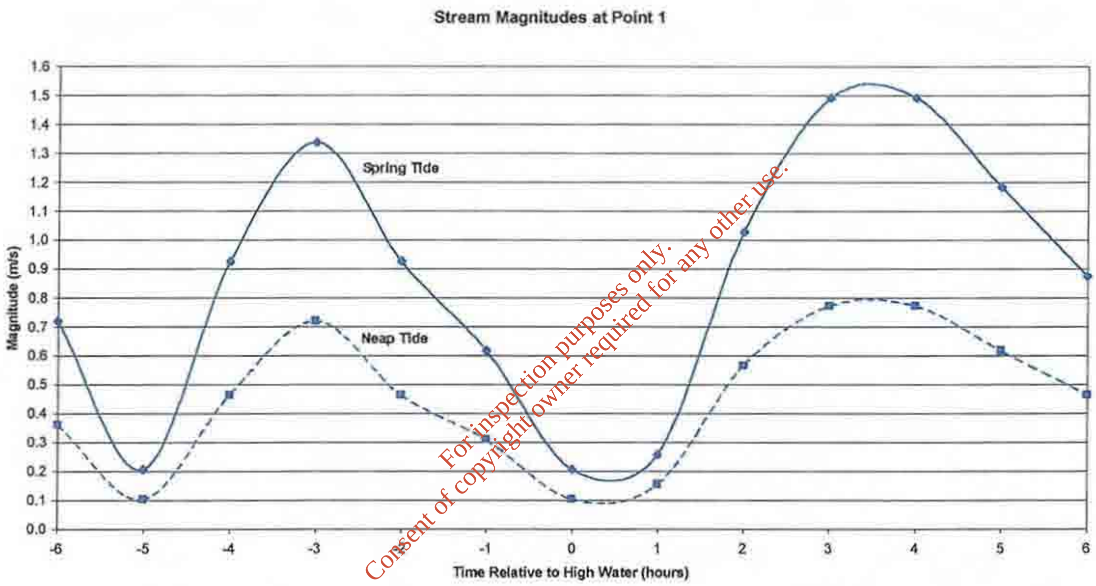
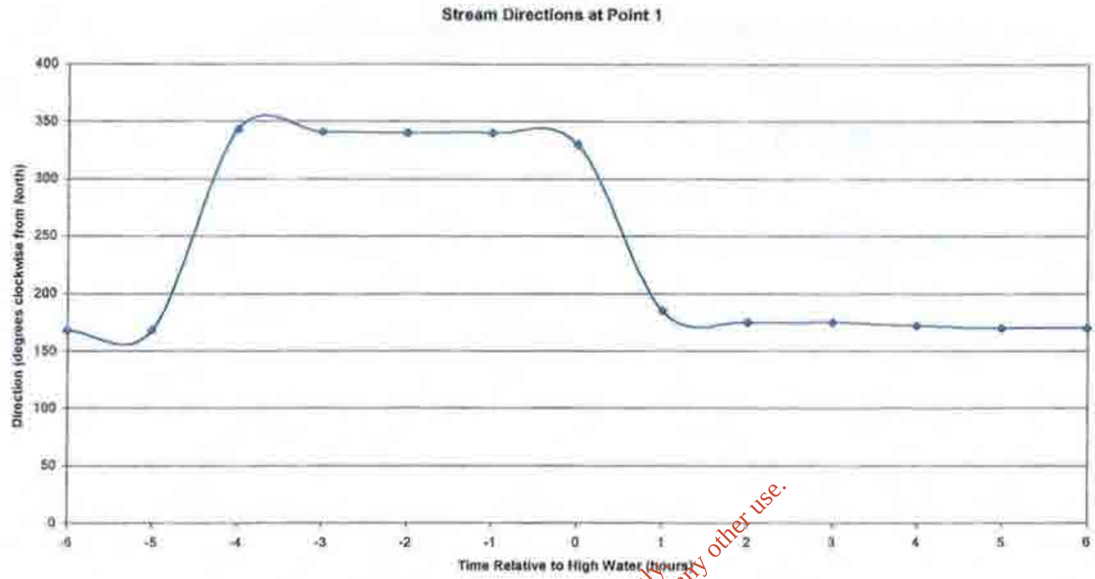


Figure 2 – Tidal Stream Directions at Point 1



Point 2 (51° 55.4′ N, 7° 49.4′ W)

Figure 3 – Tidal Stream Magnitudes at Point 2

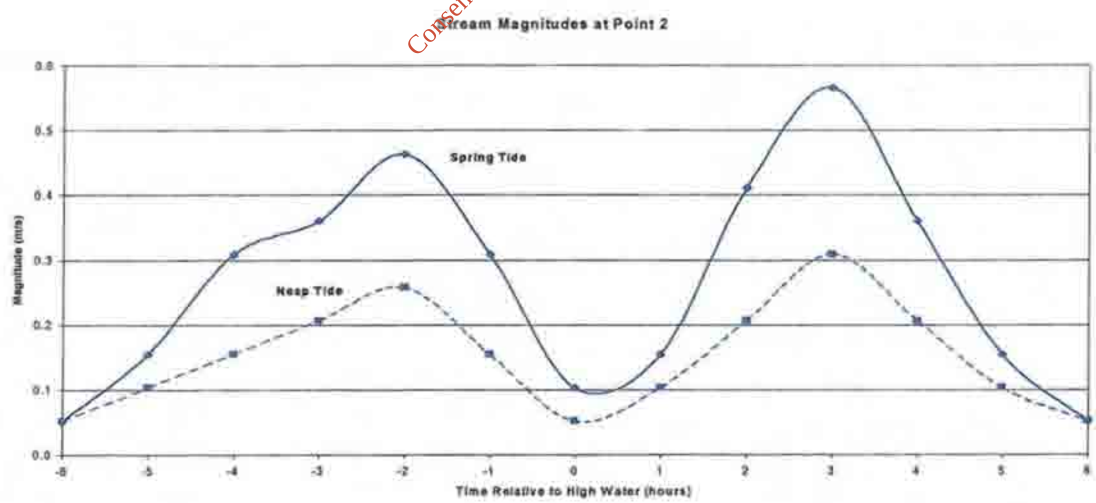


Figure 4 – Tidal Stream Directions at Point 2

1.20 Point 2 is located in about 8 metres of water approximately 2 km outside the harbour mouth. The spring tidal currents exceed 0.45 m/s on the flooding tide and 0.55 m/s on the ebb tide. The neap currents reach 0.25 m/s on the flood and 0.30 m/s on the ebb. The current directions show that the prevailing tide direction is from the south east.

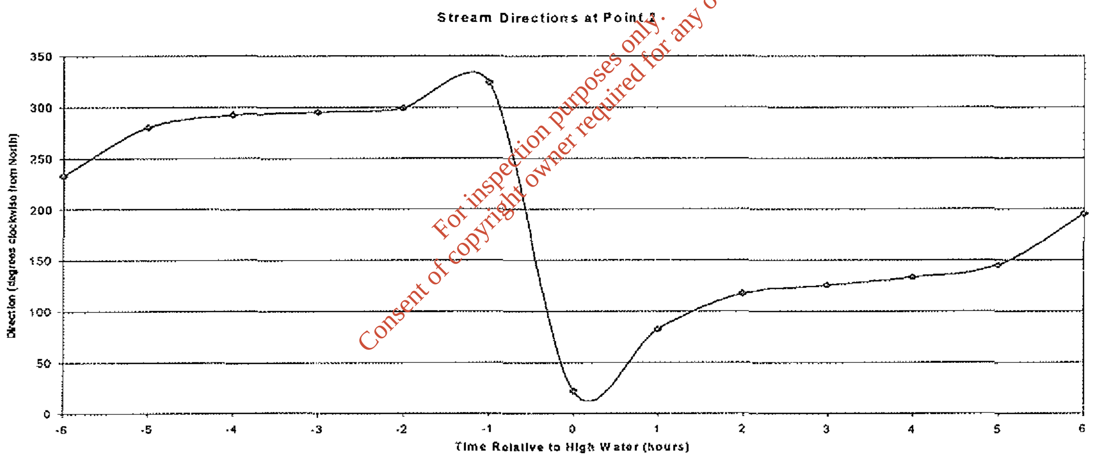
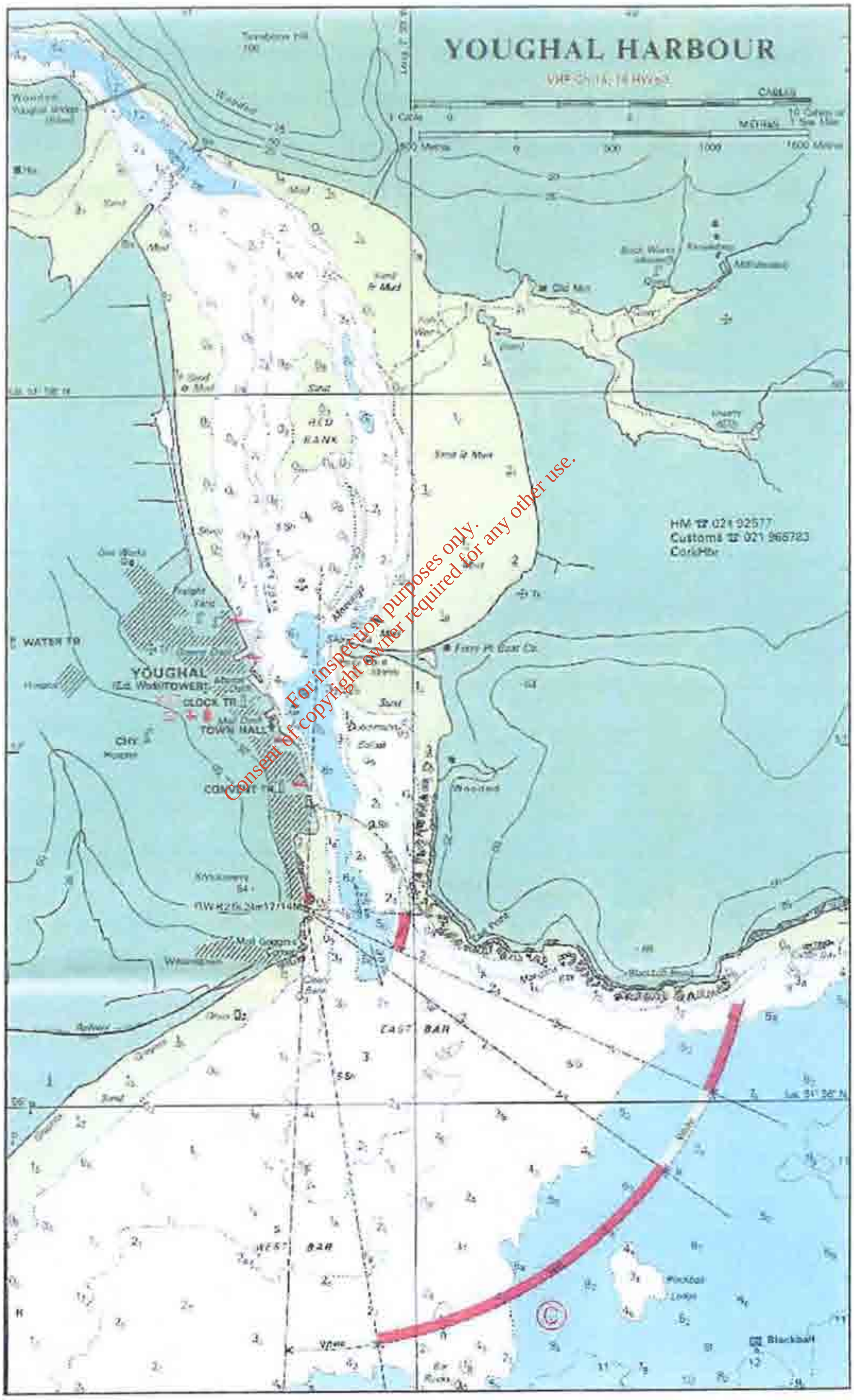


Figure 5 - Excerpt from Imray Chart Showing Bathymetry and Tidal Stream Data Points



1.21 The bathymetry and tidal stream data indicate that the flow in the estuary is more or less laterally contained, with the flow being approximately rectilinear. The estuary is relatively shallow, with maximum depths in the trench not exceeding 10m and average depths lying in the range 2-3m. Due to the relative uniformity of the flow direction in the lower harbour it is concluded that the lower estuary is suitable for a mathematical modelling analysis.

YOUGHAL SEWERAGE SYSYTEM

Current Situation

1.22 The town of Youghal has a population of approximately 7,500 with some small manufacturing industries located in an industrial estate north of the town. The municipal effluent currently discharges via 2 outfalls near the docks; the Green's Quay and Paxe's Lane outfalls (diameters 750 mm and 450 mm respectively), while a third smaller outfall discharges effluent from the industrial estate further upstream near the site of the old bridge (diameter 150 mm). The amount of effluent discharged at the old bridge site is relatively small when compared with the town effluent.

1.23 The Green's Quay outfall discharges the northern catchment effluent which accounts for approximately 60% of the town population while the Paxe's Lane outfall discharges the southern catchment effluent, accounting for the remaining 40%. The Green's Quay outfall discharges approximately 50m offshore into water of average depth 2.2m while the Paxe's Lane outfall discharges approximately 150m offshore into the deep trench with an average depth of 10.4m. The locations of these outfalls are shown in Figure 5.

1.24 There is currently no effluent treatment other than a holding tank and comminuters on the Green's Quay and Paxe's Lane outfalls.

Future Situation

1.25 The proposed scheme will involve secondary treatment of the effluent before discharging to the estuary. A site selection study has been undertaken and has indicated that the most suitable location is in the vicinity of the Youghal Mudlands north of the town.

1.26 Locating the works here would facilitate the laying of a new outfall in the vicinity of the existing outfall at Green's Quay. The existing outfall would be retained as a storm overflow pipe while a new treated effluent pipe would be laid to a distance of approximately 300m offshore, discharging to the deep trench near Ferry Point. Figure 6 also shows the location of this proposed outfall.

1.27 The estimated design population equivalent for the new works is 20,000.

OUTFALL MODELLING DATA

1.28 Secondary treatment is proposed and coliform source concentration is dependent on the efficiency of treatment and can be very variable. A well run plant would be expected to achieve a 2 log reduction from 1E7 to 1E5 per 100ml of faecal coliforms. The model outputs are linearly related to the coliform concentration so that any variation in source strength will bring about a corresponding change in the predicted concentrations.

1.29 Midleton WWTW have demonstrated that 1E5 /100ml can be readily achieved on a consistent basis and this level of FC concentration has been assumed for the secondary treated effluent without disinfection. Data from Midleton is enclosed as Appendix.2

1.30 Table 2 summarises the outfall parameters used in the model simulations. All outfalls are assumed to be single port pipes, discharging perpendicular to the shoreline at zero vertical angle. A multiple port diffuser would improve dispersion characteristics and so the single port diffuser will give a conservative result

Table 2 – Existing and Proposed Outfall Data

Outfall	: from shoreline to discharge point (m)	Depth below MSL at discharge point (m)	PipeDiameter (mm)	Rate of Discharge* (m^3/s)	Treatment Level	Effluent Faecal Coliform Concentration** (per 100ml)
EXISTING						
Green's Quay	50	2.2	750	0.0117	Untreated	$1.0x10^7$
Paxe's Lane	150	10.4	450	0.0078	Untreated	$1.0x10^7$
PROPOSED						
Ferry Point	300	8.4	600	0.0780	Secondary	$1.5x10^5$

*Rate of discharge calculations:

Green's Quay Population Equivalent = 60% of town population of 7,500 = 4,500

Dry Weather Flow = 4,500x225 litres/head/day = 0.0117 m^3/s

Discharge = 1.0xDWF = 0.0117 m^3/s

FC Concentration: 1E7 /100ml

Paxe's Lane Population Equivalent = 40% of town population of 7,500 = 3,000

Dry Weather Flow = 3,000x225 litres/head/day = 0.0078 m^3/s

Discharge = 1.0 DWF = 0.0078 m^3/s

FC Concentration: 1E7 /100ml

Ferry Point Population Equivalent = 20,000

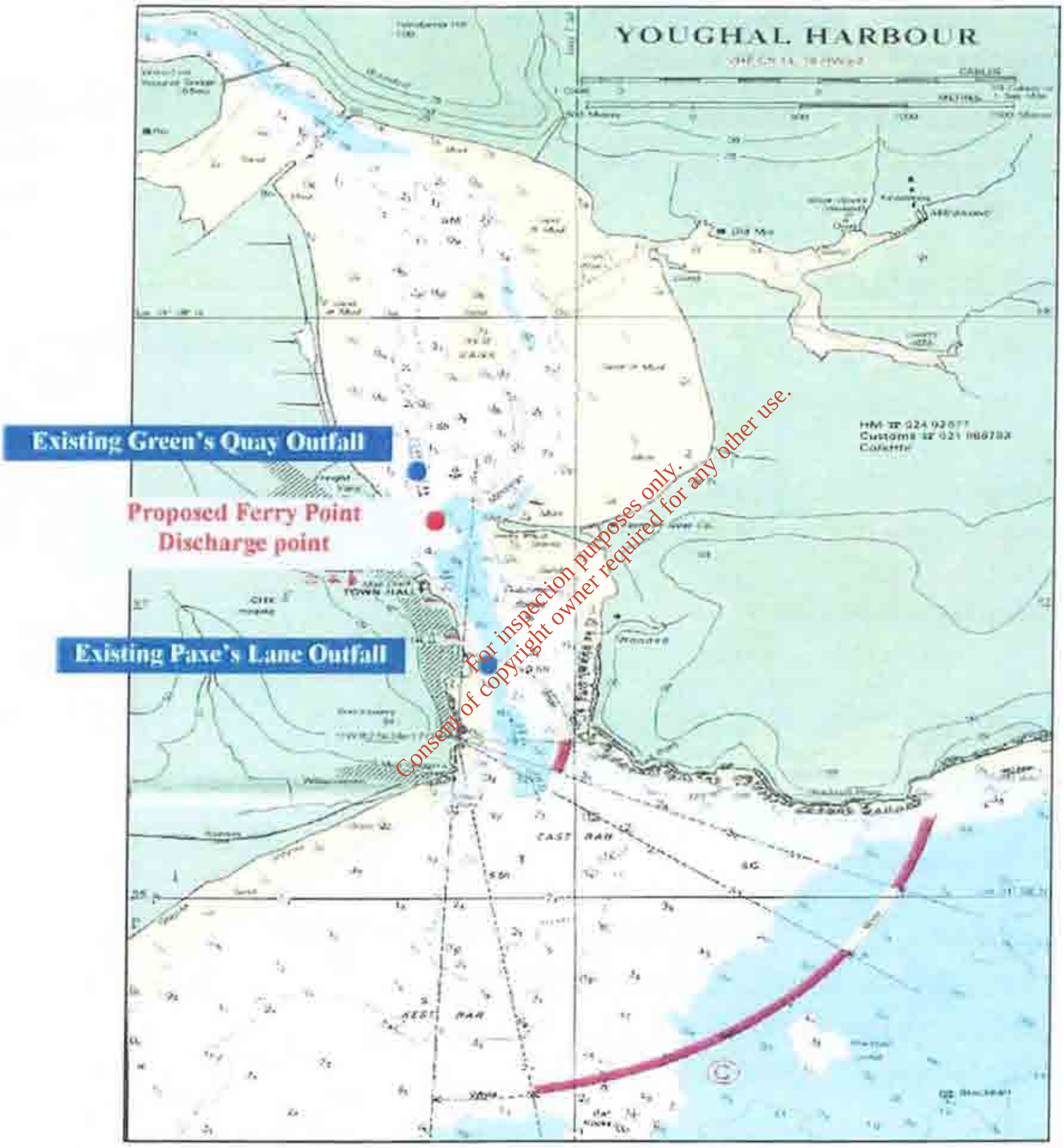
Dry Weather Flow = 20,000x225 litres/head/day = 0.052 m^3/s

Discharge = 1.5xDWF = 0.078 m^3/s

FC Concentration: 1E5 /100ml

**Assumed

Figure 6 – Current and Proposed Outfall Locations



Water Quality Standards

1.31 The current legislation sets standards for a range of water quality parameters. The critical water quality standards applicable to Youghal Harbour and Bay are those set down in the legislation relating to bathing and shellfish waters, which prescribe the required levels of faecal coliform bacteria.

