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An Ghníomhaireacht um Chaomhnú Comhshaoil

Water Quality in Ireland 2001-2003

P. Toner, J. Bowman, K. Clabby, J. Lucey, M. McGarrigle,
C. Concannon, C. Clenaghan, P. Cunningham, J. Delaney, S. O'Boyle,
M. MacCárthaigh, M. Craig and R. Quinn

Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil
PO Box 3000, Johnstown Castle, County Wexford, Ireland

Telephone: +353-53-60600 Fax: +353-53-60699
Email: info@epa.ie Website: www.epa.ie

Lo Call: 1890 335599

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SCOPE OF REPORT

This report presents a review of water quality in the State in the years 2001-2003, based on measurements made in the period at some 3000 locations on 13,200 km of river and stream channel, on 492 lakes and 25 estuarine and coastal water areas and at some 300 groundwater sampling locations. While the figures for rivers, streams and tidal waters are similar to those in the previous reporting period (1998-2000), those for lakes and groundwaters represent a significant increase in the coverage of the measurements available for the current reporting period. Information on the water quality conditions in canals is also reviewed. These water quality data have been generated primarily by the ongoing surveys carried out by EPA and the local authorities and are complemented by those provided by a number of other bodies, in particular the Central Fisheries Board and the Marine Institute. The report also presents an account of the work undertaken to date by the EPA, local authorities and other bodies to implement the Water Framework directive, adopted by the EU in 2000 and incorporated into Irish law in 2003.

WATER QUALITY OF RIVERS AND STREAMS

National Situation

The water quality situation in the 13,200 km of river and stream channel surveyed by the EPA, using a biological assessment method, is regarded as representative of the national status of such waters and to reflect any overall trends in conditions. Following the application of this method, the total river length surveyed in 2001-2003 has been apportioned to four biological Quality Classes: in terms of the estimated channel length in each class the status of this national river baseline in the current and two preceding three-year periods was as follows:

CLASS A	(unpolluted)	
2001-2003	**9163 kilometres**	**69.2%**
1998-2000	*(9237) “*	*(69.8%)*
1995-1997	*(8754) “*	*(66.9%)*
CLASS B	(slight pollution)	
2001-2003	**2370 kilometres**	**17.9%**
1998-2000	*(2257) “*	*(17.0%)*
1995-1997	*(2376) “*	*(18.2%)*
CLASS C	(moderate pollution)	
001-2003	**1637 kilometres**	**12.3%**
1998-2000	*(1637) “*	*(12.4%)*

1995-1997	*(1832) "*	*(14.0%)*

CLASS D	(serious pollution)	
2001-2003	**76 kilometres**	**0.6%**
1998-2000	*(112) "*	*(0.8%)*
1995-1997	*(122) "*	*(0.9%)*

Situation in the River Basin Districts

In order of the proportion of surveyed channel length in Class A, the River Basin Districts (RBDs), identified under the national Regulations giving effect to the Water Framework directive, may be ranked as follows (1998-2000 period in parentheses):

South Western RBD	**89%**	(83%)
Western RBD	**84%**	(84%)
North Western IRBD	**76%**	(74%)
Shannon IRBD	**63%**	(67%)
South Eastern RBD	**58%**	(62%)
Neagh Bann IRBD	**55%**	(54%)
Eastern RBD	**41%**	(42%)

As expected, the less densely populated and less developed regions have the higher proportions of unpolluted channel while the eastern and south-eastern areas are most affected by water quality degradation.

Changes since 1998-2000

The figures show that there was a slight reduction in the proportion of channel classed as unpolluted in the current compared to the previous period. This was due to a small increase in the slightly polluted category; in contrast, the proportion of moderately polluted channel has not changed between the two periods and there has been a reduction in the length of seriously polluted channel, which amounted to 76 km in 2001-2003, as compared with 112 km in 1998-2000, and is the lowest on record since the early 1990s. At RBD level, recent improvements (increase in Class A) have been recorded in the North Western and South Western RBDs in contrast to an overall deterioration in the Shannon RBD. Serious pollution has been substantially reduced in the Eastern RBD and to a lesser extent in the South Eastern RBD while moderate pollution has been reduced somewhat in the Western RBD in recent years.

Suspected Causes of Pollution

Of the 49 sampling locations classified as seriously polluted in the 2001-2003 period, 24 were suspected to be in this condition as a result of municipal, mostly sewage, discharges: this is four less than in the previous (1998-2000) survey period. The seriously polluted condition of a further seven locations was suspected to be due to agriculture, five to industry and the remaining 13 to miscellaneous or unknown sources. All of these seriously polluted locations are identified in Chapter Two. In regard to the moderate and slight pollution detected in the period, the bulk of this was suspected to be caused by municipal and agricultural sources in approximately equal measure.