Bathing Waters Regulations

1.32 Just outside the harbour along the western shoreline there is a large beach, known as Youghal Main Beach and Claycastle beach, which are designated bathing areas under the Bathing Water Regulations and at present enjoys Blue Flag. The bacteriological water quality standards relate to both the EU regulations which has a mandatory and guide standard and the National Limit Values which are mandatory. Blue Flag standards are a voluntary requirement. These ate summarised below;

Table 3 Summary Bathing Water Quality Standards

Total Coliforms No/100ml	≤5000 for ≥80% of samples ≤10,000 for ≥ 95% of samples	NLVs
Faecal Coliforms No/100ml	**≤1000 for ≥80% of samples ≤2,000 for ≥ 95% of samples**	**NLVs**
Total Coliforms No/100ml	≤500for≥80% of samples	Blue Flag
Faecal Coliforms No/100ml	**≤100 for≥80% of samples**	**Blue Flag**

Shellfish Waters Regulations

1.33 Youghal Harbour is not a designated shellfish area under the Shellfish Regulations (Quality of Shellfish Waters Regulations, S.I. 200 of 1994).

1.34 The Shellfish Production Directive concerns the laying down the health conditions for the production and the placing on the market of live bivalve molluscs (91/492/EEC). This was transposed into Irish law in 1996 Regulations (S.I. 147 of 1996) while areas were designated under subsequent Regulations. Under these regulations standards laying down health conditions for the production of bivalve molluscs, the Department of Marine and National Resources (DoMNR) were given authority to classify and monitor shellfish waters to ensure that the quality of the species is maintained or enhanced.

1.35 Under the DoMNR classification Youghal Bay (Knockadoon to Knockaverry) outside the estuary was designated as a Class B production area under the 2000 Regulations. However, it is no longer designated in the more recent Regulations (Live Bivalve Molluscs (Production Areas) Designation, 2001 (No. 1)).

1.36 The following table summarises the standards under the Regulations;

Table 4: Summary of scheme classification of shellfish production areas operated by the Department of the Marine and Natural Resources under 91/492/EEC

Classification	Faecal Coliforms/*E.coli* per gram of shellfish flesh[1]	Requirements
A	Less than 3/2.3[2]	None – sale for direct human consumption permitted
B	3/2.3 or greater with not more than 10% of samples exceeding 60/46	Purification at an approved plant for 48 hours prior to sale for human consumption[3]
C	Greater than 60/46 and not more than 600/460	Relaying for a period of at least 2 months in clean sea water prior to sale for human consumption[3]

[1]the first figure in the column must relates to faecal coliforms, the second to *E.coli*
[2]must not contain *Salmonella* in 25 grams of flesh
[3]scientifically proven cooking methods, approved by the Standing Veterinary Committee, may obviate the necessity for purification or relaying

1.37 Class B' shellfish production is the second strictest classification and requires the shellfish harvested in the area to be purified for 48 hours prior to sale for human consumption.

1.38 The standard for shellfish production areas relate to coliforms in the flesh of the shellfish. It is difficult to tranlslate this standard into water quality standards. However the DoMNR have adopted the Shellsan Classification System which relates directly to the faecal coliforms in the water in which the shellfish. The system classifies the shellfish into three categories:

1. Approved: No further purification necessary
2. Conditional: Purification necessary by relaying in uncontaminated seawater
3. Restricted: Pressure Cooking essential

The DoMNR's Shellsan classification system is set out in Table 5 below:

Table 5 – Summary of scheme classification of shellfish production areas operated by the Department of the Marine and Natural Resources under 91/492/EEC

Classification	Geometric Mean of FC /100ml	Compliance FC per 100ml
Approved	<14	90% <46
Conditional:	>14<140	90%<460
Restricted:	>140	>460

MATHEMATICAL MODEL

1.39 The model used in the analysis was the US EPA mixing zone modelling software known as CORMIX, which was developed at Cornell University and is widely used in industry in the analysis, prediction and design of pollutant discharges into diverse water bodies via single and multi-port outfalls.

Near Field Model

1.40 The major emphasis of the model is on predicting the geometry and dilution characteristics of the initial mixing zone (or near field), including compliance with regulatory constraints, but the system also predicts the behaviour of the discharge plume at larger distances.

1.41 Youghal Harbour can be suitably modelled with CORMIX provided that the downstream distance from the modelled outfall does not lead to a point that lies outside the estuary, i.e. south of East Point. Here the phasing of the tide and the cross flow will not accord with assumptions about the downstream flow inherent in CORMIX. For this reason, only the inner estuary was modelled, as described in the next chapter.

Discharge Characteristics and Tidal Reversal Options

1.42 CORMIX is suitable for discharges that are small compared to the ambient volumes of flow and where the discharge has no effect on the ambient flow. As with all mixing zone evaluations, the basic methodology relies on the assumption of steady ambient conditions. Even though the actual water body is never in a true steady state, this assumption is usually adequate since mixing processes are quite rapid relative to the time scale of hydrographic variations. In highly unsteady tidal reversing flows the assumption is no longer valid and significant concentration build-up can occur.

1.43 In the estuarine situation the rate reversal (time gradient of the tidal velocity) near the slack tides (i.e. at high water and low water) is of considerable importance for the concentration build up in the transient discharge plume, as tidal reversals will reduce the effective dilution of a discharge by re-entraining the discharge plume remaining from the previous tidal cycle. CORMIX can assess this situation and compute some re-entrainment effects on plume behaviour.

1.44 However, the tidal reversal option in CORMIX is limited and does not permit the input of detailed data on tidal currents. For this reason the tidal reversal option was avoided in favour of modelling the depth and width of the harbour at four distinct points on the tide, to take account of the time-varying depths and mudflat extent.

Model Schematisation, Stratification and Mixing

1.45 The model schematisation process requires that the actual cross-section of the water body be described as a rectangular straight uniform channel that may be bounded laterally or unbounded. The ambient velocity is assumed to be uniform within that cross-section.

1.46 The model allows for three generic types of ambient stratification profile to be used for the approximation of the actual vertical density distribution and can predict mixing for contaminants subject to both conservative and first-order decay processes.

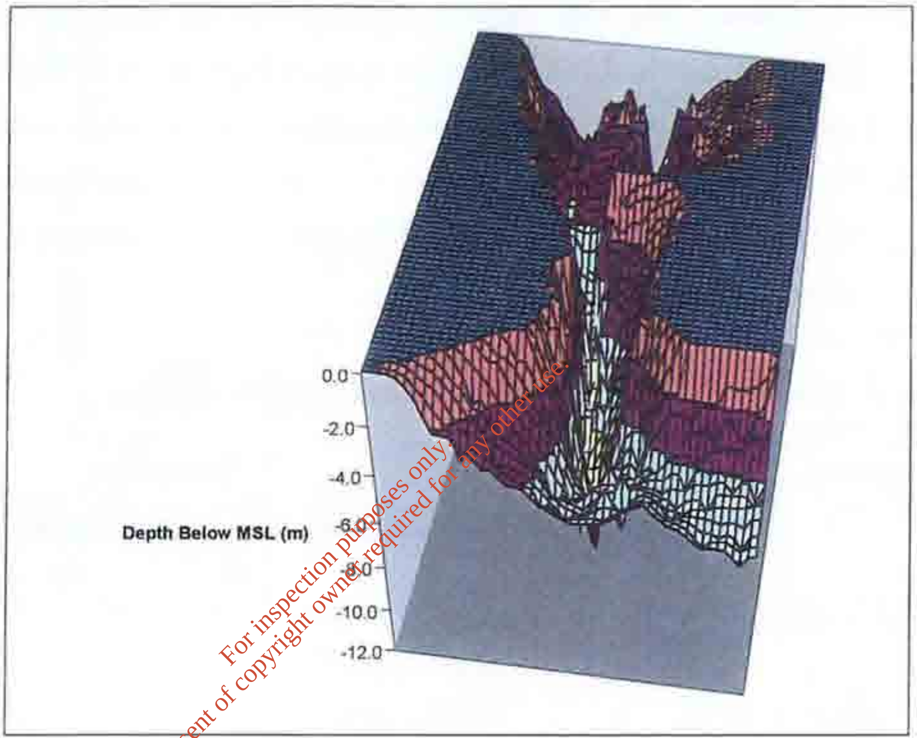
1.47 The discharge concentration of the material of interest is defined as the excess concentration above any ambient background concentration of that same material. CORMIX predicts the position of the jet/plume centreline within the receiving water, the dilution and concentration at the centreline and the jet width.

YOUGHAL HARBOUR MODEL

Physical & Hydrodynamic Model

1.48 To model the physical characteristics of the harbour, bathymetry data was taken from the Admiralty Chart and interpolated using a surface mapping software package. This was used to generate a grid of bathymetry values at a grid spacing of 50 metres. The resulting surface plot is shown in Figure 7, which shows the contours of depth below Mean Sea Level (MSL) in the harbour.

Figure 7 – Bathymetric Surface Plot of Youghal Harbour



1.49 The CORMIX schematisation procedure involves approximating the study area by means of a rectangular channel with a constant depth. The wetted volume at each cross section of the 50m grid was calculated and the volumes available for dilution were conserved in the rectangular schematisation of the natural channel.

1.50 Rather than use the limited tidal reversing option in CORMIX, the channel was schematised at four points on the tide – maximum flood velocity, high water slack, maximum ebb velocity and low water slack. For each point on the tide the volume available for dilution and hence the average rectangular depth and channel width were recalculated to reflect the varying water level and mud flat extent within the harbour.

1.51 Hydrodynamic data on both spring and neap tides were obtained from the tidal diamond included on the Admiralty Chart, which gives spring and neap speeds and directions at a point close to the Paxe's Lane outfall location. These conditions were assumed to be also applicable to the Green's Quay area of the harbour.

1.52 The current directions were assumed to reverse along the schematised estuary longitudinal axis, flowing upstream against the river on the flood and at high water and downstream towards the open sea on the ebb and at low water. Directions given for the tidal diamond show the flow to reverse along the longitudinal axis of the deep trench of the harbour. The current speeds and directions used for each point on the tide are given in Table 6.

Table 6 – Current Speeds and Directions used for Tidal Simulations

Point on Tide	Spring Tide		Neap Tide	
	Current Speed (m/s)	Current Direction	Current Speed (m/s)	Current Direction
Max Flood Velocity	1.3	flowing upstream, parallel to shore	0.7	flowing upstream, parallel to shore
High Water Slack	0.2	flowing upstream, parallel to shore	0.1	flowing upstream, parallel to shore
Max Ebb Velocity	1.5	flowing downstream, parallel to shore	0.8	flowing downstream, parallel to shore
Low Water Slack	0.2	flowing downstream, parallel to shore	0.1	flowing downstream, parallel to shore

1.53 For the upstream simulations, i.e. at maximum flood velocity and high water slack, the channel was modelled as highly irregular due to the sudden widening of the estuary north of Ferry Point (see Figure 5). For the downstream simulations, i.e. at maximum ebb velocity and low water slack, the channel was modelled as less irregular due to the relative uniformity of the downstream channel.

1.54 In all simulations the wind conditions were assumed to be calm at a speed of 2 m/s. These conditions were chosen to represent minimal additional mixing due to increased currents from surface wind shear. This ensures that the worst case scenario is modelled, particularly at slack water.

WATER QUALITY MODEL

1.55 For the analysis it was decided to model the dispersion and dilution of faecal coliform bacteria discharged in the effluent plume. The parameter was modelled as a conservative contaminant, i.e. with no decay, and was assumed to be present in concentrations of $1x10^7$ per 100ml for untreated effluent and $1.5x10^5$ for secondary treated effluent (see Table 2).

1.56 Typically, for faecal coliforms, 90% decay is assumed to occur within 24 hours. However, current research indicates that this is only true for coliforms in the water column and that, in practice, it is only representative of deposition via particle attachment. Thus, it does not account for the real time taken for coliforms to die off. It is therefore a safe approach to assume that there is no decay.

1.57 The predicted levels are over and above background level of faecal coliforms in the receiving water.

1.58 Since the estuary is well-mixed and likely to be only slightly influenced by upstream freshwater inflows, it was assumed that the water is not stratified in the study area. The density of the receiving water was taken to be that of sea water, i.e. 1022 kg/m^3, while the effluent density was taken as that for freshwater, i.e. 1000 kg/m^3. Thus, the modelled effluent plume was buoyant in the receiving water.

MODEL SIMULATIONS

1.59 A total of 24 model simulations were performed; 8 for each outfall which included 4 points on the tide for both spring and neap conditions. The model runs are listed below in Table 7 For each simulation the concentration of faecal coliforms along the centreline of the discharge plume was examined.

Table 7 – List of CORMIX Simulations Performed

No.	Outfall	Tide	Point on Tide
1	Green's Quay	Spring	Max Flood Velocity
2			High Water Slack
3			Max Ebb Velocity
4			Low Water Slack
5		Neap	Max Flood Velocity
6			High Water Slack
7			Max Ebb Velocity
8			Low Water Slack
9	Paxe's Lane	Spring	Max Flood Velocity
10			High Water Slack
11			Max Ebb Velocity
12			Low Water Slack
13		Neap	Max Flood Velocity
14			High Water Slack
15			Max Ebb Velocity
16			Low Water Slack
17	Ferry Point	Spring	Max Flood Velocity
18			High Water Slack
19			Max Ebb Velocity
20			Low Water Slack
21		Neap	Max Flood Velocity
22			High Water Slack
23			Max Ebb Velocity
24			Low Water Slack

MODEL RESULTS

Introduction

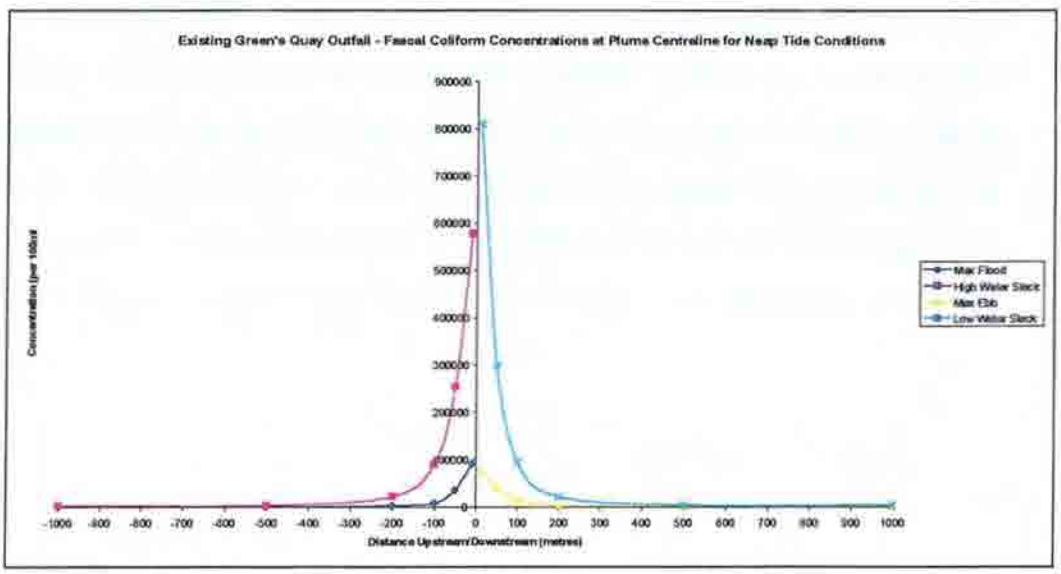
1.60 The results of the model simulations are contained in Tables 8.1 to 8.9. Tables 8.1, 8.4 and 8.7 contain the geometry of the schematised channels used in the simulations. In all cases the schematised local depth at the outfall was specified as close as possible to the actual depth but was subject to the CORMIX restriction of within 30% of the schematised average depth of the rectangular channel.

1.61 The computed faecal coliform concentrations at the plume centreline are given at distances of 10m, 50m, 100m, 200m, 500m and 1000m upstream and downstream on the flood and ebb tides respectively. In all three cases the plume centreline faecal coliform concentrations within 200m of the outfalls were higher for neap tide currents due to the slower current speeds restricting the level of dispersion of the plume. The highest concentrations were computed at the high and low water slack times, again as a result of weak current speeds restricting dispersion.

Results

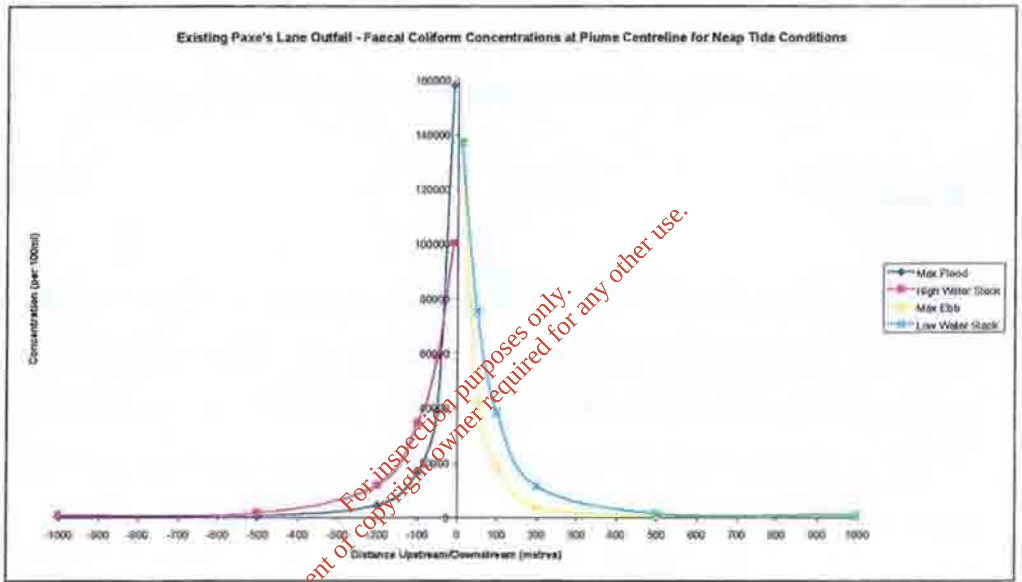
1.62 For the existing Green's Quay outfall, during periods of slack currents on the neap tide, the maximum computed concentrations of faecal coliforms in the plume centreline vary from 809,580 per 100ml within 10m of the outfall to 3,650 per 100ml at a distance of 1000m downstream. Figure 8.1 shows a plot of the computed centreline concentrations at the four points on the neap tide.

Figure 8.1 - Results of CORMIX Simulations for Existing Green's Quay Outfall



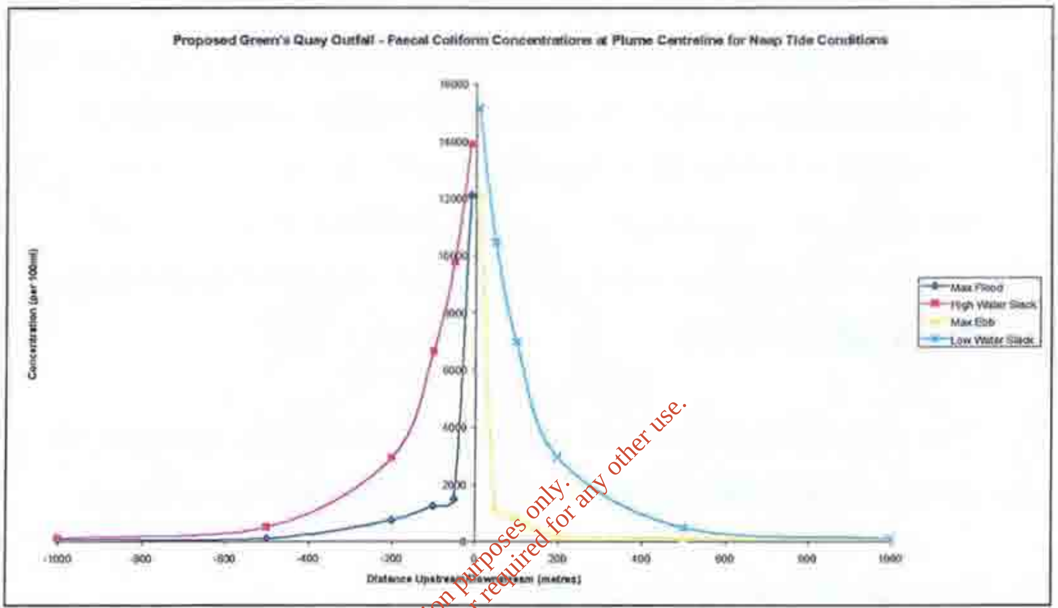
1.63 For the existing Paxe's Lane outfall, during periods of slack currents on the neap tide, the maximum computed concentrations of faecal coliforms in the plume centreline vary from 136,990 per 100ml within 10m of the outfall to 1,190 per 100ml at a distance of 1000m downstream. Figure 8.2 shows a plot of the computed centreline concentrations at the four points on the neap tide.