Fish Kills

The total numbers of fish-kills in freshwaters (rivers and lakes) reported by the Central Fishery Board (CFB) in the period under review was 147, broadly similar to the previous period but still unacceptably high. It is likely that agriculture was responsible for some 48 of these fish kills, industry for 20 and sewage discharges for 17, with the balance attributable to 'other' (47) and 'unknown (15) causes.

Quality of Salmonid Waters

Data for the rivers and streams designated under national Regulations as salmonid for the purposes of the EU Freshwater Fish directive are reviewed. These show a similar situation to previous periods, breaches of the water quality standards set by the Regulations being due mostly to exceedances for nitrite. As has been pointed out in previous reports, the limit set for this parameter seems too stringent as it is exceeded in many cases where the levels of other substances are within requirements. Other parameters breached include dissolved oxygen, ammonium and copper but there were only a few instances of such breaches.

Impact of Selected Sewage Treatment Plants

The performance of several sewage treatment plants upgraded in the early 1980s, as well as four newly upgraded plants was assessed in the period, based on the conditions in the receiving waters. Serious pollution has been eliminated below most of these plants but restoration to fully satisfactory conditions has been observed in only a few cases, e.g. on the R. Liffey below the Osberstown treatment plant. It is likely that factors such as un-intercepted wastewater sources, plant overloading or under-performance and poor water quality upstream of the outfall are responsible for the failure to achieve such conditions in many cases; in addition, the absence of phosphorus removal facilities may allow eutrophic conditions to persist in some cases.

Nitrates

While the recent data confirm that nitrate concentrations in Irish surface waters are generally well within the mandatory limit set for abstraction and drinking waters, the concentrations recorded, in the south-east particularly, are significantly above natural levels and, therefore, may contribute to eutrophication in both fresh and tidal waters. However, it is noted that the recently measured levels represent a continuance of the downward trend in concentrations which became apparent in the mid 1990s in the major rivers of the south-east.

Toxic Substances in Rivers and Streams

The results of surveys of the levels of toxic and bioaccumulative substances ("Dangerous Substances") in rivers, undertaken by the EPA in the period, are reviewed. These measurements included the substances specified in the Dangerous Substances Regulations of 2001. With the exception of trace concentrations of the herbicides simazine and atrazine, the synthetic organic compounds included in the survey were not present above the analytical detection levels. Metal contamination was most pronounced in the R. Avoca, a situation which has been on record for many years and is attributable to the presence of the now defunct copper mines. The results of a recently completed research project, commissioned by the EPA, on the levels of endocrine disrupting chemicals (EDCs) in rivers are also summarised. Indications of an EDC effect in fish were only detected below the Osberstown sewage treatment plant on the R. Liffey.

Quality of Canal Waters

While the major canals, based on the results of recent surveys, continue to have generally good water quality, they are nonetheless subject to some pressures. The majority of cases of canal enrichment or faecal contamination detected can be attributed, for the most part, to the incoming feeder streams. The monitoring programme of the canals and their feeder streams, carried out by the CFB for Waterways Ireland, has among its objectives the identification of sources of enrichment or microbiological contamination and to eliminate these where possible. The monitoring programme will have to be expanded to include biological elements, such as phytobenthos, macrophytes and fish, in order to meet the needs of the Water Framework directive.

WATER QUALITY OF LAKES

National Situation

The main assessment of the water quality of lakes is based on estimates of the annual maxima of the chlorophyll concentrations. These are taken as indicators of the level of algal and cyanobacterial growth in the water column and thus of the tendency to eutrophication. In the 2001-2003 period, the great majority (82%) of the 492 lakes sampled were assessed as oligotrophic or mesotrophic, i.e.

having low or moderate levels of algal and cyanobacterial production and they were deemed, therefore, to be of satisfactory water quality status. The combined areas of these lakes represent 91 per cent of the total area of such waters included in the surveys in the period. Agricultural activities are considered to be the source of the nutrient enrichment affecting most of the 90 lakes assessed as eutrophic or hypertrophic on the basis of their chlorophyll concentrations but point sources including sewage discharges are involved in some cases.

Regional Situation

On a regional basis, the proportion (91%) of lakes sampled in the western counties showing satisfactory water quality was much greater than in the case of the midlands (59%) and the remainder of the country (77%). Most of the lakes assessed as polluted in the period, including 10 of the 12 classified as hypertrophic, are located in the north midlands area. The bulk of the lakes in the State are located in three of the seven River Basin Districts identified for the purposes of the Water Framework directive, viz Western RBD, North Western IRBD and Shannon IRBD. The Western RBD had the highest proportion of lakes with a satisfactory status in the period but such lakes were in the majority in all of the RBDs.

Analysis by Size

Most lakes in the State have areas less than 0.05 km^2 and only 100 are greater than 1 km^2. Of the 393 lakes surveyed in the period with areas less than 1 km^2, 80 per cent were assessed as having satisfactory water quality while a larger proportion (89%) of the medium sized waters (1.0-7.5 km^2) were similarly classified. Most (81%) again of the larger lakes (>7.5 km^2) were assessed as satisfactory in the period, these including Loughs Corrib, Derg, Ree and Mask, the largest lakes in the State. However, in the case of Loughs Ree and Derg, it is likely that the recent infestation of these lakes by the Zebra mussel has been partially responsible for the much of the reduction of the chlorophyll concentrations recorded in recent years. In the case of the large western lakes, while the open waters showed low or moderate levels of planktonic algae, instances of excessive algal growth have been noted in the littoral areas and these may indicate some localised nutrient enrichment. Chlorophyll concentrations indicative of serious pollution were again recorded in four of the large lakes, viz Loughs Sheelin, Gowna, Ramor and Oughter while in Lough Carrowmore in Co. Mayo algal and cyanobacterial growths were indicative of a moderate degree of eutrophication.

Trends in Lake Water Quality

The proportions of the surveyed lakes assessed as oligotrophic or mesotrophic have not changed appreciably since the mid 1990s despite the increased coverage in recent years. However, there has been a marked increase in the area of lake water assessed as mesotrophic, due mainly to the change of the of the large Shannon lakes from the eutrophic to the lower trophic status. Of 21 lakes examined periodically since 1976, roughly half have shown satisfactory conditions on all occasions although some have fluctuated between the oligotrophic and mesotrophic categories. Other lakes, e.g. Loughs Ennell and Leane, have shown significant reduction of pollution following earlier enrichment during the 29 year period, while a further group, including Loughs Sheelin and Ramor, have remained in a eutrophic or hypertrophic condition throughout the period.

Acid-Sensitive Waters

Monitoring of the representative acid-sensitive lakes and their feeder streams, in Cos Donegal (Lough Veagh), Galway (Lough Maumwee) and Wicklow (Glendalough Upper), continued in the report period and the results are presented. The biological and physico-chemical measurements continued to demonstrate the unimpacted status of the Donegal and Galway lakes while the indications of artificial acidification in the water of the afforested feeder stream catchment at Glendalough were again clear. There is no indication of any change vis-à-vis acidification in these lakes and streams over the last twenty years but the levels of non-marine sulphate recorded have declined, reflecting a European-wide trend in response to controls on emissions of acidifying gases to the atmosphere.

Bathing Waters

There are nine bathing water areas located on lakes which are designated for the purposes of the EU Bathing Waters directive. Monitoring showed that these were of good quality during the period, all complying with the directive's mandatory standards in each of the three years and only one failing to match the more stringent guideline values set by the directive in 2001.

QUALITY OF TRANSITIONAL AND COASTAL WATERS

National Situation

The general assessment of water quality conditions of tidal waters reported herein was intended primarily to detect any tendencies to eutrophication and was based on the combined survey data for the 1999-2003 period. A total of 69 individual estuaries and coastal waters bodies in 25 estuarine and coastal areas were assessed in this period. Of these, 12 were classed as Eutrophic, three as Potentially Eutrophic, 28 as of Intermediate Status and 26 as Unpolluted. The eutrophic waters include all or part of the estuaries of the Broadmeadow in Co. Dublin, the Slaney in Co. Wexford and the Blackwater and Bandon in Cos Waterford and Cork. The designation of a further estuary, Argideen, in Co. Cork as eutrophic is tentative as it is based solely on field observations of the growths of attached algae.

The status of some two thirds of the waters surveyed has remained unchanged since the previous assessment period (1995-1999) while of the remainder approximately equal numbers have shown either improvement or deterioration. Among those tidal water bodies showing improvement between the two periods were the Liffey estuary, the Upper Slaney estuary and the Upper Blackwater estuary each of which changed from Eutrophic to Intermediate status; notable instances of deterioration were those in Castletown Estuary, Dundalk and South Wexford Harbour where the trophic status changed from Intermediate in 1995-1999 to Eutrophic in 1999-2003. The assessments have implications for the level of treatment required for sewage in the context of the EU Urban Waste Water Treatment directive.

Data on nitrate and phosphate levels in the offshore waters of the Irish Sea arising from winter/spring surveys carried out by the Marine Institute indicate that these are not artificially enhanced to any significant extent.

Toxic Contaminants in Estuarine and Coastal Waters

Information on the levels of potentially toxic and bioaccumulative substances in tidal waters arises mainly from the monitoring of fish and shellfish tissue undertaken by the Marine Institute in connection with consumer protection requirements. Data for the 2001-2003 period continued to demonstrate the relatively low levels of such substances in samples taken in Irish waters which are well within those set for the purposes of consumer protection. Special surveys of the occurrence of the pesticide toxaphene and flame retardant chemicals were carried out in the period. Levels of the former in fish tissue were within recommended limits for consumers while those of the latter substances found in fish and sediment were at the lower end of the range reported for other European sites.