Figure 8.2 - Results of CORMIX Simulations for Existing Paxe's Lane Outfall



1.64 When the proposed secondary treatment scenario is modelled, the computed concentrations are greatly reduced. For the proposed Ferry Point outfall, during periods of slack currents on the neap tide, the maximum computed concentrations of faecal coliforms in the plume centreline vary from 15,160 per 100ml within 10m of the outfall to 100 per 100ml at a distance of 1000m downstream. Figure 8.3 shows a plot of the computed centreline concentrations at the four points on the neap tide.

Figure 8.3 - Results of CORMIX Simulations for Proposed Ferry Point Outfall



1.65 Details of these initial model results are given in Appendix 1 for existing and proposed outfalls.

SUPPLEMENTARY ESTUARY MODELLING

Introduction

1.66 The initial modelling of the estuarine discharge which was based on desk data available from the Admiralty charts and tidal diamonds. Field data was gathered subsequently during April to June of 2001 to verify the initial assumptions on bathymety and tidal currents. Drogue and dye tests were also undertaken to confirm the dispersion Characteristics of the Estuary. Details of these field studies are given in Appendix D Part A.

1.67 The section summarises and appraises the field data collected and presents the results of additional CORMIX model runs undertaken using this data.

Additional Field Data Collected

1.68 The additional data collected during the period from April to June 2001 comprised the following:

- Depth soundings along longitudinal and lateral transects taken across the inner harbour during June 2001.
- Results of dye release and tracking exercises undertaken on the following dates:
    - 25/04/01 – released at low water on spring tide
    - 26/04/01 – released at high water on spring tide
    - 03/05/01 – released at high water on neap tide
    - 04/05/01 – released at low water on neap tide
- Results of drogue release and tracking exercises undertaken on the following dates:

- 01/05/01 – released at high water on neap tide
- 024/05/01 – released at low water on neap tide

- Current speed and direction, salinity and temperature measurements taken at bottom, mid-depth and surface on the following dates:

  - 06/06/01 – spring tide measurements at Site A (near proposed outfall location)
  - 06/06/01 – spring tide measurements at Site B (near Existing Paxe's Lane outfall)
  - 13/06/01 – neap tide measurements at Site A

- Wind speed and direction measurements for 06 and 13/06/01

ANALYSIS OF ADDITIONAL FIELD DATA

Bathymetry

1.69 The new bathymetry data was analysed by interpolation of the spot depths using a surface mapping software package. This was used to generate a grid of bathymetry values at a grid spacing of 100 metres. The resulting surface plot is shown in Figure 9, which shows the contours of depth below Lowest Astronomical Tide (LAT) in the harbour. This was then compared with the bathymetry used in the original CORMIX model of the harbour, the grid for which is shown below in Figure 10.

1.70 As can be seen from the figures, the original bathymetric grid is more detailed. This is due to the larger number of depth values input from the Admiralty Chart and the finer grid spacing of 50m. The new bathymetric grid is coarser due to a significantly lesser number of points and the uniform positioning of the depth values, i.e. along straight line transects across the harbour rather than at random points as on the Admiralty Chart.

1.71 Although the grids differ in resolution and orientation it can be seen that the general shape of the contours is very similar and the depths within the main trench correspond quite closely. Thus, it is concluded that the bathymetry of the harbour has not changed significantly since the depths given on the Admiralty Chart were recorded and the original model schematisation is valid and does not require updating

Figure 9 100m Bathymetric Grid generated from New Bathymetry Data

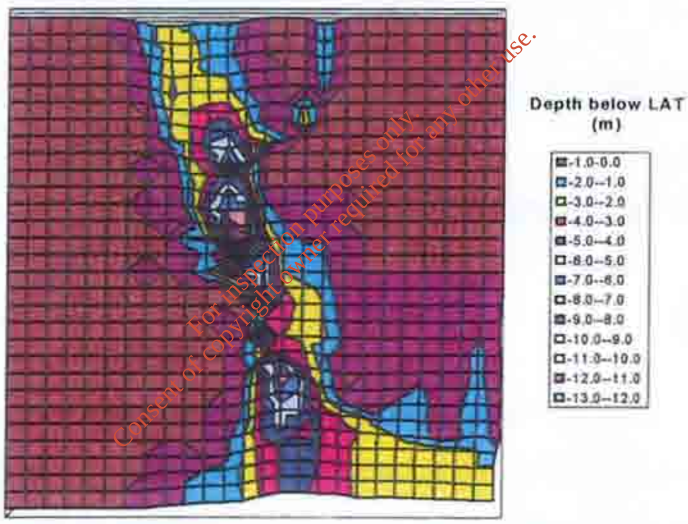
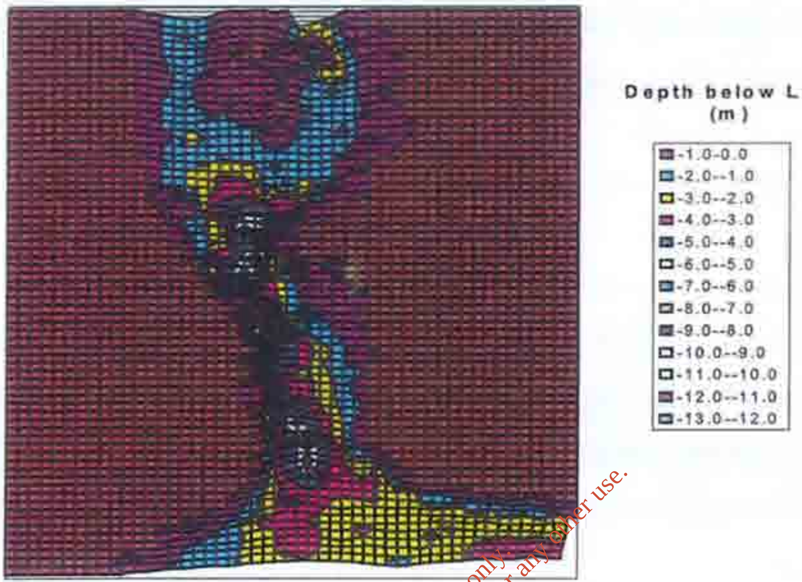


Figure 10 50m Bathymetric Grid used in Original Model



Dye and Drogue Surveys

1.72 The results of the dye and drogue tracking exercises are detailed in a Appendix D Part A. In summary, the findings of the surveys were as follows:

- The general trend for the dye was as expected; north for the flood and south for the ebb tide, with some variation during slack periods.
- The drogue study also indicated a rectilinear current regime.
- Weather conditions would have an impact on dispersion and dilution of an effluent plume and a large freshwater input may cause some stratification resulting in density differences through the water column and impeding mixing. However, very little stratification was observed during the course of the surveys.
- The surveys indicated that the dilution and dispersion characteristics of the estuary are good.

1.73 Thus, the survey results were found to verify the initial assumptions made when setting up the original model, i.e. that the flow in the estuary is more or less laterally contained, with the flow being approximately rectilinear. The original model is therefore considered to be sufficiently accurate and reliable within the constraints of the modelling package used.

Current Measurements

1.74 The current measurements at Site A near the proposed outfall off Ferry Point provided a good data set for both the spring and neap tides. No measurements were available for Site B near the existing Paxe's Lane outfall for the neap tide and the spring tide measurements for Site B were poor, being disrupted after approximately 2 hours. Plots of the current speeds and directions for both sites are given in Figures 11 to 16.

Figure 11

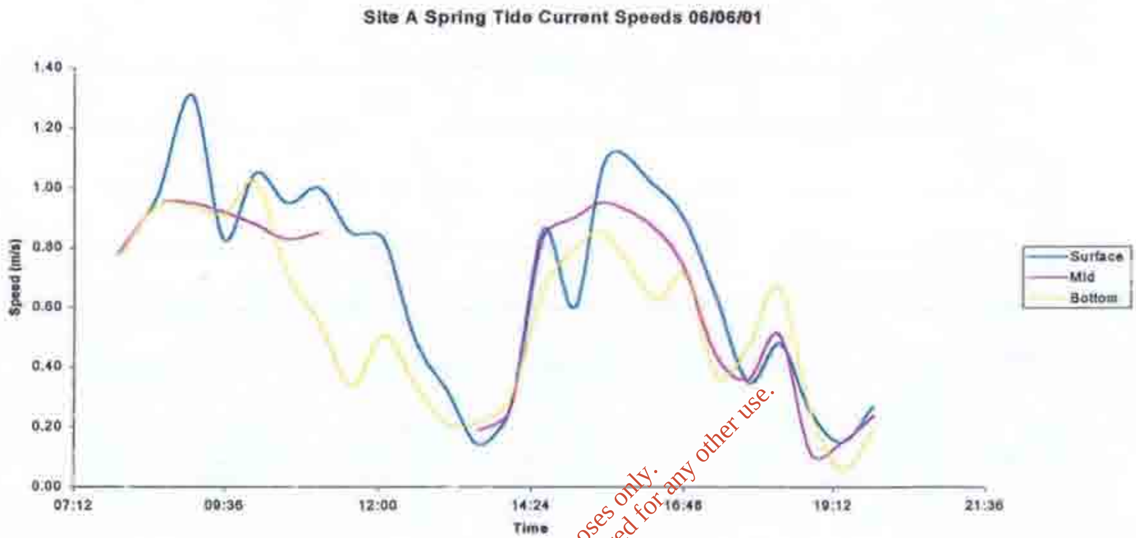


Figure 12

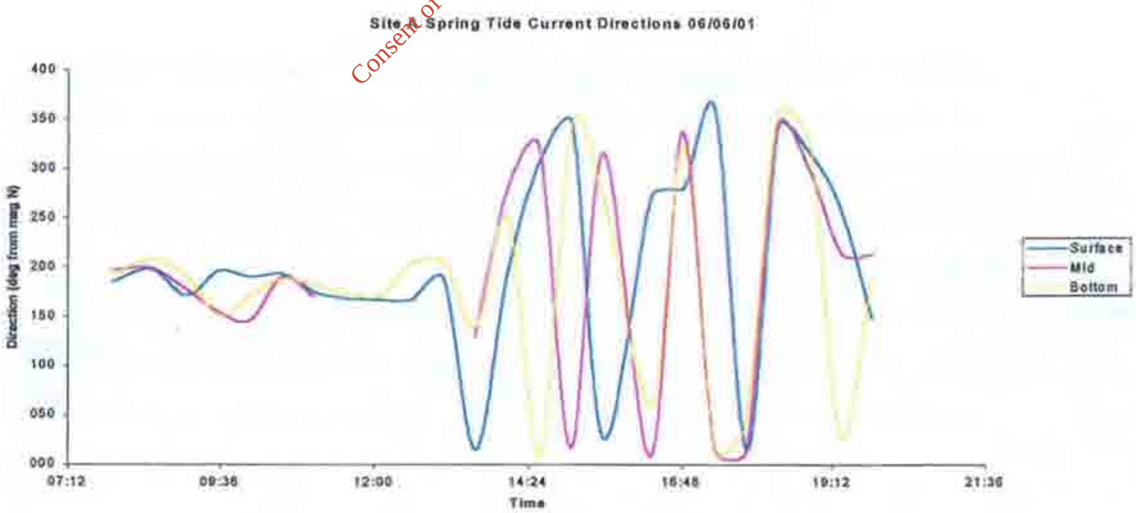


Figure 13

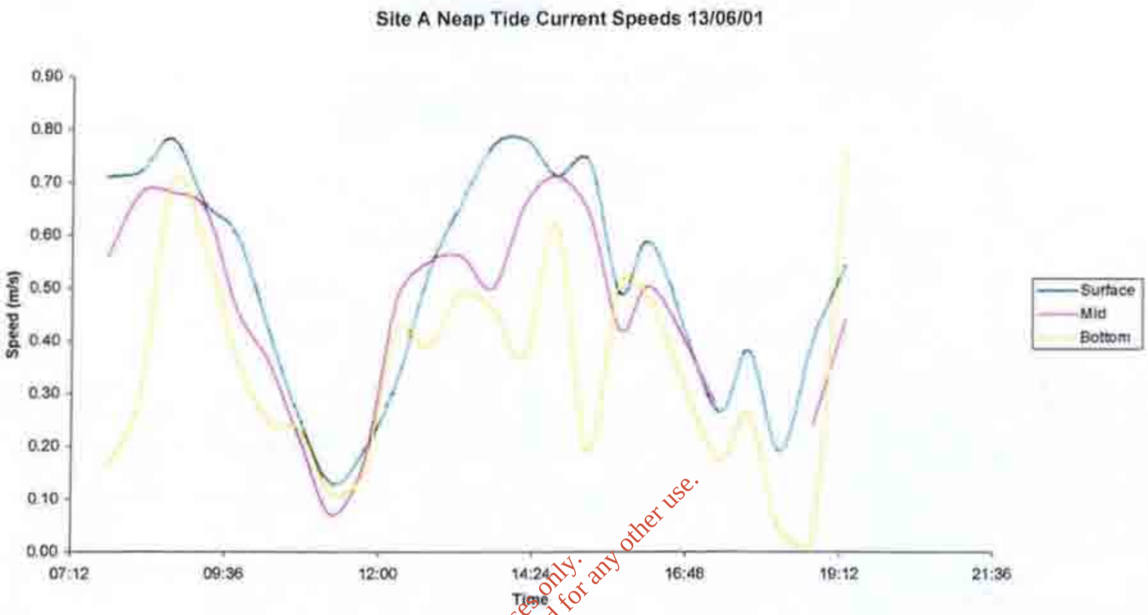


Figure 14

Figure 15

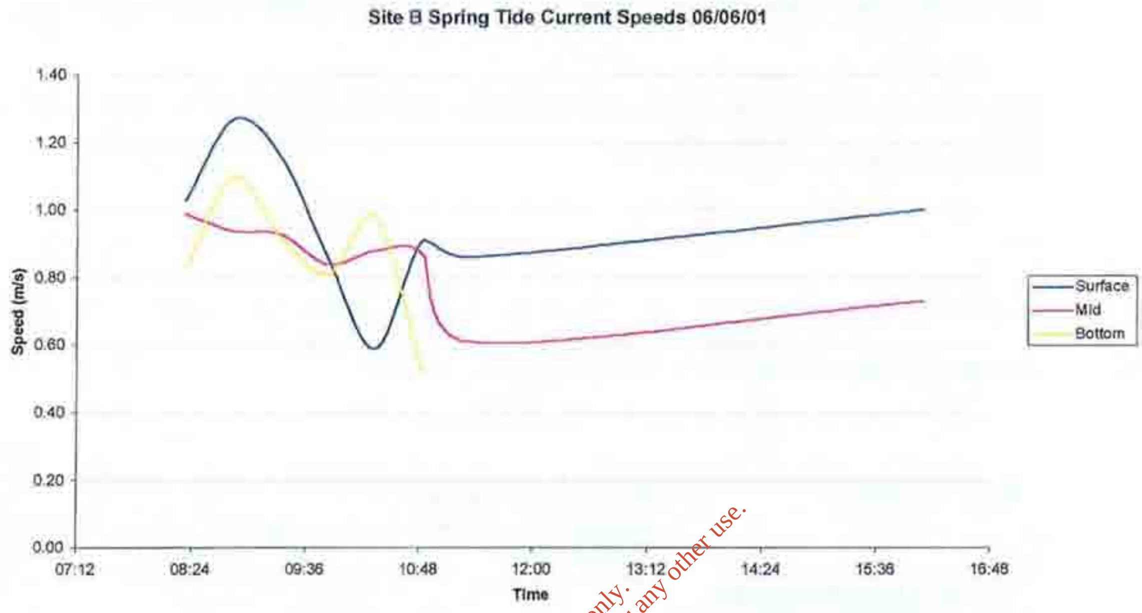
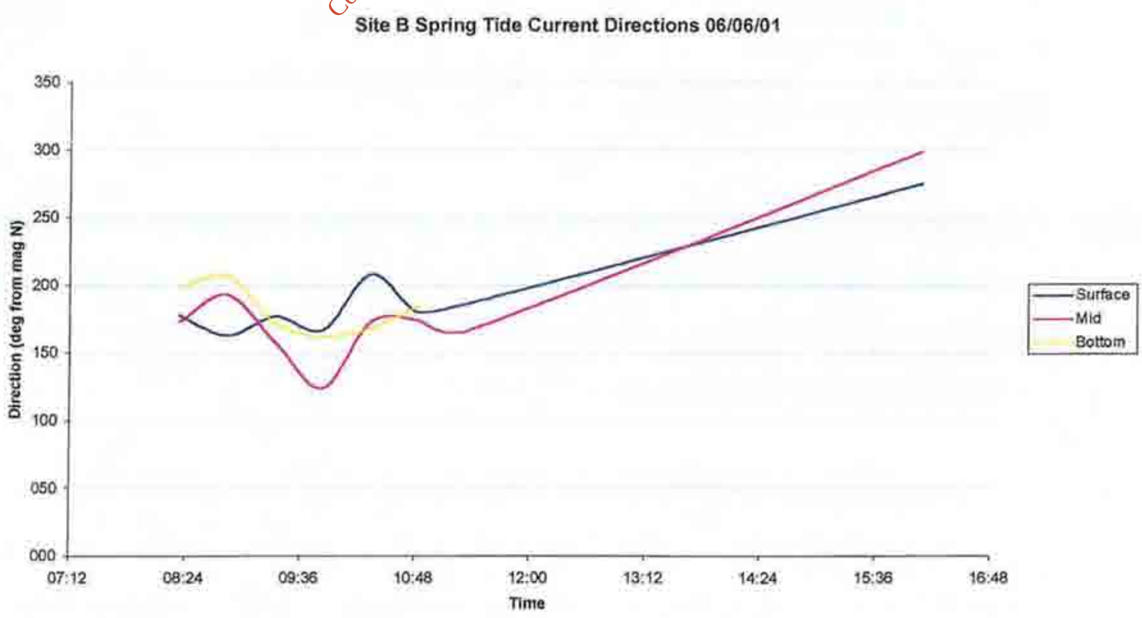


Figure 16



1.75 The current measurements for Site A show that the velocities are reasonably constant over the depth, particularly in the surface and mid regions, indicating that the water column is well mixed and not significantly stratified at this point.

1.76 The magnitudes of the measured velocities are compared with those used in the original model in Table 8 below.

Table 8: Comparison of Current Speeds used in Original Model with Measured Data at Site A (near proposed outfall)

Tide	Time	Current Speeds (m/s)		
		Original Model*	Measured Data 2001	Difference
Spring	Low Water Slack	0.20	0.14	+0.06
	Max Ebb	1.50	0.95	+0.55
	High Water Slack	0.20	0.11	+0.09
	Max Flood	1.30	0.95	+0.35
Neap	Low Water Slack	0.10	0.19	-0.09
	Max Ebb	0.80	0.71	+0.09
	High Water Slack	0.10	0.07	+0.03
	Max Flood	0.70	0.68	+0.02

*Data obtained from Admiralty Chart

1.77 The current speeds used in the original model, which are average values obtained from the Admiralty Chart, agree quite well with the measured data except at maximum flood and ebb on the spring tide. At these times the original model values exceed the measured data by up to 0.55 m/s.

1.78 The direction measurements for the spring tide display high fluctuation which were due to extremely strong winds of up to 11.5 m/s on the day of recording. Thus, the presence of strong winds can significantly disrupt the general rectilinear flow pattern within the harbour and can cause fluctuating directions throughout the water column. However, wind speeds of this magnitude can be considered to be relatively rare.

ADDITIONAL MODELLING RUNS

Introduction

1.79 Additional modelling runs using the original CORMIX model were performed using the measured current and wind speeds as new input data. Since the current measurements at Site B were inconclusive only Site A, i.e. the site of the proposed outfall, was subject to further modelling analysis.