Quality of Shellfish and Shellfish Waters

The monitoring of the sanitary status of shellfish from commercial production areas in the period again showed that the majority of these sites fall into the category (B) of the official classification scheme, indicating the need for pre-purification before live molluscs are offered for sale. The sites receiving a C rating, and thus necessitating re-laying of molluscs for at least two months in clean areas before offering for sale, was less than 5 per cent , similar to the position in previous periods. Monitoring of the quality of shellfish waters in 2001-2003 showed that physico-chemical conditions were good and complied with the requirements of the relevant EU directive.

The occurrence of biotoxins in shellfish rearing waters continued to be monitored by the Marine Institute through the reporting period. This is based mainly on examination of phytoplankton samples for the presence of toxin producing algae, in particular species of Dinoflagellates. DSP (Diarrhetic Shellfish Poisoning) was again the toxin most frequently detected but a number of other toxins were recorded in the period. Several complete closures or restricted harvesting of shellfish areas were required in the period due to the presence of toxin-bearing algae, lasting up to 10 months in some cases.

Quality of Bathing Waters

Monitoring of the quality of 122 bathing areas indicated that these were generally of satisfactory status, over 97 per cent of the sites being in compliance with mandatory standards set by the EU Bathing Waters directive and with national regulations in each year of the reporting period. *In toto*, there were ten instances of annual data in non-compliance with the mandatory limits during the period but none of the locations involved failed in more than one of the three years. There was some reduction of the number of sites attaining the more stringent guideline conditions set by the EU directive compared to the previous period, the proportion attaining these dropping from 92 per cent in 2000 to 84 per cent in 2003.

The proposed revision of the Bathing Waters directive includes more stringent bacteriological standards than the existing instrument and, if adopted, could lead to lower compliance levels for the designated waters.

The Blue Flag designation for bathing waters, administered in Ireland by An Taisce and which, besides water quality, takes into account general amenity and other factors, was awarded to some 60 per cent of the designated beaches in the period.

Radioactivity Monitoring

The measurements of radioactivity in the marine environment carried out by the Radiological Protection Institute of Ireland are mainly intended to assess the impact of the discharges to the eastern Irish Sea from the Sellafield nuclear reprocessing facility in north-west England. The main artificial radionuclide of concern in these discharges, caesium-137, has remained at a relatively stable level in the Irish marine environment since the mid 1990s, these levels being considerably lower than those measured in the preceding decades. Caesium-137 continues to be the largest contributor to the total intake of artificial radionuclide via the consumption of fish and shellfish taken from Irish Sea waters.

Discharges of technetium-99 from the Sellafield facility have increased in recent years but as this isotope has a relatively low radiotoxicity, it contributes only a minor fraction of the total intake of artificial radionuclide through the consumption of seafood.

The currently estimated radiation dosage to heavy consumers of such food is, however, only a very small proportion ($<0.05\%$) of the total annual dosage received from all sources.

Oil Pollution Incidents

The documentation and investigation of oil pollution in the marine environment is the responsibility of the Irish Coast Guard whose remit covers an area stretching to 200 miles off the west coast and to the median line between Ireland and the UK in the Irish and Celtic Seas. Anti-pollution measures were successfully deployed in the period in most cases of vessel grounding or similar incident. In addition, 148 reports of pollution were investigated. Mineral oils accounted for the bulk of the polluting material observed but, in most cases, it was not possible to identify of the vessels involved. The position, in this respect, may be improved in future by the use of aerial surveillance.

QUALITY OF GROUNDWATERS

National Situation

Since many groundwaters are used directly, without treatment, for potable supply, it is considered appropriate that their quality should be assessed in relation to the requirements for such water set out in the EU Drinking Water directive and corresponding national regulations. The data obtained from the measurements made in the 2001-2003 period, at some 300 locations representative of the main aquifers and abstraction points, show again that the groundwater quality at the majority of locations was in conformance with these requirements at the times of sampling. However, a significant number of instances of exceedances of the limits, including those for faecal coliforms, were recorded and suggest that protection of these waters is not effective in some cases. A comparison of the 2001-2003 data with those for the 1995-1997 and 1998-2000 periods shows only minor changes for most parameters measured although there has been a reduction in the level of faecal coliform contamination.

pH and Conductivity

Most samples showed values within the normal range for these parameters which are generally reflective of natural characteristics. However, 51 samples had pH values less than 6.0, the most acidic having a pH of 4.8. Relatively high conductivity (>1000 µS/cm) was recorded in 41 samples, of which 15 exceeded 1500 µS/cm, the Maximum Acceptable Concentration (MAC) for drinking water.

Ammonia

Appreciable concentrations of ammonia in groundwater are indicative of contamination with organic waste and thus of the potential presence *inter alia* of sewage derived material. Some 6 per cent of the samples taken had ammonia concentrations over 0.23 mg/l N, the drinking water MAC, the highest concentration recorded being 30 mg/l N. Mean concentrations over 0.23 mg/l N were recorded at 20 of the 302 locations assessed for ammonia contamination. The data showed only minor differences when compared to those for the previous reporting periods.

Nitrate

The presence of high nitrate concentrations in groundwaters is of public health concern if these are used for potable supply and, in addition, may contribute to surface water eutrophication at times when these waters contribute the bulk of the flow in rivers and streams. More than one fifth of the samples analysed for nitrate had concentrations over the guide level (25 mg/l NO_3) for drinking water while in 34 samples the nitrate concentration exceeded the mandatory limit of 50 mg/l NO_3. Mean concentrations exceeded the guide level at 70 of the 301 sampling stations assessed and exceeded the mandatory limit at five of these locations. Again, only minor changes were recorded compared to the results for the earlier reporting periods.

Chloride

Chloride levels in freshwaters are largely determined by the amount of sea-derived salts entrained in precipitation. However, the presence of organic wastes such as sewage may significantly increase the chloride content of waters and if high enough these may impart a taste. The drinking water MAC for chloride is 250 mg/l and this was not exceeded in any of the groundwater samples taken in the period. Most (85%) of the sampling locations had mean concentrations less than 30 mg/l. There were no significant differences to results from the earlier periods.

Phosphate

The main implication of above natural levels of phosphate in groundwaters is the potential to contribute to eutrophication in associated rivers and lakes. The MAC for drinking water set by the 1988 directive is around 2.2 mg/l P, a level well above the concentrations typical of surface waters. However a limit for phosphate is not specified in the revised directive of 2000 which took effect in 2004. Mean phosphate concentrations exceeded 0.03 mg/l P, the limit set for the annual median concentration in rivers under the Phosphorus Regulations, at 94 of the 303 sampling locations assessed while this concentration was exceeded in 27 per cent of the samples analysed. The proportion of locations with raised concentrations of phosphate was greater than in the preceding reporting periods.

Iron and Managnese

High concentrations of these naturally occurring elements may cause tastes and the staining of fabrics during washing. Organic pollution of groundwaters can exacerbate this effect by producing the reducing conditions which lead to the formation of the soluble ions of the metals. MACs of 0.2 mg/l Fe and 0.05 mg/l Mn have been set by the drinking water directive. Mean concentrations of iron and manganese, respectively, exceeded the MACs at 16 and 17 per cent of the sampling locations in the 2001-2003 period, the highest concentrations recorded in individual samples being 7.9 mg/l Fe and 4.6 mg/l Mn. A continuing reduction in the proportion of sampling locations having mean concentrations over the MAC has been noted in the case of both metals over the three reporting periods.

Bacteriological Examination

The main threat to users of groundwaters is contamination with pathogenic microorganisms, such as *Salmonella,* originating in sewage, animal manures or other organic wastes. The potential presence of such agents is usually inferred from the level of contamination of waters with bacteria of faecal origin, in particular faecal coliforms. Thus, the drinking water directive requires that these be undetectable in samples. In the period under review, faecal coliforms were detected in 22 per cent of the samples of groundwater taken and at 49 per cent of the sampling locations. In 12 per cent of samples, counts of faecal coliforms exceeded 10/100 ml, a level indicating gross contamination. While these figures indicate that a significant level of faecal contamination of groundwaters persists, it is noted that the 2001-2003 data indicate a significant reduction of the incidence of such contamination compared to the earlier periods.

Uranium

Following the detection of uranium in some groundwater samples taken by the EPA in 2001, it was decided to conduct a more systematic survey of its occurrence in these waters in the current reporting period. Of the 1228 samples analysed, 80 per cent had concentrations less than the detection level of 1 μg/l while only 24 had concentrations over 10 μg/l. The highest concentration recorded was 132 μg/l in a sample from Co. Wicklow. These results may be compared with a tentative guideline limit of 15 μg/l for drinking waters proposed by the World Health Organisation. High levels of uranium may have a toxic effect on the kidneys. While an investigation by the Health Services Executive found no evidence of kidney disease associated with the use of water from the Wicklow source, some changes in the sourcing of water supplies were made as a result of the findings.