1.80 A total of 16 additional runs were undertaken, using the original model schematisation of the bathymetry, physical and outfall parameters but with the observed current and wind speeds for both neap and spring tides. Two treatment scenarios were modelled using these observed conditions; secondary treatment only (discharge faecal coliform concentration of 150,000 per 100ml) and secondary treatment with disinfection (discharge faecal coliform concentration of 1,000 per 100 ml). Table 9 outlines the additional runs performed and the new current and wind speed data input.

Table 9 Details of Additional Modelling Runs Undertaken

Run No.	Tide	Time	Current Speed (m/s)	Wind Speed (m/s)
Secondary Treatment Only				
1	Spring	Max Flood Velocity	0.95	8.90
2		High Water Slack	0.11	6.00
3		Max Ebb Velocity	0.95	3.50
4		Low Water Slack	0.14	3.50
5	Neap	Max Flood Velocity	0.68	2.20
6		High Water Slack	0.07	0.00
7		Max Ebb Velocity	0.71	3.50
8		Low Water Slack	0.19	2.30
Secondary Treatment with Disinfection				
9	Spring	Max Flood Velocity	0.95	8.90
10		High Water Slack	0.11	6.00
11		Max Ebb Velocity	0.95	3.50
12		Low Water Slack	0.14	3.50
13	Neap	Max Flood Velocity	0.68	2.20
14		High Water Slack	0.07	0.00
15		Max Ebb Velocity	0.71	3.50
16		Low Water Slack	0.19	2.30

RESULTS OF ADDITIONAL MODELLING RUNS

1.81 The results of the additional runs undertaken are displayed in Figures 17 to 20 and Appendix A (Tables 10 to 17). Figures 17 to 20 show plots of the computed centreline concentrations at four points on the spring and neap tides for both treatment scenarios.

Secondary Treatment Only

1.82 Using the observed conditions at low water slack on the **spring tide** of 06/06/01, the model computed maximum concentrations of faecal coliforms in the plume centreline (Table 10) of 13,550 per 100ml within 10m of the outfall to 70 per 100ml at a distance of 1750m downstream at the mouth of the estuary. These values are of the same order but significantly higher than those computed in the original analysis which varied from 8,900 to 100 per 100ml. This is due to the lower current speeds used in the more recent analysis.

1.83 For these spring tide runs the very high wind speeds observed at max flood and high water slack did not result in better dispersion and dilution as might be expected. This was due to the corresponding lower current speeds used, which were up to 0.55 m/s less than those used in the original runs. For all runs lower current speeds resulted in higher computed concentrations.

1.84 Using the observed conditions at low water slack on the **neap tide** of 13/06/01, the model computed maximum concentrations of faecal coliforms in the plume centreline of 8,265 per 100ml within 10m of the outfall to 75 per 100ml at a distance of 1750m downstream at the mouth of the estuary . These values are significantly lower than those computed in the original analysis which varied from 15,160 to 100 per 100ml. This is due to the higher current and wind speeds used in the more recent analysis.

1.85 For the neap tide runs the highest concentrations were actually computed at high water slack due to the very low current speed of 0.07 m/s and zero wind speed. In this case the computed maximum concentrations in the plume centreline varied from 16,430 per 100ml within 10m of the outfall to 230 per 100ml at a distance of 1000m upstream. This confirms the importance of the ambient current speed in diluting the plume, i.e. very low current speeds combined with low wind speeds will result in higher concentrations remote from the outfall regardless of the depth of water available for dilution.

1.86 These values indicate that the beaches outside the harbour are not threatened by the discharge and Blue Flag status standards are achieved i.e, <100 FC/100ml.

1.87 The Shellsan standards for Shellfish are also obviously achieved outside the estuary in the previously designated area. They are also achieved within the estuary within 1000m up and down stream of the outfall discharge point.

Secondary Treatment with Disinfection

1.88 The results of the secondary treatment with disinfection scenario are given in Tables 12 and 13. This level of treatment greatly reduces the faecal coliform concentration in the discharged plume and hence in the receiving waters. The tables show that the coliform concentration is reduced to below 100 per 100ml within 10 metres of the outfall and fall to negligible levels at further distances.

Figure 17

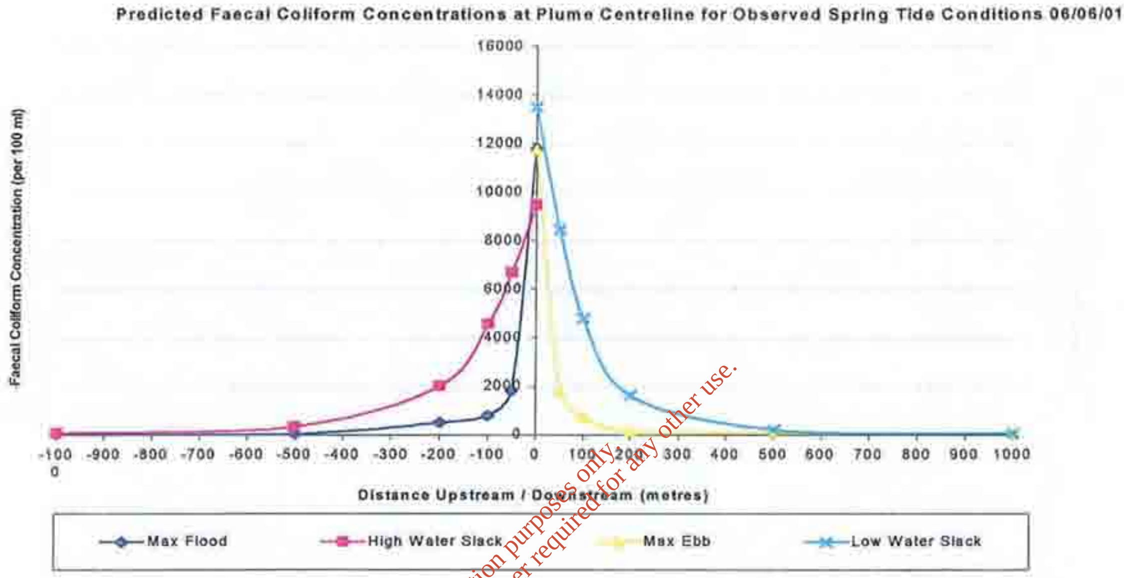


Figure 18

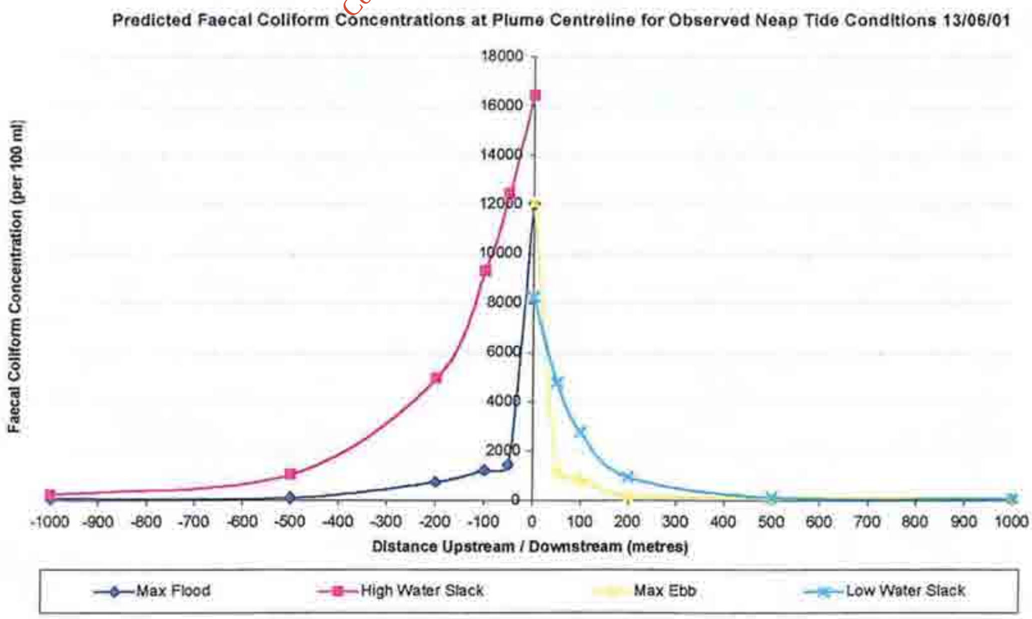


Figure 19

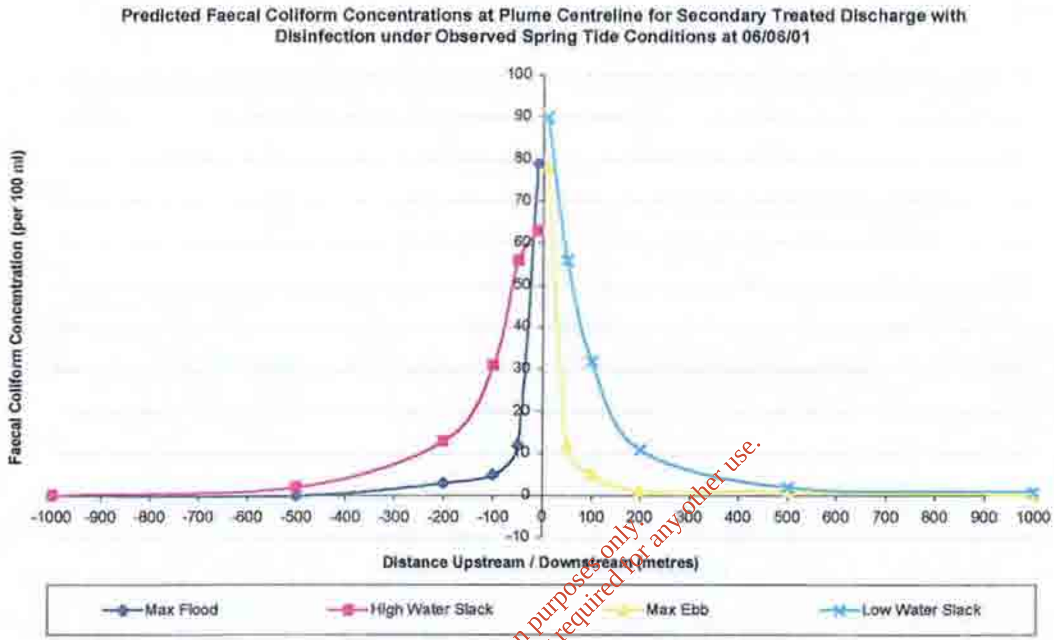
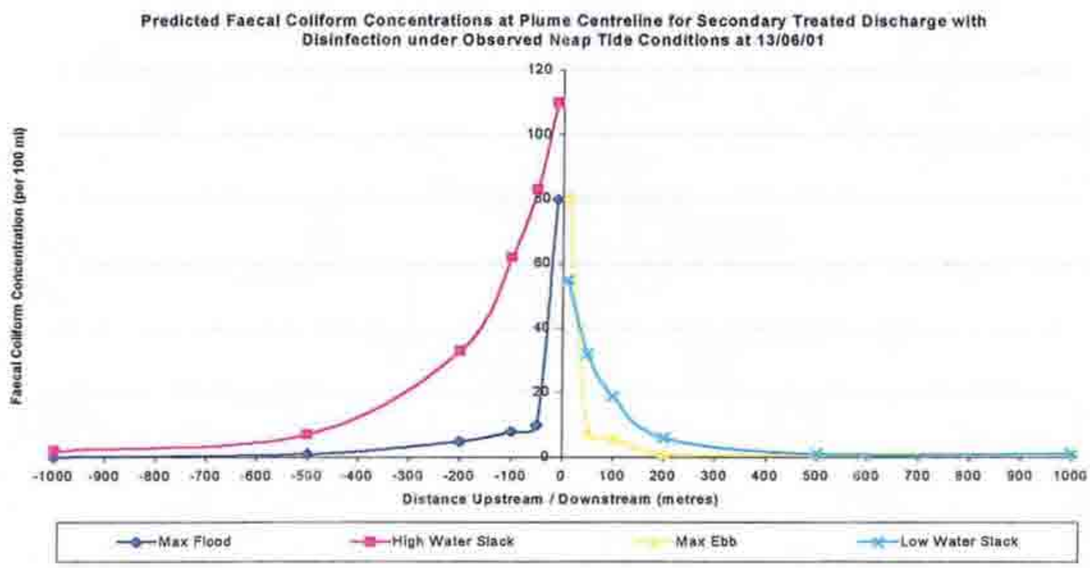


Figure 20



Bacteriological Decay Estimates

1.89 Bacteria decay over time in the water column. CORMIX does not account for the decay of bacteria in the water column as it is only a dilution based model so the results above are regarded as conservative.. However an estimate can be made for the die off of bacteria using the first order equation

$$C= C_0 Exp(-kT/T_n)$$

1.90 Based on an assumed T_{90} of 12 hours the bacteria die off factor over a three hour period is 0.562. **3 hours** is the approximate amount of time conditions at each point of the tide prevails e.g. high water slack conditions are assumed in the model to be about 3 hours. This will have an obvious impact on the concentrations and these are reported in Tables 14 to 17 for neap and spring tide conditions with reductions of over 50% in concentrations.

1.91 Caution needs to applied to the issue of decay of bacteria in the seawater. While the bacteria do die off in the water column they can also attach themselves to particles in the water column and settle. Once attached to the bed sediments they can survive for considerable periods of time. If the sediment is resuspended then the water column concentrations can increase again.

CONCLUSIONS

1.92 The analysis indicates the following with respect to to modelling:

- The bathymetry of the harbour has not changed significantly since the Admiralty Chart soundings were taken.
- The harbour is well-mixed and has good dilution and dispersion characteristics, although a large fresh water input may cause significant stratification of the harbour and reduce the dispersion and dilution potential.

- Extremely high wind speeds can disrupt the general rectilinear current pattern of the harbour.
- The model results confirm the importance of current speed on dispersion and dilution of the plume.
- Low current speeds at slack tides combined with low wind speeds will result in the highest concentrations regardless of the depth of water available for dilution.
- The conclusions arrived at in the original modelling report are valid and are substantiated by the recent field data.

1.93 The CORMIX modelling system has been applied to Youghal Harbour to examine the effect of a new outfall discharge on short-term faecal coliform concentrations at critical times on the tidal cycle. The model has been carefully applied and the assumptions needed to apply the model are reasonable. The results can therefore be considered reliable.

1.94 From the model results it is concluded that the proposed new discharge will improve bacteriological water quality in the harbour. The large reduction in the effluent concentration of faecal coliforms afforded by secondary treatment (without disinfection) will lower significantly the concentrations occurring in the harbour at the design population equivalent of 20,000.

1.95 The computed concentrations for the proposed new outfall at Ferry Point fall below the Bathing Waters Directive guide value of 100 per 100ml at a distance of 1750m downstream at the estuary mouth. Since the Blue Flag beach is located outside the estuary, the new discharge situation will not adversely affect the Blue Flag status of the beach.

1.96 The Shellfish production (Shellsan) Conditional Classification water quality standards for the previously designated area in Youghal Bay outside the estuary (Knockadoon to Knockaverry)

1.97 The model is based on dilutions and by applying a first order decay rate for the coliform concentrations with a T_{90} of 12 hours the bacteria levels can reduce by another 50% based on a three hour time to reach the harbour mouth.on a flood spring tide.

1.98 For a secondary treated effluent with disinfection the coliform concentrations are greatly reduced and do not exceed 100 per 100ml within 10 metres of the outfall.

APPENDIX 1 WATER QUALITY M ODELLING RESULTS -

Green's Quay Outfall Simulation Results

Table 1 - Channel Schematisations for Green's Quay Outfall Simulations

Direction	Point on Tide	SPRING TIDE				NEAP TIDE			
		Schematised Width of Channel (m)	Schematised Depth of Channel (m)	Schematised Local Depth at Outfall (m)	Actual Local Depth at Outfall (m)	Schematised Width of Channel (m)	Schematised Depth of Channel (m)	Schematised Local Depth at Outfall (m)	Actual Local Depth at Outfall (m)
Upstream	Max Flood	1475.2	3.8	2.8	3.1	1475.3	3.3	2.6	2.6
	High Water Slack	1475.2	4.7	4.0	4.0	1475.2	3.8	3.1	3.1
Downstream	Max Ebb	675.6	3.6	2.6	1.2	770.1	3.6	2.6	1.7
	Low Water Slack	565.1	3.3	2.4	0.3	675.1	3.6	2.6	1.2

Table 2 - Results of Spring Tide Simulations for Green's Quay Outfall

Point on Tide	FAECAL COLIFORM CONCENTRATIONS AT PLUME CENTRELINE ON SPRING TIDE (per 100ml)											
	UPSTREAM						DOWNSTREAM					
	1000m	500m	200m	100m	50m	10m	10m	50m	100m	200m	500m	1000m
Max Flood	980	1,380	2,980	9,690	29,820	45,930	-	-	-	-	-	-
High Water Slack	2,200	2,790	6,340	18,380	33,640	171,220	-	-	-	-	-	-
Max Ebb	-	-	-	-	-	-	41,190	36,130	10,660	2,190	1,340	940
Low Water Slack	-	-	-	-	-	-	172,390	48,590	20,520	7,660	4,620	3,740

Table 3 - Results of Neap Tide Simulations for Green's Quay Outfall

Point on Tide	FAECAL COLIFORM CONCENTRATIONS AT PLUME CENTRELINE ON NEAP TIDE (per 100ml)											
	UPSTREAM						DOWNSTREAM					
	1000m	500m	200m	100m	50m	10m	10m	50m	100m	200m	500m	1000m
Max Flood	900	1,300	2,270	7,520	35,670	90,100	-	-	-	-	-	-
High Water Slack	2,970	3,120	21,920	90,130	253,280	577,600	-	-	-	-	-	-
Max Ebb	-	-	-	-	-	-	78,800	42,250	15,000	2,670	1,500	1,030
Low Water Slack	-	-	-	-	-	-	809,580	297,950	94,710	21,850	3,680	3,650

Paxe's Lane Outfall Simulation Results

Table 4 - Channel Schematisations for Paxe's Lane Outfall Simulations

Direction	Point on Tide	SPRING TIDE				NEAP TIDE			
		Schematised Width of Channel (m)	Schematised Depth of Channel (m)	Schematised Local Depth at Outfall (m)	Actual Local Depth at Outfall (m)	Schematised Width of Channel (m)	Schematised Depth of Channel (m)	Schematised Local Depth at Outfall (m)	Actual Local Depth at Outfall (m)
Upstream	Max Flood	835.0	4.4	5.7	11.3	835.0	3.9	5.0	10.8
	High Water Slack	835.0	5.3	6.8	12.2	835.0	4.4	5.7	11.3
Downstream	Max Ebb	570.0	3.7	4.8	9.4	600.0	4.0	5.1	9.9
	Low Water Slack	515.0	3.1	4.0	8.5	570.0	3.7	4.8	9.4

Table 5 - Results of Spring Tide Simulations for Paxe's Lane Outfall

Point on Tide	FAECAL COLIFORM CONCENTRATIONS AT PLUME CENTRELINE ON SPRING TIDE (per 100ml)											
	UPSTREAM						DOWNSTREAM					
	1000m	500m	200m	100m	50m	10m	10m	50m	100m	200m	500m	1000m
Max Flood	230	350	590	35,630	60,930	81,170	-	-	-	-	-	-
High Water Slack	850	1,240	4,640	9,460	15,310	136,510	-	-	-	-	-	-
Max Ebb	-	-	-	-	-	-	68,830	43,230	11,230	650	360	250
Low Water Slack	-	-	-	-	-	-	136,690	26,340	11,470	5,050	3,310	2,400

Table 6 - Results of Neap Tide Simulations for Paxe's Lane Outfall

Point on Tide	FAECAL COLIFORM CONCENTRATIONS AT PLUME CENTRELINE ON NEAP TIDE (per 100ml)											
	UPSTREAM						DOWNSTREAM					
	1000m	500m	200m	100m	50m	10m	10m	50m	100m	200m	500m	1000m
Max Flood	380	580	4,500	16,460	38,710	158,000	-	-	-	-	-	-
High Water Slack	860	1,670	11,760	34,120	58,570	100,180	-	-	-	-	-	-
Max Ebb	-	-	-	-	-	-	138,000	42,310	18,480	4,110	710	460
Low Water Slack	-	-	-	-	-	-	136,990	75,170	38,400	11,600	1,550	1,190