IMPLEMENTATION OF THE WATER FRAMEWORK DIRECTIVE

The directive establishing a framework for Community action in the field of water policy, commonly known as the Water Framework directive (WFD), was formally adopted by the EU Parliament and Council in October 2000 and incorporated into Irish law by Regulation in December 2003. The directive establishes a comprehensive basis for the management of water resources in the Member States and provides for the repeal of a number of existing directives dealing with water quality. The new directive requires the establishing of River Basin Districts (RBDs) as the units for water resource management; the primary role for RBDs is the formulation of management plans incorporating those measures required to meet the objectives of the directive, including the attainment of good quality for all waters by 2015. Good quality in the context of the directive means only minor change of the physical, chemical and biological characteristics of water bodies compared to the natural state and this is a more comprehensive requirement than that of existing directives which deal mainly with water quality.

The Regulations identify the EPA and the local authorities as the competent authorities for the implementation of the directive. The latter constitute the RBDs while the Agency is responsible for a number of technical aspects, including the formulation of monitoring programmes. In addition, the Regulations identify other public bodies which are required to assist in the implementation process.

The Regulations identify four RBDs wholly within the State (Eastern, South-Eastern, South-Western and Western) and three International RBDs shared with N. Ireland (Shannon, North-Western and Neagh-Bann). Implementation at RBD level is being undertaken by the local authorities with the assistance of consultants. Special arrangements have been made with the NI authorities to undertake the implementation in the three IRBDs. A national steering committee was convened by the Department of the Environment, Heritage and Local Government in 2001 to oversee the implementation of the directive. In January 2004, the EPA convened a Technical Co-ordination Group to deal with this at a more detailed level; a number of Working Groups have been established under the former to investigate and make proposals on specific matters.

The main task undertaken to date was the preparation of the Characterisation Reports for the RBDs. This involved the documentation of the physical, chemical and biological features of the surface and groundwaters and an assessment of the pressures acting on them due to human activity. For the surface waters this included the discrimination of the different physical types present having biological significance and the reference or high quality conditions for these types. Groundwaters were characterised on the basis of physical and chemical features. Water bodies subject to major physical alterations were identified; these will be candidates for designation as heavily modified water bodies in which appropriate objectives will apply.

The data on pressures were used to assess the risk of water bodies not achieving the objectives of the directive. Pressures in this context include, in addition to those with a potential to cause pollution, physical impacts on the morphology of the water body, presence of alien species and fishing pressure. Almost two thirds of river and larger lakes water bodies and a similar proportion of groundwater bodies were assessed as at such risk, with lower proportions in the case of transitional (estuarine) (~50%) and coastal (27%) water bodies. In most cases, the 'at risk' status was assigned on the basis of morphological factors or diffuse sources of pollution.

The Characterisation report was placed on the national web site for the directive (www.wfdireland.ie) in December 2004 in accordance with the Regulations and a summary of this was submitted to the EU Commission in March 2005. Tasks currently in hand are further refinement of the characterisation process, the formulation of monitoring programmes and the participation in intercalibration exercises related to classification systems. The next main task following will be the consideration of the measures needed to meet the objectives of the directive in those water bodies not achieving or at risk of not achieving good status.

CONCLUSIONS

The data and other information available for the 2001-2003 period indicate that:

- Eutrophication affects a considerable proportion of the surface waters of the State and is the main threat to these systems. At least in the freshwaters this is attributed primarily to excess phosphorus input.

- Intermittent contamination of groundwaters with faecal coliforms appears to be relatively widespread and constitutes a risk for those using such waters for drinking without sterilisation.

- Nitrate contamination, to a lesser or greater extent, affects both surface and groundwaters. In the former it is generally present at levels less than the guide limit set for drinking water but is likely to be contributing to the impact of eutrophication; in the latter it is often present at levels higher than those in surface waters and in a number of the locations sampled exceeds the limits for drinking water.

- The waters identified as unsatisfactory herein are not likely to be of good status in terms of the Water Framework directive and will, therefore, require improvement within the time limits set by that directive.

- The main restorative measure required for surface water is nutrient loss control. In relation to point sources, this will necessitate further upgrading of sewage and industrial waste treatment plants to facilitate the removal of phosphorus and/or nitrogen; for certain sewage treatment plants such upgrading is also a requirement under the Urban Waste Water Treatment directive.

- Control of nutrient loss from farming activities is a more widespread need. The National Action Plan for the implementation of the Nitrates directive should provide a basis for the reduction of both nitrate and phosphate losses from farm land, which is the main contributor of these nutrients to waters. It should also benefit groundwaters in reducing the potential for bacterial and nitrate contamination.

Chapter One

INTRODUCTION

In many countries, reporting on water quality is probably the longest established accounting of environmental conditions, reflecting the importance of water resources and their susceptibility to pollution. The usual purposes of such reports are to describe the current position, as shown by the measurements made in the particular period covered, and to highlight any trends apparent when comparisons are made with preceding periods. Of particular interest are any responses to recently introduced remedial measures or indeed to new or increased pressures generated by economic activities. On a more general note, water quality trends constitute one of the main environmental indicators used to assess progress towards sustainable development.