PROPOSED FERRY POINT OUTFALL SIMULATION RESULTS

Table 7 - Channel Schematisations for Proposed Ferry Point Outfall Simulations

Direction	Point on Tide	SPRING TIDE				NEAP TIDE			
		Schematised Width of Channel (m)	Schematised Depth of Channel (m)	Schematised Local Depth at Outfall (m)	Actual Local Depth at Outfall (m)	Schematised Width of Channel (m)	Schematised Depth of Channel (m)	Schematised Local Depth at Outfall (m)	Actual Local Depth at Outfall (m)
Upstream	Max Flood	1475.2	3.8	4.9	9.3	1475.3	3.3	4.2	8.8
	High Water Slack	1475.2	4.7	6.1	10.2	1475.2	3.8	4.9	9.3
Downstream	Max Ebb	675.6	3.6	4.6	7.4	770.1	3.6	4.6	7.9
	Low Water Slack	565.1	3.3	4.2	6.5	675.1	3.6	4.6	7.4

Table 8 - Results of Spring Tide Simulations for Proposed Ferry Point Outfall

Point on Tide	FAECAL COLIFORM CONCENTRATIONS AT PLUME CENTRELINE ON SPRING TIDE (per 100ml)											
	UPSTREAM						DOWNSTREAM					
	1000m	500m	200m	100m	50m	10m	10m	50m	100m	200m	500m	1000m
Max Flood	30	50	450	660	2,330	9,010	-	-	-	-	-	-
High Water Slack	50	140	870	2,080	3,130	5,040	-	-	-	-	-	-
Max Ebb	-	-	-	-	-	-	7,810	2,560	1,120	260	60	40
Low Water Slack	-	-	-	-	-	-	8,900	5,050	2,720	870	120	100

Table 9 - Results of Neap Tide Simulations for Proposed Ferry Point Outfall

Point on Tide	FAECAL COLIFORM CONCENTRATIONS AT PLUME CENTRELINE ON NEAP TIDE (per 100ml)											
	UPSTREAM						DOWNSTREAM					
	1000m	500m	200m	100m	50m	10m	10m	50m	100m	200m	500m	1000m
Max Flood	70	110	750	1,240	1,480	12,100	-	-	-	-	-	-
High Water Slack	110	500	2,930	6,630	9,760	13,870	-	-	-	-	-	-
Max Ebb	-	-	-	-	-	-	12,110	1,160	830	190	110	80
Low Water Slack	-	-	-	-	-	-	15,160	10,470	6,980	2,960	490	100

SUPPLEMENTARY MODELLING RESULTS

Table 10 – Revised Results (based on Field Data)of Spring Tide Simulations for Secondary Treated Discharge from Proposed Ferry Point Outfall

Point on Tide	FAECAL COLIFORM CONCENTRATIONS AT PLUME CENTRELINE ON SPRING TIDE (per 100ml)												
	UPSTREAM						DOWNSTREAM						
	1000m	500m	200m	100m	50m	10m	10m	50m	100m	200m	500m	1000m	1750m
Max Flood	45	65	515	805	1,850	11,800	-	-	-	-	-	-	-
High Water Slack	75	345	2,025	4,585	6,695	9,485	-	-	-	-	-	-	-
Max Ebb	-	-	-	-	-	-	11,755	1,850	730	165	95	65	50
Low Water Slack	-	-	-	-	-	-	13,550	8,465	4,820	1,650	240	75	70

Table 11 – – Revised Results (based on Field Data)of Neap Tide Simulations for Secondary Treated Discharge from Proposed Ferry Point Outfall

Point on Tide	FAECAL COLIFORM CONCENTRATIONS AT PLUME CENTRELINE ON NEAP TIDE (per 100ml)												
	UPSTREAM						DOWNSTREAM						
	1000m	500m	200m	100m	50m	10m	10m	50m	100m	200m	500m	1000m	1750m
Max Flood	70	110	750	1,230	1,470	12,010	-	-	-	-	-	-	-
High Water Slack	230	1,045	4,950	9,300	12,440	16,430	-	-	-	-	-	-	-
Max Ebb	-	-	-	-	-	-	12,085	1,260	890	205	125	85	65
Low Water Slack	-	-	-	-	-	-	8,265	4,790	2,790	965	135	80	75

Table 12 – – Revised Results (based on Field Data) of Spring Tide Simulations for Secondary Treated Discharge with Disinfection from Proposed Ferry Point Outfall

Point on Tide	FAECAL COLIFORM CONCENTRATIONS AT PLUME CENTRELINE ON SPRING TIDE (per 100ml)												
	UPSTREAM						DOWNSTREAM						
	1000m	500m	200m	100m	50m	10m	10m	50m	100m	200m	500m	1000m	1750m
Max Flood	0	0	3	5	12	79	-	-	-	-	-	-	-
High Water Slack	0	2	13	31	56	63	-	-	-	-	-	-	-
Max Ebb	-	-	-	-	-	-	78	12	5	1	1	0	0
Low Water Slack	-	-	-	-	-	-	90	56	32	11	2	1	0

Table 13 – Revised Results (based on Field Data) of Neap Tide Simulations for Secondary Treated Discharge with Disinfection from Proposed Ferry Point Outfall

Point on Tide	FAECAL COLIFORM CONCENTRATIONS AT PLUME CENTRELINE ON NEAP TIDE (per 100ml)												
	UPSTREAM						DOWNSTREAM						
	1000m	500m	200m	100m	50m	10m	10m	50m	100m	200m	500m	1000m	1750m
Max Flood	0	1	5	8	10	80	-	-	-	-	-	-	-
High Water Slack	2	7	33	62	83	110	-	-	-	-	-	-	-
Max Ebb	-	-	-	-	-	-	81	8	6	1	1	1	0
Low Water Slack	-	-	-	-	-	-	55	32	19	6	1	1	0

MODELLING RESULTS WITH DECAY INCLUDED.

Table 14 – Revised Results (based on Field Data) of Spring Tide Simulations for Secondary Treated Discharge from Proposed Ferry Point Outfall with Decay

Point on Tide	FAECAL COLIFORM CONCENTRATIONS AT PLUME CENTRELINE ON SPRING TIDE (per 100ml)												
	UPSTREAM						DOWNSTREAM						
	1000m	500m	200m	100m	50m	10m	10m	50m	100m	200m	500m	1000m	1750m
Max Flood	20	28	226	353	810	5,168	-	-	-	-	-	-	-
High Water Slack	33	151	887	2,008	2,932	4,154	-	-	-	-	-	-	-
Max Ebb	-	-	-	-	-	-	5,149	810	320	72	42	28	22
Low Water Slack	-	-	-	-	-	-	5,935	3,708	2,111	723	105	33	31

Table 15 – Revised Results (based on Field Data) of Neap Tide Simulations for Secondary Treated Discharge from Proposed Ferry Point Outfall with Decay

Point on Tide	FAECAL COLIFORM CONCENTRATIONS AT PLUME CENTRELINE ON NEAP TIDE (per 100ml)												
	UPSTREAM						DOWNSTREAM						
	1000m	500m	200m	100m	50m	10m	10m	50m	100m	200m	500m	1000m	1750m
Max Flood	31	48	329	539	644	5,260	-	-	-	-	-	-	-
High Water Slack	101	458	2,168	4,073	5,449	7,196	-	-	-	-	-	-	-
Max Ebb	-	-	-	-	-	-	5,293	552	390	90	55	37	28
Low Water Slack	-	-	-	-	-	-	3,620	2,098	1,222	423	59	35	33

Table 16 – Model Results Revised Results (based on Field Data) of Spring Tide Simulations for Secondary Treated Discharge with Disinfection from Proposed Ferry Point Outfall with Decay

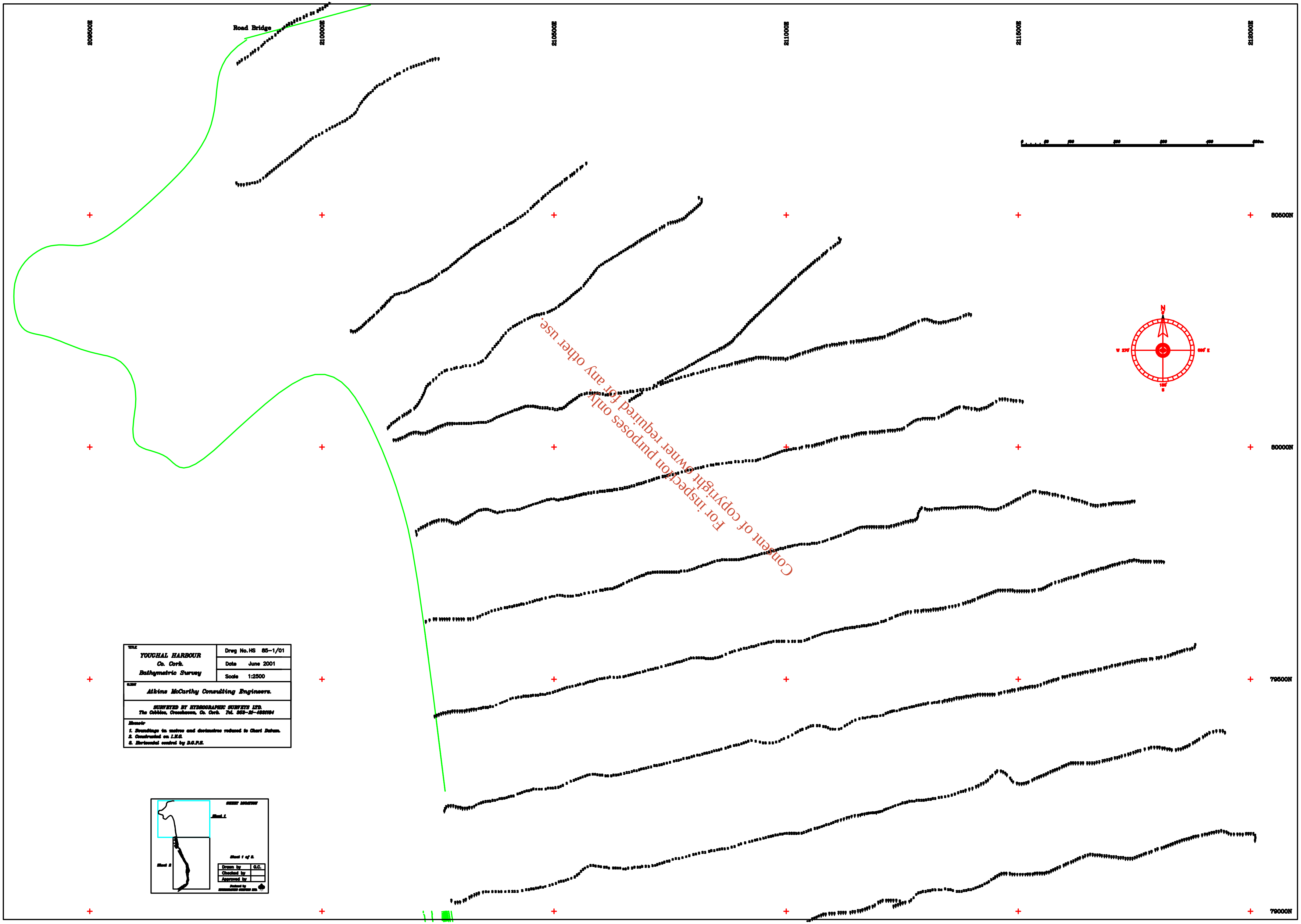
Point on Tide	FAECAL COLIFORM CONCENTRATIONS AT PLUME CENTRELINE ON SPRING TIDE (per 100ml)												
	UPSTREAM						DOWNSTREAM						
	1000m	500m	200m	100m	50m	10m	10m	50m	100m	200m	500m	1000m	1750m
Max Flood	0	0	1	2	5	35	-	-	-	-	-	-	-
High Water Slack	0	1	6	14	25	28	-	-	-	-	-	-	-
Max Ebb	-	-	-	-	-	-	34	5	2	0	0	0	0
Low Water Slack	-	-	-	-	-	-	39	25	14	5	1	0	0

Table 17 – Revised Results (based on Field Data) of Neap Tide Simulations for Secondary Treated Discharge with Disinfection from Proposed Ferry Point Outfall with Decay

Point on Tide	FAECAL COLIFORM CONCENTRATIONS AT PLUME CENTRELINE ON NEAP TIDE (per 100ml)												
	UPSTREAM						DOWNSTREAM						
	1000m	500m	200m	100m	50m	10m	10m	50m	100m	200m	500m	1000m	1750m
Max Flood	0	0	2	4	4	35	-	-	-	-	-	-	-
High Water Slack	1	3	14	27	36	48	-	-	-	-	-	-	-
Max Ebb	-	-	-	-	-	-	35	4	3	0	0	0	0
Low Water Slack	-	-	-	-	-	-	24	14	8	3	0	0	0

APPENDIX 2 MIDLETON WWTW BACTERIOLOGICALWATER QUALITY RESULTS -

MIDLETON SEWERAGE SCHEME - Results of Bacteriological Sampling						
	Influent		Pre UV		Post UV	
	Total coli per 100 ml	Faecal coliform per 100 ml	Total coli per 100 ml	Faecal coliform per 100 ml	Total coli per 100 ml	Faecal coliform per 100 ml
28/06/00	100,000		>12,000	7,300	10	0
04/07/00	12,000,000	8,800,000	>120,000	11,800	50	10
11/07/00	10,000,000	4,200,000	>12,000	8,900	80	2
18/07/00	11,800,000	9,500,000		>12,000	164	1
25/07/00	4,800,000	800,000	140,000	40,000	30	0
01/08/00	75,000,000	19,000,000	444,000	44,000	63	24
08/08/00	21,400,000	9,066,667	58,000	1,000	30	0
15/08/00	59,000,000	4,000,000	119,000	37,000	4,300	390
22/08/00	60,000,000	8,200,000	140,000	30,000	70	0
30/08/00	44,000,000	11,850,000	720,000	50,000	120	20
05/09/00	9,300,000	2,600,000	300,000	30,000	470	20
12/09/00	39,000,000	11,000,000	6,800,000	460,000	220	20
20/09/00	35,000,000	5,700,000	70,000	10,000	66	14
26/09/00	18,000,000	2,000,000	200,000	10,000	150	20
04/10/00	7,100,000	2,300,000	110,000		3,100	20
11/10/00	3,900,000	1,000,000	30,000	7,000	40	2
18/10/00	9,200,000	2,400,000	68,000	16,000	90	8
24/10/00	16,000,000	1,000,000	870,000	120,000	13	1
31/10/00	5,100,000	1,180,000	60,000	17,000	19	7
07/11/00	4,000,000	810,000	40,000	6,000	190	37
15/11/00	18,000,000	2,500,000	158,000	27,000	2	0
21/11/00	5,100,000	2,150,000	1,270,000	470,000	15	5
29/11/00	2,800,000	1,060,000	76,000	11,000	101	25
05/12/00	2,800,000	1,000,000	73,000	13,000	15	3
12/12/00	1,300,000	90,000	80,000	20,000	18	8
03/01/01	3,100,000	810,000	90,000	25,000	69	30
09/01/01	840,000	520,000	82,000	33,000	400	140
16/01/01	3,800,000	1,400,000	66,000	28,000	20	7
24/01/01	870,000	320,000	59,000	28,000	690	90
30/01/01	4,200,000	2,300,000	100,000	9,000	5	0
08/02/01	670,000	290,000	20,000	6,000	9	4
13/02/01	1,270,000	970,000	20,000	5,000	12	0
20/02/01	1,900,000	510,000	40,000	7,000	19	2
28/02/01	4,000,000	1,080,000	22,000	3,000	9	3
07/03/01	3,200,000	960,000	28,000	5,000	4	3
14/03/01	1,500,000	900,000	80,000	20,000	170	10
21/03/01	2,200,000	500,000	460,000	80,000	45	27
27/03/01	12,000,000	4,000,000	130,000	100,000	100	27
05/04/01	10,000,000	1,000,000	16,000		46	6
09/04/01	6,700,000	1,100,000	25,000	2,000	89	2
18/04/01	8,600,000	180,000	1,080,000	90,000	50	2
25/04/01	21,000,000	3,200,000	2,600,000	350,000	2,000	230
02/05/01	36,000,000	2,000,000	3,300,000	230,000	86	10
09/05/01	38,000,000	4,300,000	33,000	38,000	26	2
15/05/01	14,130,000	1,660,000	52,000		17	3
22/05/01	41,000,000	2,900,000	320,000	30,000	34	4
28/05/01	9,200,000	2,100,000	600,000	64,000	53	5
05/06/01	5,600,000	3,800,000	550,000	50,000	560	23
11/06/01	1,800,000	700,000	>24,000	11,199	4,604	155
18/06/01	7,100,000	3,400,000	45,000	3,000	73	23
25/06/01	77,000,000	22,000,000	111,667	6,000	4,000	290
02/07/01	35,000,000	13,300,00	290,000	39,500	185	31
09/07/01	21,000,000	2,300,000	68,000	17,500	20	4
17/07/01	3,000,000	700,000	105,000	33,000	31	1
23/07/01	190,000	190,000	74,000	41,000	35	13
31/07/01	10,100,000	3,300,000	91,000	26,000	31	3
07/08/01	5,600,000	1,000,000	52,000	5,000	3,900	800
13/08/01	6,200,000	1,500,000	83,000	17,000	510	84



TITLE
YOUGHAL HARBOUR
Co. Cork.
Bathymetric Survey
Drwg No. HS 85-1/01
Date June 2001
Scale 1:2500
Atkins McCarthy Consulting Engineers.
SURVEYED BY HYDROGRAPHIC SURVEYS LTD.
The Cobbles, Crosshaven, Co. Cork. Tel. 353-21-4831184
Memoir
1. Soundings in metres and decimetres reduced to Chart Datum.
2. Constructed on I.N.G.
3. Horizontal control by D.G.P.S.
Road Bridge
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210000E
210500E
211000E
211500E
212000E
80500N
80000N
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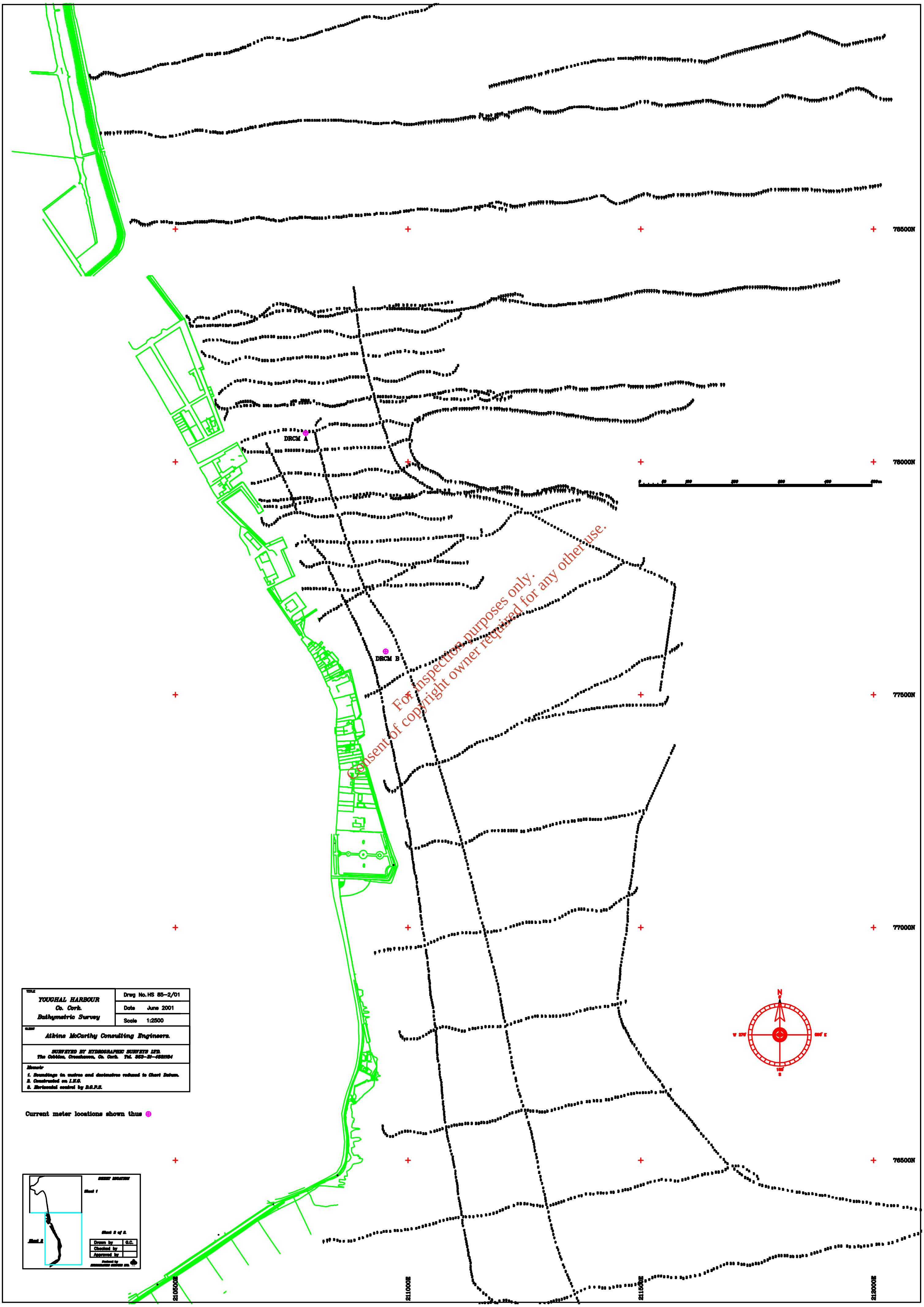
79000N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76500N
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211500E
212000E
DRCM A
DRCM B
N
YOUGHAL HARBOUR
Co. Cork.
Bathymetric Survey
Drwg No. HS 85-2/01
Date June 2001
Scale 1:2500
Atkins McCarthy Consulting Engineers.
SURVEYED BY HYDROGRAPHIC SURVEYS LTD.
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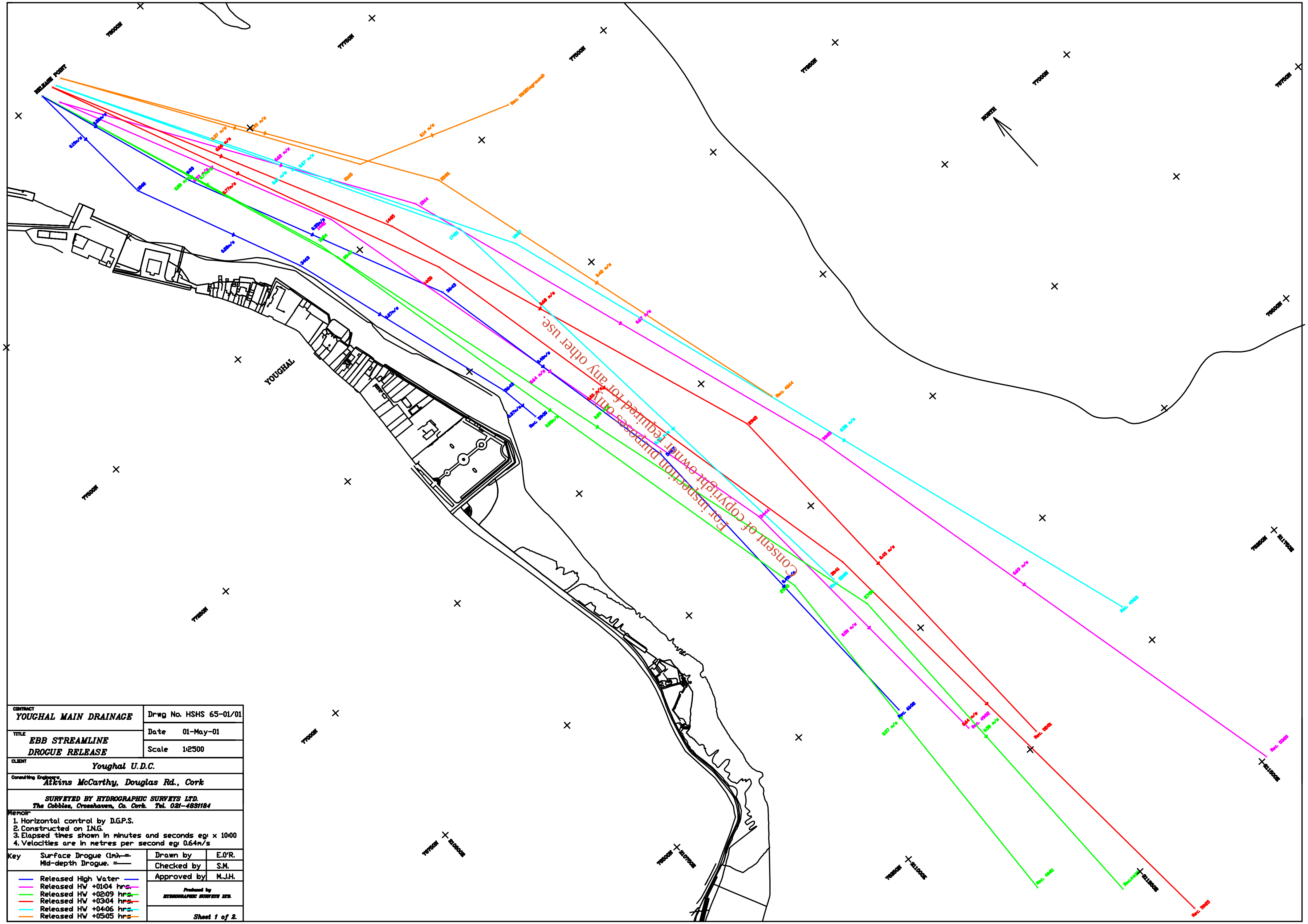
Memoir
1. Soundings in metres and decimetres reduced to Chart Datum.
2. Constructed on I.N.G.
3. Horizontal control by D.G.P.S.
Current meter locations shown thus



CONTRACT
YOUGHAL MAIN DRAINAGE

Drwg No. HSHS 65-01/01

TITLE
EBB STREAMLINE
DROGUE RELEASE

Date 01-May-01

Scale 1:2500

CLIENT
Youghal U.D.C.

Consulting Engineers
Atkins McCarthy, Douglas Rd., Cork

SURVEYED BY HYDROGRAPHIC SURVEYS LTD.
The Cobbles, Crosshaven, Co. Cork. Tel. 021-4831184

Memoir
1. Horizontal control by D.G.P.S.
2. Constructed on I.N.G.
3. Elapsed times shown in minutes and seconds eg: x 10:00
4. Velocities are in metres per second eg: 0.64m/s

Key	
Surface Drogue (1m)	
Mid-depth Drogue	
Released High Water	blue
Released HW +01:04 hrs.	magenta
Released HW +02:09 hrs.	green
Released HW +03:04 hrs.	red
Released HW +04:06 hrs.	cyan
Released HW +05:05 hrs.	orange

Drawn by	E.O'R.
Checked by	S.M.
Approved by	M.J.H.

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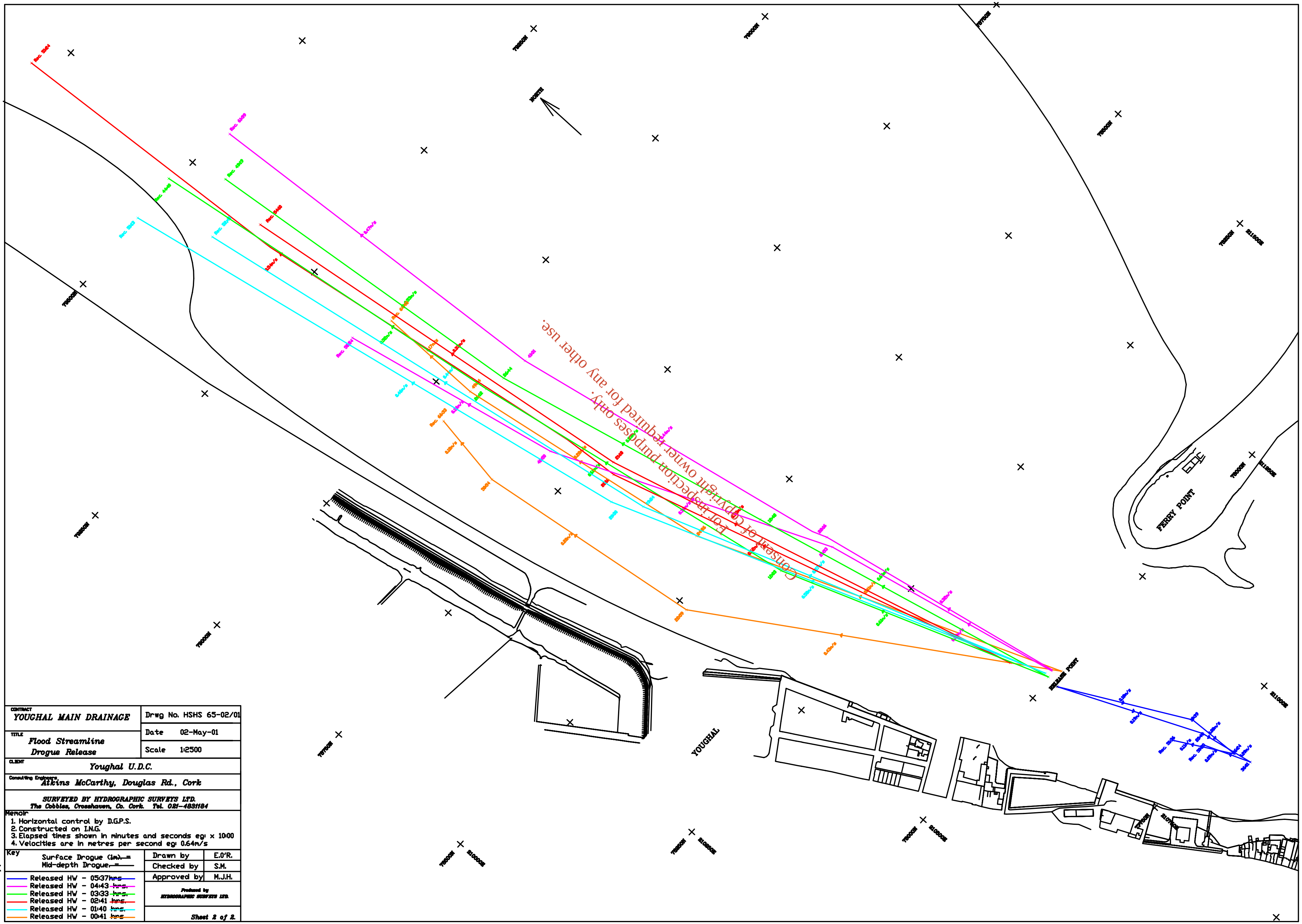
Sheet 1 of 2.



CONTRACT
YOUGHAL MAIN DRAINAGE

Drwg No. HSHS 65-02/01

TITLE
Flood Streamline
Drogue Release

Date 02-May-01

Scale 1:2500

CLIENT
Youghal U.D.C.

Consulting Engineers
Atkins McCarthy, Douglas Rd., Cork

SURVEYED BY HYDROGRAPHIC SURVEYS LTD.
The Cobbles, Crosshaven, Co. Cork. Tel. 021-4831184

Memoir
1. Horizontal control by D.G.P.S.
2. Constructed on I.N.G.
3. Elapsed times shown in minutes and seconds eg: x 10:00
4. Velocities are in metres per second eg: 0.64m/s

Key
Surface Drogue (1m)
Mid-depth Drogue

Released HW - 05:37 hrs.
Released HW - 04:43 hrs.
Released HW - 03:33 hrs.
Released HW - 02:41 hrs.
Released HW - 01:40 hrs.
Released HW - 00:41 hrs.

Drawn by	E.O'R.
Checked by	S.M.
Approved by	M.J.H.

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Sheet 2 of 2.

APPENDIX E

Odour Modelling Assessment

Aquavarra Research Ltd, 22A Brookfield Avenue, Blackrock, Co. Dublin.

Youghal Wastewater Treatment Works

Odour Emission and Dispersion

Client: **Youghal Urban District Council**
Town Hall
Youghal
Co.Cork

Engineer: **Atkins McCarthy,**
Consulting Engineers,
Balgriffin,
Dublin 17.

Aquavarra Research Limited
22A Brookfield Avenue
Blackrock
Co. Dublin.

September 01

YOUGHAL WASTERWATER TREATMENT WORKS

EMISSION, DISPERSION AND CONTROL OF ODOUR

1. INTRODUCTION

This report presents the results of a computer model of the dispersion of odour from three potential sites for a new wastewater treatment plant for Youghal, Co. Cork. As the project has not yet reached the design stage, a conventional activated sludge system was modelled, providing a worst case scenario with regard to process free surfaces.

2. ODOUR

Odour is the sensation transmitted to the brain by the olfactory receptors in the nasal cavity when exposed so called odorous substances in the inhaled air. If these substances are of a malodorous nature and are present in air above a certain threshold concentration they may cause annoyance and constitute an environmental nuisance. The science of odour response measurement is known as olfactometry. Standard olfactometric methods for odour strength measurement by dilution techniques using a panel of people operating according to standard procedures, have been developed (Frechen, 1994).

The concentration of odorants in air is expressed in odour units per cubic metre (OU/m^3). Its numerical value is quantified as the number of dilutions with clean air required to reach the perception threshold, the latter being the lowest odour concentration which is detectable by half the members of a test panel (half the members do not detect any smell while the other half still smells something). At a concentration of 2 OU/m^3 an odour is faintly perceivable, at 3 OU/m^3 it is clearly perceivable while at 5 OU/m^3 is strongly perceivable and likely to give rise to environmental nuisance. The duration of an odour is also significant. Dispersion calculations are normally based on meteorological data using mean 1-hour wind speeds, producing hourly means of odour concentration. A concentration of 5 OU/m^3 lasting 15 to 30 minutes is commonly used as the nuisance threshold. If the mean hourly odour concentration is less than 1 OU/m^3, it is unlikely that shorter duration odour concentrations will exceed 5 OU/m^3.

3 WASTEWATER ODOURS

Wastewater odours arise either through the discharge of odorous substances of industrial origin to the sewer system or from the anaerobic decomposition of biodegradable matter in the wastewater. Anaerobic biodegradation produces volatile fatty acids and a variety of reduced sulphur compounds most of which have a very low odour threshold concentration as indicated in Table 1.

Anaerobic biodegradation is inhibited in the presence of dissolved oxygen and thus does not occur while wastewaters remain aerobic. However, where there is a long residence time in the sewer system or where sewer gradients are small, resulting in low velocities and solids deposition, wastewaters are likely to become septic and malodorous. Biodegradation rates are also strongly influenced by temperature, hence odour problems are likely to be accentuated during warm weather or where industrial discharges raise the wastewater temperature.

3.1 Odour standards for wastewater treatment plants

The European Community has not as yet developed environmental directives relating to the control of odour nuisance nor are there any mandatory national standards in force in Ireland. The Irish EPA, in its general approach to environmental protection, promotes the use of so-called BATNEEC solutions (use of the best available technology not entailing excessive cost). It is well established that odour nuisance in the vicinity of wastewater treatment facilities can be avoided by the application of this principle to the design new wastewater treatment facilities.

It is also useful to look to the example of the approach used in other countries. The Netherlands, for example, has adopted a policy aimed at the reduction of environmental odour to an as low as reasonably achievable level. For wastewater treatment plants this translates into the following maximum environmental concentration levels:

At locations surrounded by residential areas, ribbon-development or other odour-sensitive receptors:

- 1 ou/m^3 at 98% non-exceedence level for new WWTWs
- 3 ou/m^3 at 98% non-exceedence level for existing situations

At locations with scattered houses or industrial estates:

- 2 ou/m^3 at 98% non-exceedence level for new WWTWs
- 7 ou/m^3 at 98% non-exceedence level for existing plants

An odour level of 2 OU/m^3 at a 98% non-exceedence level at the site boundary has been adopted as the target odour standard for the Youghal WWTW.

3.2 Odour emission from treatment processes

The rate of release of odorous compounds into the atmosphere at wastewater treatment works (WWTWs) is influenced by:

(a) concentration of odorous substances in liquid phase exposed to air
(b) total air/wastewater interface area
(c) conditions at air/wastewater interface.

Raw wastewaters and sludges generally have high concentrations of odorous substances. Processes that generate surface turbulence and high rates of interface renewal, such as open channel flow, weir overflows, biofilter flow distribution systems etc., have much higher rates of volatilisation of odorous compounds than quiescent processes such as sedimentation.

Table 1
Odour threshold concentrations (Vincent & Hobson, 1998)

Substance	Threshold conc. (μg/m^3 air)
Ammonia	100-11000
Methylamine	1.2-65
Dimethylamine	47-160
Indole	7.1
Scatole	0.012-0.35
Ethylmercapton	0.043
Diethyl sulphide	1.4
Hydrogen sulphide	0.76
Methylmercapton	0.003-38
Methyl sulphide	0.34-1.1
Acetic acid	43
Butyric acid	0.35-86
Acetaldehyde	0.01-4
Butyraldehyde	15
Isobutyraldehyde	15-22
Valeraldehyde	2.5-34

The specific odour emission rate from a water or sludge surface can be measured experimentally in a standardised way using a floating collector hood into which is discharged a measured flow of odour-free air. The odour concentration is then measured in the emergent air stream. The specific odour emission rate (OU/m^2.h) is quantified as the product of the emitted odour concentration (OU/m^3) and the specific air flow rate (m^3/m^2.h). A sample set of wastewater process odour emission rates, measured in this way, is presented in Table 2.

Table 2
Odour emission measurement results
(Frechen, 1992)

Odour source	Odour Concentration (OU/m^3)	Specific air flow rate (m^3/m^2.h)	Specific emission rate (OU/m^2.s)
Aerated grit chamber	1021	7.00	1.99
Grit container	10520	7.00	20.46
Storm tank, dirty	71	6.30	0.12
Influent water	995	8.4	2.32
Primary sedimentation surface	100	8.00	0.22
Primary sedimentation overflow	193	8.00	0.43
Aeration tank	63	7.10	0.12
Secondary sedimentation tank	37	5.30	0.05
Secondary sedimentation overflow	52	5.50	0.08
Final sludge thickener	1045	5.40	1.57
Fresh dewatered sludge	102	6.00	0.17

The inlet works, primary treatment processes, biofiltration processes and sludge handling processes are the major odour sources at WWTWs. With the exception of aerobically stabilised sludges, sludge residues are the primary sources of very high odour concentration at WWTWs. This is because of their potentially high concentrations of reduced volatile substances including hydrogen sulphide (H_2S). It should be noted that anaerobically digested sludge, though biologically stable, can be a significant source of malodour, particularly if it contains H_2S - 1 ppm by volume of H_2S in air is approximately equivalent to an odour concentration of 200 OU/m^3. Aerobically stabilised sludges, on the other hand, have a relatively low odour emission rate. Surplus activated sludges from medium or high rate processes also have low odour emission rates while maintained in an aerobic condition.

3.3 Odour Abatement at WWTPs

The emission of foul odours from wastewater treatment facilities can be controlled by covering/housing the primary odour sources and by providing forced ventilation of the enclosed air spaces to appropriate air treatment facilities. The required rate of ventilation should, at minimum, maintain a slight negative pressure within the enclosed air space, thus preventing air escape other than to the forced ventilation system. Higher rates of ventilation are required for accessible enclosures while low rates are adequate for enclosures that are not accessible. Ventilation rates are typically expressed in terms of a ventilation factor or frequency of air change (ventilation factor x enclosed air volume = ventilation rate). Ventilation factors may vary from 2 h^{-1} for non-accessible enclosures to 20 h^{-1} for frequently used rooms with high odour-emission potential.

Treatment technologies for odorous air streams, such as generated at wastewater treatment plants, include:

- Biofiltration and bioscrubbing
- Activated carbon
- Wet chemical scrubbing
- Thermal oxidation

In biological treatment processes such as biofiltration and bioscrubbing the odour contaminants are adsorbed on to a moist contact medium, where they are decomposed by selected bacteria that are capable of using the contaminants as a growth substrate. Peat or heather is used as the contact medium in biofilters while a variety of packing materials is used in biotower scrubbers.

Biofiltration will probably be the most suitable method of treatment for the Youghal WWTW application. A well-designed enclosed biofilter, equipped with a wetting system for the filter bed, should be capable of achieving an odour reduction efficiency of in the range 90%-95%.

The following odour abatement measures were assumed to be adopted for Youghal WWTW:

- The enclosing of the inlet works in a building ventilated to odour treatment.
- The ventilating of the sludge building to odour treatment.
- The ventilating of the sludge thickening tank to odour treatment.