Reporting on water quality has been carried out on a regular basis in Ireland since the early 1970s when the initial surveys were undertaken by the Water Resources Division of An Foras Forbartha. The present report covers the period 2001-2003 and is the fourth such report to be issued by the EPA, the earlier reviews covering the years 1991-1994, 1995-1997 and 1998-2000 (Bowman *et al.* 1996, Lucey *et al.*, 1999, McGarrigle *et al.*, 2002). The survey work undertaken by the EPA itself and by the local authorities is again the principal source of the data on which the report is based; additional data have been obtained from a number of other public bodies, in particular the Marine Institute and the Central and Regional Fisheries Boards.

The scope of this review is wider than that of preceding reports in the series due to greater coverage of lakes and groundwaters. Data are available for almost 500 lakes in the current period compared to 300 in 1998-2000 while the number of groundwater sampling points used has increased from around 200 to over 300 between the two periods. In the case of the freshwater reaches of rivers, the channel length of 13,000 km surveyed in 2001-2003 is the same as that covered in the previous report while the 25 estuarine and coastal waters dealt with below are also the same as those reported on for the 1998-2000 period.

The proportions of all waters in the State which these surveyed rivers, lakes, estuaries and groundwaters represent is relatively limited. In relation to surface waters, the currently accepted baseline is the representation of such waters on the 1:50000 series of Ordnance Survey maps (the Discovery Series) which have been used for the purposes of the Water Framework directive (see below). These show approximately 74,000 km of river and stream channel, 12,000 lakes and 500 estuaries and saline lagoons. Clearly these greatly outnumber the surveyed waters, especially in the case of lakes and estuaries. However, the majority of such waters depicted on the OS maps are very small, e.g. in the case of rivers and streams, over 50 per cent is first order channel while in the case of lakes some 95 per cent are less than 1 ha in extent. On the basis of *surface area*, the proportions of the different waters covered by the surveys are much greater than the foregoing statistics would suggest since these surveys include all of the larger river channels, lakes and estuaries. In the case of groundwaters, sampling points are located in all of the significant aquifers identified by the Geological Survey Office. It is likely, however, that the monitoring requirements of the Water Framework directive will result in an expansion of the coverage for all waters compared to the current position.

The surveys reported on here largely reflect the implementation of the national monitoring programmes prepared by the Agency for surface and groundwaters in accordance with its statutory obligations under Section 65 of the Environmental Protection Agency Acts 1992 and 2003. These are available for inspection on the Agency's web site (www.epa.ie). The primary obligation to implement these programmes rests with the local authorities and the EPA but the Agency can make arrangements for specific monitoring tasks to be carried out by other bodies. In this respect the programmes incorporate, as appropriate, monitoring of waters carried out by a number of other public authorities, in particular the Central and Regional Fisheries Boards and the Marine Institute.

The biological survey of rivers, on the results of which the quality classification of such waters is primarily based, is carried out by the Agency itself while the physico-chemical aspects are monitored in surveys undertaken directly or indirectly by the local authorities. With regard to lakes, the bulk of the monitoring is undertaken by the local authorities and the fishery boards but the Agency carries out annual surveys of the larger lakes on the main channel of the R. Shannon and of a number of acid-sensitive lakes. The monitoring of groundwater quality is undertaken by the Agency with analytical support from a number of the local authorities.

The Agency itself currently undertakes the bulk of the monitoring of the general water quality conditions in tidal waters; this survey work is complemented by the bathing waters monitoring programmes of the local authorities and the shellfish waters monitoring and other marine monitoring programmes operated by the Marine Institute. Data on radioactive substances in the marine environment is available from the investigations undertaken by the Radiological Protection Institute of Ireland while information on oil pollution incidents occurring in the period have been supplied by the Irish Coast Guard.

In recent years, a considerable amount of additional data on water quality has been generated in the course of research projects carried out with the support of the EPA-managed Environmental Research, Technological Development and Innovation Programme. This applies in particular to the projects intended to support the implementation of the Water Framework Directive. Such data have been used to complement those arising from the routine monitoring surveys in the assessments of waters presented in this report.

The national monitoring programmes will be reviewed in the near future to bring them into line with the requirements of the Water Framework Directive. The directive was incorporated into Irish law under Regulations made in December 2003 (Minister for the Environment, Heritage and Local Government, 2003); *inter alia*, these require the EPA to develop monitoring programmes and to identify the public bodies by whom the monitoring is to be undertaken. The programmes are to be prepared by June 2006 and to be operational not later than December of that year. This and other aspects of the Regulations are described in more detail in Chapter Six.

The following four chapters set out and discuss, in turn, the data for the rivers, streams and canals, for lakes, for estuarine and coastal waters and for groundwaters. This is followed by a chapter describing the work carried out to date to implement the Water Framework Directive. A final chapter provides a general discussion of the information presented in the report together with conclusions.