4. ODOUR DISPERSION MODELLING

The malodours emitted from WWTWs are carried downwind and are diluted through atmospheric dispersion by mixing and transport mechanisms. This atmospheric dilution process can be mathematically modelled as a Gaussian plume (Pasquill, 1974), taking wind speed, wind direction and atmospheric stability conditions into account (USEPA, 1992). Thus, using the local meteorological data and the estimated odour emission rates from the individual treatment processes (Table 2), it is possible to compute the odour concentration fluctuation at sensitive receptor locations in the vicinity of a WWTW.

The required meteorological data consists of the mean hourly values for wind speed, wind direction and Pasquill stability classification for the WWTW location for at least one year's duration. The prevailing Pasquill stability category has a strong influence on the rate odour dilution with distance from source. Unfavourable dispersion conditions arise when there is a combination of low wind velocity and reduced solar radiation such as occurs at night-time or in overcast conditions during the daytime.

The output from such a computer modelling exercise can be presented in a variety of formats to suit the needs of the user. Environmental regulations commonly specify a cumulative non-exceedence frequency for the threshold odour value (1 OU/m^3) at particular receptor locations - for example, if this limit value is set at 99.5%, it infers 44 computed exceedences per year, based on hourly input data. Similarly, isolines for any other odour concentration can also be plotted. Alternatively, the model can be used to define the odour threshold boundary for the WWTW, or the boundary corresponding to any specified odour concentration.

4.1 Odour dispersion modelling for Youghal WWTW

4.1.1 Input data

(a) **Meteorological data**: Hourly wind speed, direction and stability class at Cork Airport for 2000 were used in the model dispersion run. In order to check whether the 2000 data deviate from the long term average conditions, the frequency distributions of wind direction for the critical wind speeds in the range 0.5 - 3.0 m/s for the 30-year period 1962-1991 and for 2000 are plotted in Fig 1. Examination of these distributions shows that the 2000 frequencies generally exceed the 30-year average frequencies and thus provide a margin of safety in respect of odour dispersion computations.

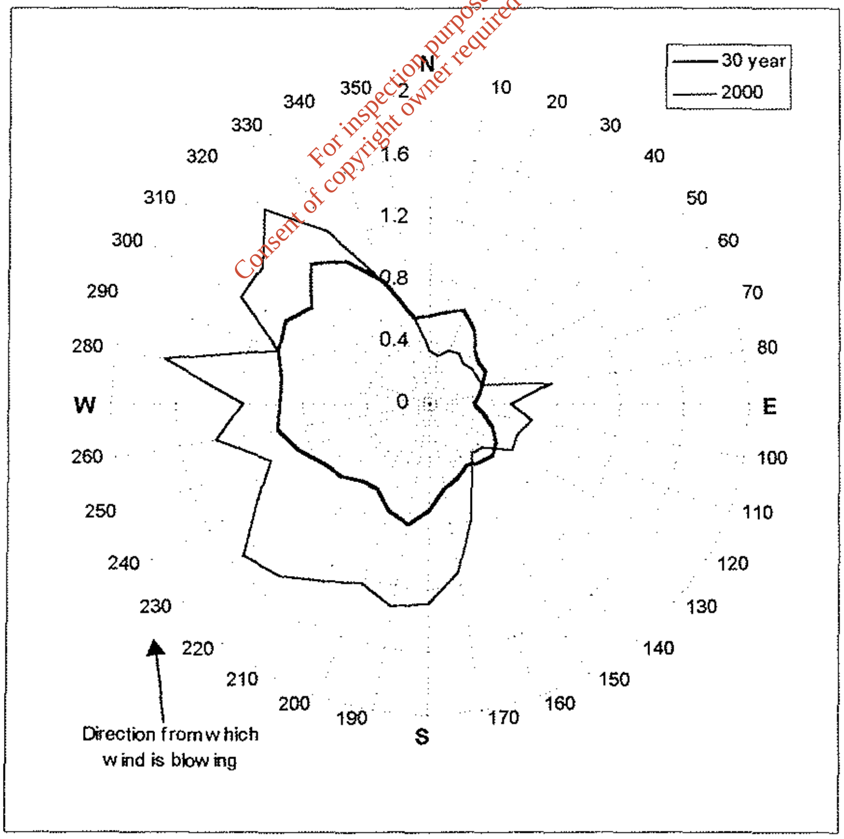


Fig 1 **Wind direction frequency for wind speeds in range 0.5 - 3 m/s for Cork Airport Meteorological Station**

(b) **Process odour emission data**
A schematic layout of the Youghal WWTW is presented in Fig 2. For dispersion modelling purposes, the overall odour emission from the Youghal WWTW was allocated to the 11 discrete sources listed in Table 3. The odour emission rates were calculated using the values given in Table 2, as the product of source surface area and the associated specific odour emission rate and a peaking factor of 2. The odour emission rates from the odour treatment biofilters were based on an assumed 90% odour removal from the treated air.

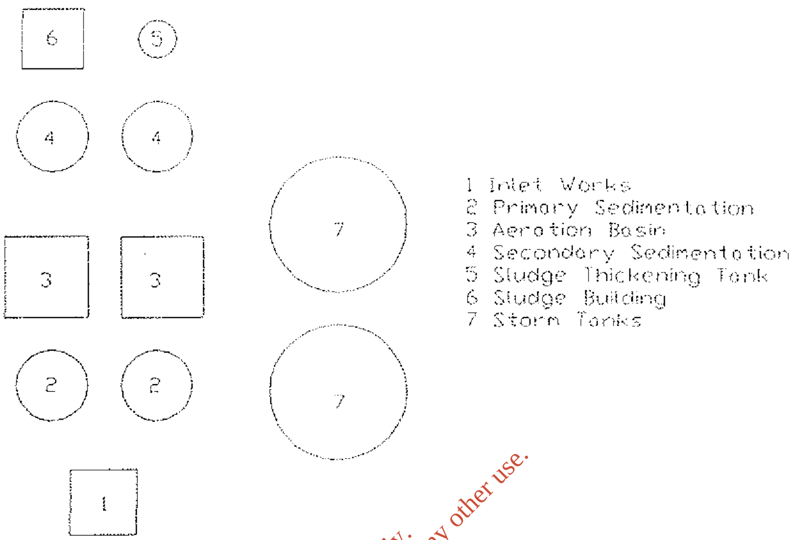


Fig 2 **Youghal WWTW: schematic layout**

4.2 **Dispersion analysis**

For each of the three proposed sites as indicated in Fig 4, two odour emission scenarios were examined:

(a) without odour abatement measures – data as in table 4
(b) with specific odour abatement measures – data as in table 5

A computer analysis of odour dispersion from the outline design, based on the odour emission rates in Table 4 and Table 5 and the 2000 Cork Airport hourly wind data, was carried out for each site. For all sites, the output data was analysed to define the 99.5% odour threshold isoline for the plant i.e. the boundary line within which the threshold odour concentration of 1 OU/m^3 was exceeded during 0.5% of the time or 44 hours of the one year test period. In addition, the 99.5% and 98% odour threshold isolines for 2 OU/m^3 were plotted for the preferred site option, site 3.

The plotted isolines are presented in Fig 5 (Site 1) Fig 6 (Site 2) and Fig 7 (Site3).

Table 4
Odour emission rates used in dispersion computation without odour treatment

	Source	Surface area (m^2)	Mean specific odour emission rate ($OU/m^2.s$)	Source odour emission rate (OU/s)
1	Inlet Works[1]	100	6.29	629
2	Primary Clarifiers [2]	332	0.46	153
3	Aeration Tanks	600	0.25	150
4	Secondary Clarifiers [2]	500	0.07	35
5	Sludge Thickening Tank [3]	38	3.14	119
6	Sludge Building [4]	-	-	20
7	Storm Tanks [5]	1000	0.25	250
8	Screenings Skip	10	40.91	409

Notes for Table 4:
1) The inlet works includes screening ($25m^2$ at 12.56 $OU/m^2.s$), aerated grit chamber ($50m^2$ at 3.97 $OU/m^2.s$) and open channels ($25m^2$ at 4.64 $OU/m^2.s$)
2) Combined surface and overflow values
3) Combined primary and secondary thickening
4) Housing Belt press ($8m^2$ at 2.1 $OU/m^2.s$) & sludge skip ($10m^2$ at 0.34 $OU/m^2.s$)
5) Assumed to be in an un-cleaned state

Table 5
Odour emission rates used in dispersion computation with odour treatment

	Source	Surface area (m^2)	Odour Treatment	Mean specific odour emission rate ($OU/m^2.s$)	Source odour emission rate (OU/s)
1	Odour Treatment Unit 1 [1]	-	-	-	14
2	Odour Treatment Unit 2 [2]	-	-	-	104
3	Primary Clarifiers	332	No	0.46	153
4	Aeration Tanks	600	No	0.25	150
5	Secondary Clarifiers	500	No	0.07	35
7	Storm Tanks [3]	1000	No	0.25	250

Notes for Table 5:
1) Input 139 OU/s from Belt Press Building and Sludge Thickening Tank, Output 13.9 OU/s after 90% odour removal
2) Input 1038 OU/s from Inlet Works Building (incl Grit Skip), Output 103.8 OU/s after 90% odour removal
3) Assumed to be in an un-cleaned state

Odour Treatment Units:

Odour Unit	Corrected Sources	Ventilation Rate (h^{-1})	Headspace (m^3)	Flow (m^3/s)
Unit 1	Belt Press Building	14	363.0	1.41
	Sludge Tank	2	38.4	0.02
Unit 2	Inlet Works	8	702.0	1.56

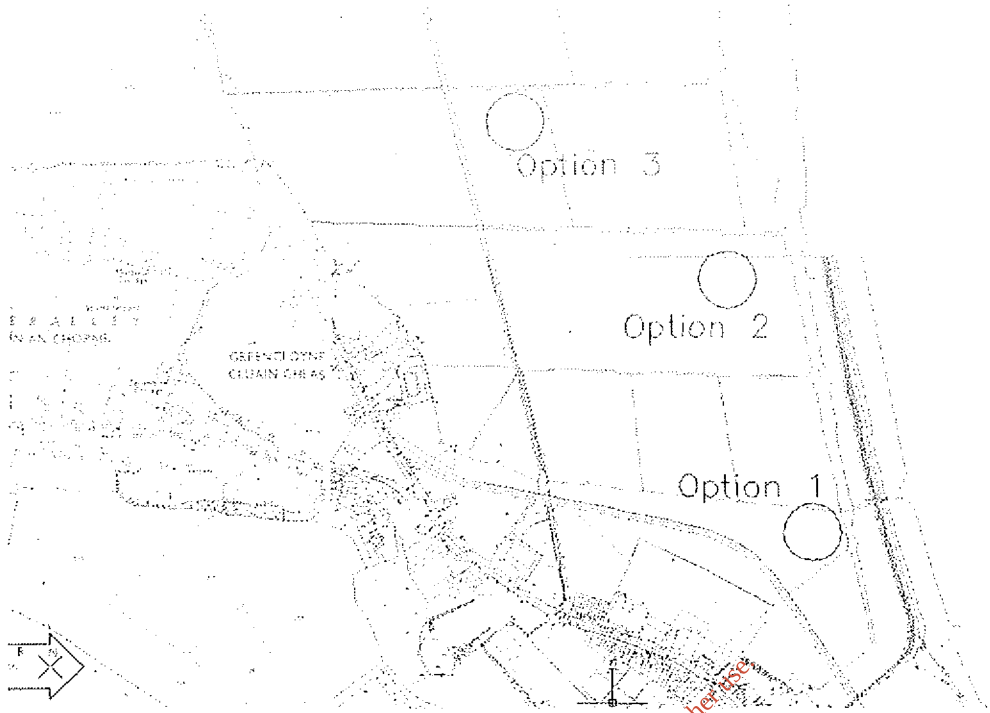


Fig 4. **The three proposed sites for the new Youghal WWTW.**

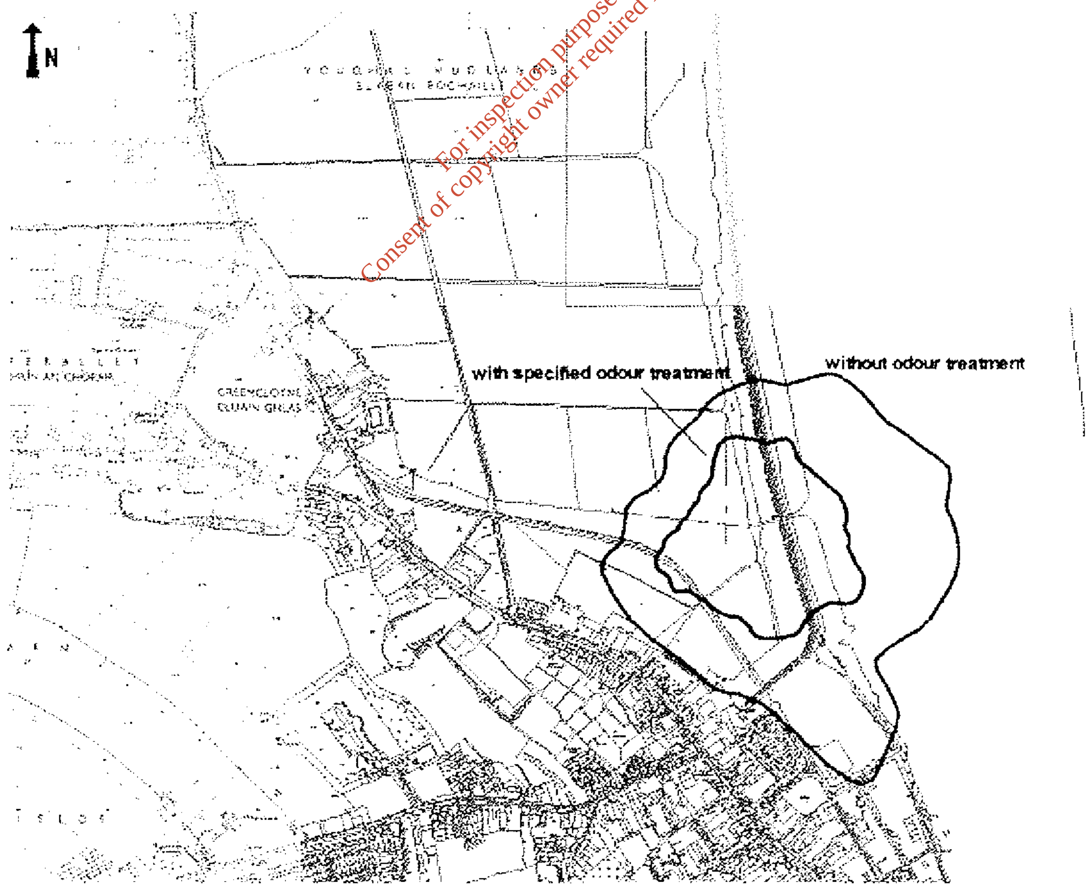


Fig 5. **99.5% Odour contour lines of 1 OU/m³ for Site 1**

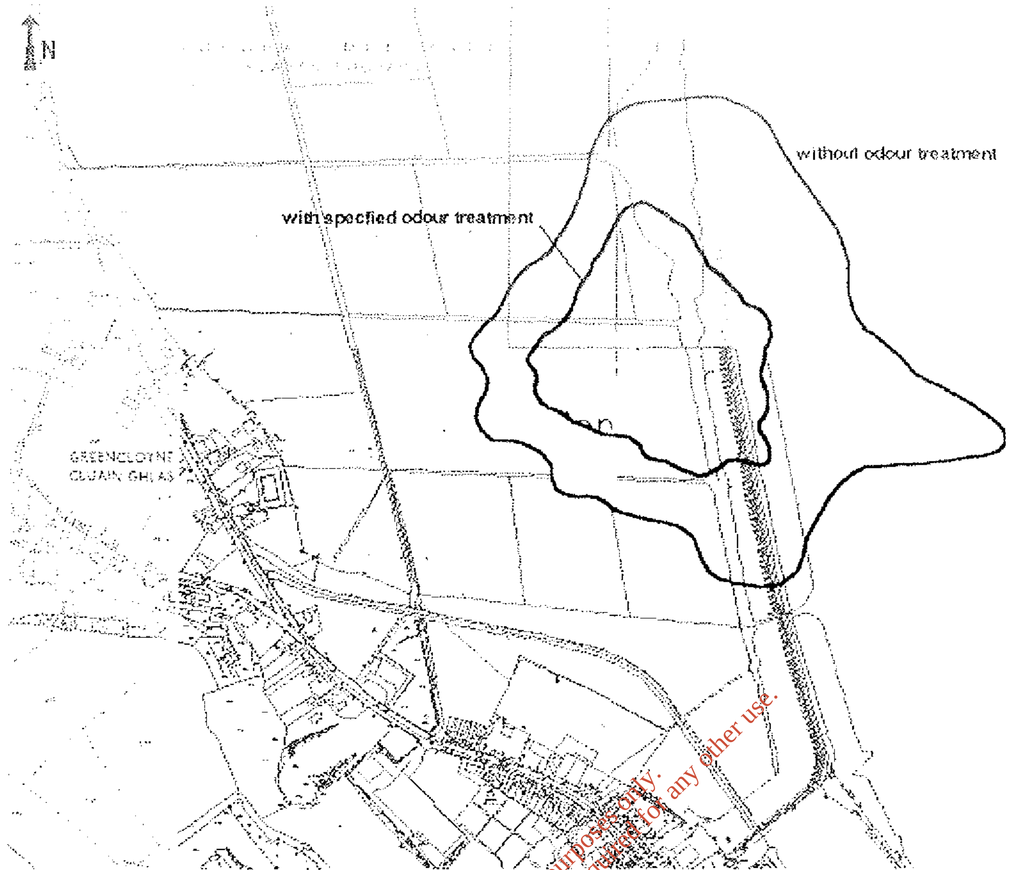


Fig 6. **99.5% Odour contour lines of 1 OU/m³ for Site 2**

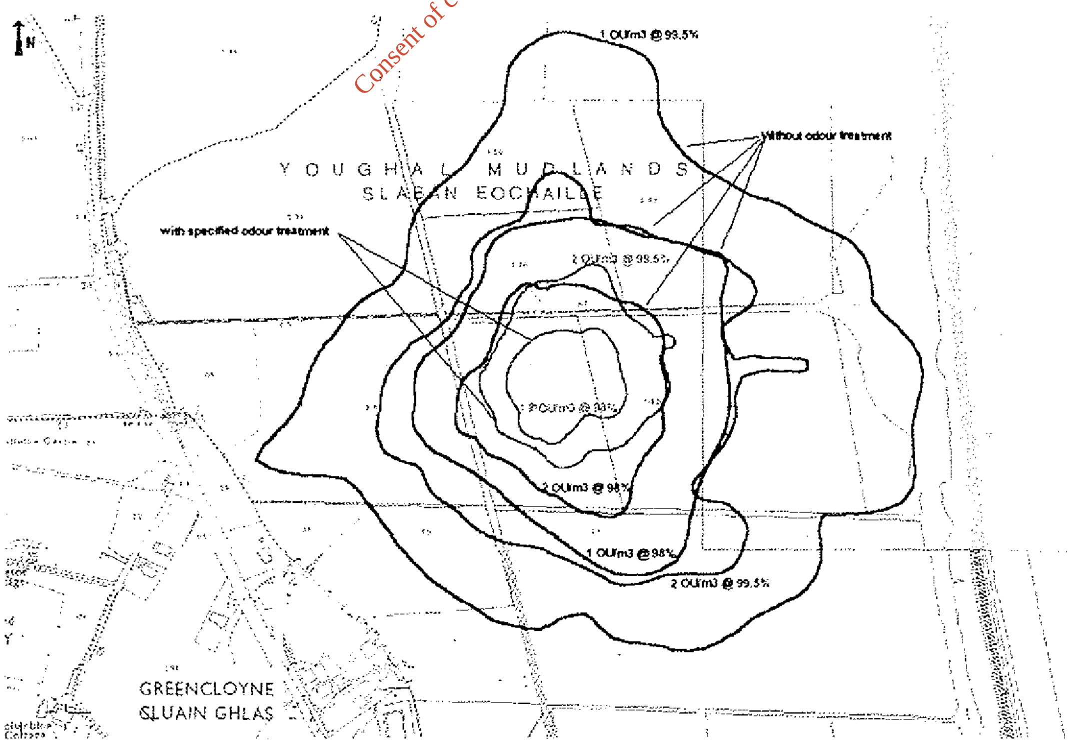
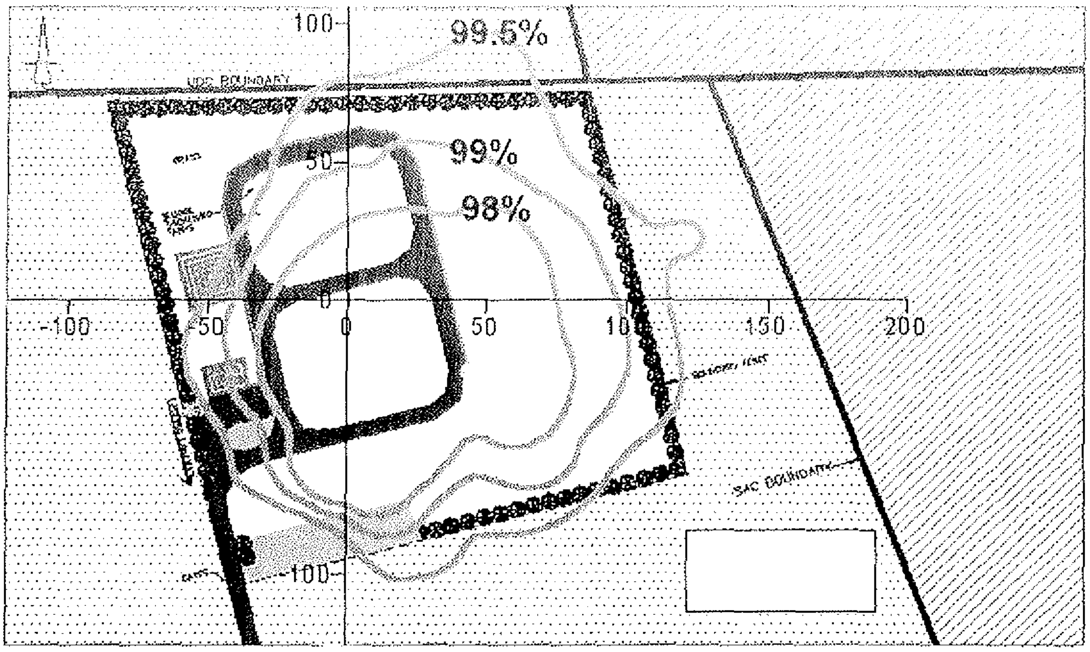


Fig 7. **Odour contour lines for site 3 (1OU/m³ and 2 OU/m³)**



2 OU/m3 Odour Contours for site 3 with specfied odour treatment measures

Fig 8. **2 OU/m^3 contour lines for site 3**

5. COMMENT

While computer analysis can produce a precise definition of odour concentration isolines of specified cumulative frequency, the accuracy of such predictions is critically dependent on the accuracy of the input meteorological and odour emission data.

In this instance, meteorological data from Cork Airport Meteorological station were used. While the degree to which this wind data matches the local wind climate at Youghal cannot be quantified since local hourly wind data for Youghal is not available, the use of the Cork Airport data is not likely to give rise to a serious distortion of the odour dispersion results.

The odour emission data used in the analysis are best estimates based on data reported in the literature as referenced in the body of the report

The specified odour abatement measures represent good design practice and can be implemented without incurring excessive cost. As can be seen in Figures 5,6 and 7, they achieve considerable reduction in odour emission as indicated by the reduced areal extent of the 99.5% odour isolines at the 1 OU/m^3 concentration. Figure 8 shows that the 2 OU/m^3 98% isolines can be maintained within the site boundary using the specified odour abatement measures.

Professor T J Casey

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APPENDIX F

Noise Assessment

RPS Environmental Sciences Ireland Ltd., Unit 3A, University Technology Centre, Curraheen Road, Cork.

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED YOUGHAL WASTE WATER TREATMENT WORKS

FOR:

Atkins Mc Carthy
Villa Franca
Douglas Road
Cork

Report prepared by: Maureen Marsden
Ref: NA0509
Date: 11-6-01

CONTENTS

1.0 INTRODUCTION

A noise assessment was conducted by RPS Consultants on behalf of Atkins Mc Carthy Consulting Engineers, as part of an environmental impact assessment of the proposed Waste Water Treatment Plant at Youghal.

The following potential noise impacts have been assessed:

- Noise impact on the nearest noise sensitive locations from noise generated by the permanent works associated with the development
- Noise impact on the nearest noise sensitive locations due to changes in traffic flow as a result of the development
- Noise and vibration impact associated with the operations generated during the construction works

The site for the proposed development is north of Youghal and extends along the coastline east of the main road to Waterford (N25). Currently there are three options for siting the sewage treatment works which are being considered. The area which contains the three proposed options is bounded to the south and southwest by the outskirts of Youghal. The largest number of residents are located here, and therefore it is at this location that the largest impact would occur. The residential locations to the west of the site are generally on the west side of the N25. The exception to this is one house located towards the northwest of the site, which is positioned on the east side of the N25. The east of the site is located along the coastline, and therefore there are no noise sensitive locations. However there is a footpath along this boundary of the site which is used as a public amenity area. The area towards the north of the site is generally industrial, and there is a marble works, coal depot and landfill site. Immediately to the south of the site is an industrial site.

2.0 METHODOLOGY

The noise assessment has consisted of the following:

- A noise survey at the nearest noise sensitive locations, to establish the current ambient noise levels.
- Measurement of noise from a similar sized plant to assess the effect of the proposed plant
- In addition to this the British Standard BS4142: Assessment of noise in mixed residential and industrial areas has been used as the basis of the assessment of noise from the permanent works has been used to assess the likelihood of complaints from the permanent works
- Prediction of traffic noise at noise sensitive locations. The calculation method used for this assessment is the UK Calculation of Road Traffic Noise, Department of Transport Document, 1988.
- The impact of construction noise has been assessed, based on the prediction methodology in BS 5228: Noise and vibration control on construction and open sites.

3.0 EXISTING BASELINE CONDITIONS

Noise measurements have been made on site during the daytime and night-time periods, from 9:30am on the 25th April 2001 to 8am on the 26th of April. Measurements were made with a Type 1 sound level meter. During the daytime the weather conditions were dry and sunny, with a light breeze. During the nighttime, the weather was windy with some rain showers.

Noise measurements were made at six locations, along the east side of the site and along the west and south of the site, at the nearest noise sensitive locations. Figure 1 shows the position of these noise monitoring locations. In general the dominant noise source at the measured locations are road traffic noise from the N25. A summary of the measured noise levels is shown in Table 1. This shows that the average daytime noise level at the residential locations depends very much on the location. The most northern end of the site is the noisiest, being dominated by road traffic noise. Further south, as the properties become more distant from the N25, the measured levels are much lower.

Measurement Location	L_{Aeq}	Average L_{Aeq}
1		
Daytime (0800-2200)	47-53	66
Nighttime (2200-0800)	37-51	44
2		
Daytime	46-52	49
Nighttime	33-52	43
3		
Daytime	44-51	48
Nighttime	33-52	43
4		
Daytime	70-77	75
Nighttime	63-72	67
5		
Daytime	63-67	65
Nighttime	48-58	54
6		
Daytime	55	55
Nighttime	42-52	47

Table 1 Summary of Noise measurements

4.0 IMPACT ASSESSMENT

Assessment of Permanent Works

There are currently a number of possible types of sewage treatment works which are being considered at the Youghal site and those listed below are indicative:

- Conventional activated sludge
- Sequenced batch reactors
- Membrane bioreactors

Generally of these, the first is typically the noisiest. Given that the design of the plant is as yet undetermined, noise measurements were made at a similar sized treatment plant in order to assess the impact of the development. Noise measurements were made at the Greystones/Delganey sewage treatment plant in Co Wicklow. This is a fairly modern plant (conventional activated sludge), with a design population of 40,000. Currently the plant operates at a population of 15,000. Table 2 below, summarises the noise measurements at the main noise sources on site.

Noise Source Description	L_{Aeq}
Secondary Treatment plant (at 1m)	60
Aeration tanks (at 1m)	55
10m from boiler rooms/air handling plant	56
10m from pump room	61

Table 2 Summary of noise measurements at Greystones, Co Wicklow

Generally the most dominant noise sources on site were from the plant rooms. The maximum measured L_{Aeq} at the site was 61dB(A). Given that the nearest noise sensitive location is 150m from the proposed site, the maximum noise level would be below the ambient background noise level.

The Standard BS 4142 has been used to determine the level, which if emitted from the site would be likely to lead to complaints. The results of this assessment are shown in Table 3. This standard recommends that a level of noise from a new industry of 10dB lower than the background noise level would be unlikely to lead to complaints. It has been assumed that the noise from the site will be tonal in nature. Table 3 shows that options 2 and 3 are much less likely to cause complaints. Comparing the maximum limits with the measurements at Greystones, options 2 and 3 would be unlikely to cause complaints and option 1 would be of marginal significance.

Table 3 Summary of BS4142 assessment

Option	Distance to Nearest Resident	Nighttime Measured L_{90}	Maximum L_{Aeq} at the boundary of the site which would be unlikely to lead to complaints
1	150m	29	58
2	350m	29	65
3	300m	33	69

In summary, the impact of the proposed plant in terms of operational noise is likely to be minimal. With choice of suitable plant, and consideration of noise during the design process, the impact of operational noise from the plant can be minimized.

Table 3 lists the maximum noise level at the boundary of the site that would be unlikely to lead to complaints at the nearby existing residents for the three site options. It is important to mention the EPA's Guidance for noise in relation to scheduled activities, normally used to assist with Integrated Pollution Control Licensing. Guideline values of 55dB(A) daytime and 45dB(A) nighttime levels are normally recommended.

During operation, it is anticipated that the traffic generated by the treatment plant employees will be approximately 10 car movements in and out of the site each day. Also, there will be one sludge delivery in and out of the site per day. The increase in noise level as a result of this traffic flow would be insignificant compared with the noise resulting from existing road traffic noise.

Assessment of Temporary Works

There is likely to be some increase in noise levels during the construction phase. The impact would be most significant with option 1, as the properties are closest to the construction site, and this is also the largest group of properties. Table 4 summarises the typical noise levels which would be expected at a distance of 150m (representative of Option 1) and 300m (representative of Options 2 and 3) from the site. These predictions are based on the methodology in British Standard 5228: Noise control on construction and open sites. The predictions do not take account of reduction in noise due to screening effects.

Generally a level of 65dB(A) incident outside a house would be audible indoors, and generally could be tolerated for limited durations. A level exceeding 70dB(A) would be likely to be intrusive, if it maintained this level for prolonged periods.

Table 4 Construction noise level predictions

Construction Type	Predicted Noise Level LAeq	
	150m	300m
Wheeled excavator (57kW)	42	36
Compressor (26kW)	43	37
Concrete mixer (2kW)	36	30
Lorry mounted Crane (78kW)	61	55
Piling Hydraulic vibratory driver	63	57

As yet the length of the construction works has not been finalised. The impact of the construction works would be less significant for Options 2 and 3. Piling operations would be likely to cause the greatest impact.

It is anticipated that 100 construction vehicles will visit and leave the site per day. The predicted noise level at 150m from the site entrance is 55dB. There would therefore be a slight impact as a result of construction noise traffic.

Vibration arising from piling activities could have a slight impact on properties. Both noise and vibration can be minimized through choice of suitable piling techniques, as detailed in BS 5228.

5.0 MITIGATION MEASURES

Noise from operational activities on the proposed waste water treatment plant can be minimized during the design phase, by careful selection of plant. Also noise can be minimized through site design layout such that noisier sources are distant from noise sensitive locations and are screened by buildings, or earthworks on site. It is proposed to apply the EPA guidelines for new industry at 45db(A) nighttime and 55dB(A) daytime noise levels (LAeq) at the boundary of the site.

Noise generated during the construction phase is likely to be more significant. This can be limited through application of the recommendations in BS5228. These include the following measures:

- Limiting the hours during which noisy site activities are permitted
- Establishing channels of communication between the contractor/developer, Local Authority and residents
- Monitoring typical levels of noise during critical periods and a sensitive locations

6.0 CONCLUSIONS

In summary the noise impact as a result of operation of the site can be minimized with choice of suitable plant and consideration of noise during the design process. The impact from noise from operational traffic to the site is expected to be minimal.

Construction noise is expected to generate a slight impact as a result of construction traffic, particular to the south and south west of the site. There would also be an impact as a result of construction works. The degree of this impact depends on which option is chosen, option 1 would lead to the most significant impact. This impact can be minimized through the application of the recommendations in BS5228: Control of Noise from Construction and Open Sites.

APPENDIX A

SURVEY DETAILS

A.1 Location of Survey

Measurements were made at 6 locations as detailed in Figure 1.

A.2 Date & Time of Survey

Measurements were made on 5-4-01 and 21-4-01. Dates for individual measurements are presented in the measurement tables, Appendix B.

A.3 Personnel Present During Survey

Maureen Marsden (MM)

Simon Barnes (SB)

Wijnand Udema (WU)

A.4 Instrumentation

The following instrumentation has been used:

Brűel and Kjær Integrating Sound Level Meter Type 2260.

Brűel and Kjær Integrating Sound Level Meter Type 2231.

Brűel and Kjær Calibrator 4231

Larson Davies 2800

A.5 Procedure

Measurements were made in accordance with ISO 1996. Equipment was calibrated before each measurement to ensure that the equipment had not drifted during the measurement period.

APPENDIX A

Measurement Period	L_{Aeq}	L_{Amax}	Comments
Noise Sensitive Location 1			
9:44-10:01	53	60	Dominated by traffic noise, also aircraft, birdsong
13:30-13:45	53	80	
17:15-17:30	47	58	
19:30-19:45	50	61	
00:15-00:30	37	62	
02:30-02:45	40	58	Lorry parked opposite for approximately 1 minute
04:50-05:10	47	72	
06:50-07:05	51	66	
Noise Sensitive Location 2			
10:15-10:30	50	72	
14:00-14:15	52	79	
17:30-17:45	47	69	
19:50-20:05	46	61	
23:50-00:05	38	53	
02:10-02:25	33	54	
04:30-04:45	47	60	
06:30-06:45	52	62	

Measurement Period	L_{Aeq}	L_{Amax}	Comments
		Noise Sensitive Location 3	
11:00-11:15	50	66	Road Traffic noise, aircraft, birds
14:30-14:45	51	81	Traffic, cows, Noise from landfill site
17:45-18:00	44	59	
20:15-20:30	46	67	
23:25-23:40	41	61	
01:50-02:05	33	55	
04:05-04:20	46	62	
06:15-06:30	52	66	
		Noise Sensitive Location 4	
12:30-12:45	70	93	N25 road traffic noise
15:00-15:15	77	94	
18:40-18:55	77	94	
22:40-22:55	72	92	
01:00-01:15	66	90	
03:00-03:15	63	92	
05:30-05:45	68	90	

Measurement Period	L_{Aeq}	L_{Amax}	Comments
Noise Sensitive Location 5			
13:00-13:15	67	115	Traffic, Lmax HGV
16:40-16:55	65	83	Ambient without traffic 40-42dB(A)
19:15-19:30	63	80	
23:00-23:15	55	76	
01:25-01:40	48	72	
03:35-03:50	56	85	
05:50-06:05	58	86	
Noise Sensitive Location 6			
18:15-18:30	55	74	
22:00-22:15	52	71	
00:40-00:55	43	65	
02:55-03:10	42	68	
05:10-05:25	52	69	

APPENDIX B

GLOSSARY

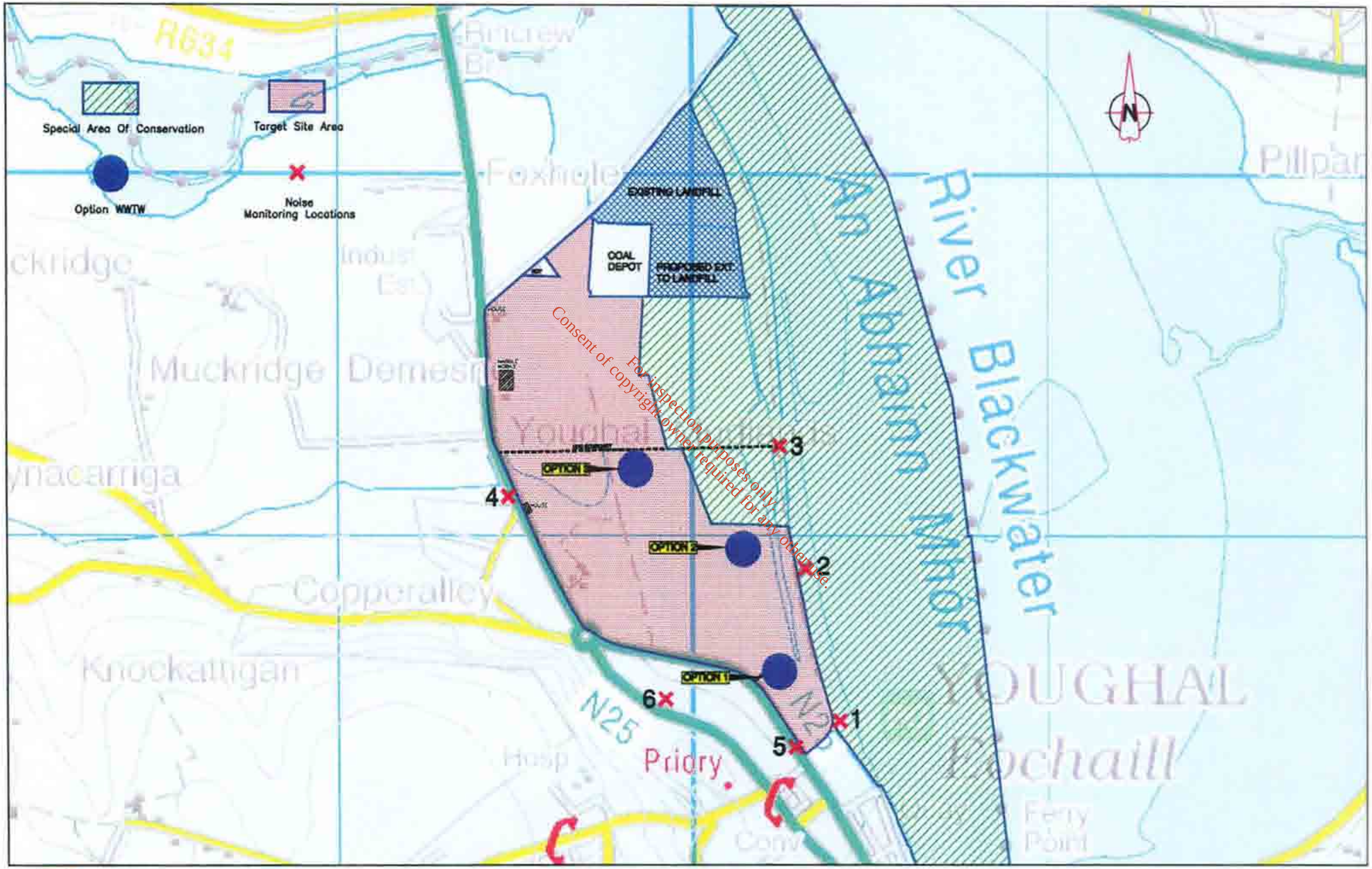
LAeq The continuous equivalent A-weighted sound pressure level. This is an "average" of the sound pressure level.

LA90 The noise level exceeded for 90% of the measurement period. This is normally used to measure background noise.

LA10 The noise level exceeded for 10% of the measurement period. This is normally used to measure road traffic noise.

A-weightings The human ear is sensitive to different frequencies of sound. The A-weighting represents the response of human ear to sound.

BS 4142 The Standard BS 4142 has been used to determine the level, which if emitted from the site would be likely to lead to complaints. The results of this assessment are shown in Table 3. This standard recommends that a level of noise from a new industry of 10dB lower than the background noise level would be unlikely to lead to complaints. If the noise level from the industrial source is the same level as the background noise, then this is of marginal significance. An increase of 10dB would be likely to lead to complaints. It has been assumed that the noise from the site will be tonal in nature. Table 3 shows the maximum level which, if emitted from the site would be unlikely to lead to complaints. This shows that options 2 and 3 are much less likely to cause complaints. Comparing the maximum limits with the measurements at Greystones, options 2 and 3 would be unlikely to cause complaints and option 1 would be of marginal significance.



Atkins McCarthy

NOISE MONITORING LOCATIONS FIGURE F.1