In a change from preceding reports, the tabulations of the detailed analyses of river quality in each Hydrometric Area, together with data summaries for individual lakes, are now presented on the accompanying CD ROM. The statistical compendium of the physico-chemical and biological data on the water quality of rivers and streams, together with the physico-chemical data for tidal waters, will be available later, on request, on a separate compact disk (price €10). Copies of such data for specific rivers will be made available free on request.

Colour-coded River, Lake and Tidal Water Quality Maps are included on the accompanying CD ROM as PDF files. Printed versions of these maps (70 cm x 100 cm, approx.) may be purchased separately (Price €10 each) in flat (poster) or folded form from the EPA Publications Office, McCumiskey House, Richview, Clonskeagh Road, Dublin 14.

Chapter Two

THE WATER QUALITY OF RIVERS AND STREAMS

INTRODUCTION

This chapter gives an overview of water quality in a representative 13,200 km baseline length of channel comprising 1132 of the country's rivers and streams, which were biologically surveyed in the period 2001-2003. Water quality trends on a national, regional and local basis are identified by comparison with previous overviews of the position. Results of physico-chemical measurements made on these waters in the period are also presented, in relation, in particular, to the levels of nitrate contamination and to the quality of designated salmonid waters. The chapter also presents information on the measurements of toxic substances in river waters and on the quality of canal waters.

The 13,200 km baseline includes all of the readily accessible rivers and streams depicted on the Ordnance Survey map entitled 'Rivers and their Catchments Basins'. Since one complete survey of this channel length takes three years, it is important to note that the overview presented in these reports cannot represent the most recent position for all rivers. As discussed in Appendix I, water quality is optimally assessed by a combination of biological and chemical methods but the national position in this and in previous reviews is largely based on the biological surveys, as many rivers and streams, particularly those in more remote areas, are either not surveyed chemically or the frequency of such surveys is inadequate.

Routine water quality monitoring programmes are of most value in assessing the effects of more or less continuous inputs of waste but short-term pollution events may well escape detection, particularly by routine chemical surveys which generally rely on relatively infrequent grab samples. However, effects of such once-off events on flora and fauna are usually detectable for some considerable time afterwards, so that the biological surveys are likely to detect them in many instances. Again, however, because of the current frequency of assessment (three yearly), the biological survey is not expected to adequately reflect all such transient events.

The rivers surveyed biologically in the current period are tabulated by Hydrometric Area (see below) on the accompanying CD ROM. For each river, the year of the most recent survey is shown and the surveyed channel length is apportioned to four biologically-based Quality Classes. The overall condition of each Hydrometric Area is also summarised in diagrammatic form and shown alongside a similar representation of the national position for comparative purposes.

A colour-coded River Quality Map depicting biological quality at each of the 3150 locations surveyed is also to be found on this CD ROM: hard copies of this map are available from Publications, EPA, Richview, Clonskeagh, Dublin 14. Smaller streams which were are not routinely surveyed are shown without an identification code on this map.

Detailed biological and chemical information for individual sampling stations will be made available later on the a separate CD ROM. In this connection, EPA gratefully acknowledges the physico-chemical data kindly supplied by the local authorities and by special projects such as the Three Rivers Project (Boyne-Liffey-Suir).

WATER QUALITY ASSESSMENT

The biological river quality (Q or biotic index) classification system is set out and discussed in detail in Appendix I and is summarised hereunder:

'Q' Value	**Community Diversity**	**Water Quality**	**Condition***
Q5	High	Good	Satisfactory
Q4	Reduced	Fair	Satisfactory
Q3	Much reduced	Doubtful	Unsatisfactory
Q2	Low	Poor	Unsatisfactory
Q1	Very low	Bad	Unsatisfactory

* 'Condition' refers to the likelihood of interference with beneficial or potential beneficial uses.

Intermediate indices Q1-2, 2-3, 3-4 and 4-5 are also used to denote transitional conditions. The scheme mainly reflects the effects of biodegradable organic wastes (i.e. deoxygenation and eutrophication) but toxic effects are also readily discernible and where such effects are suspected or apparent the suffix '0' is added to the biotic index (e.g. Q1/0, 2/0 or 3/0). In order to simplify this scheme the biotic indices are related to four Water Quality Classes viz., Unpolluted, Slightly Polluted, Moderately Polluted and Seriously Polluted as follows:-

Biotic Index	**Quality Status**	**Quality Class**
Q5, 4-5, 4	Unpolluted	Class A
Q3-4	Slightly Polluted	Class B
Q3, 2-3	Moderately “	Class C
Q2, 1-2, 1	Seriously “	Class D

Class A waters are those in which problems relating to existing or potential uses are unlikely to arise; they are, therefore, regarded as being in a 'satisfactory' condition. Classes B, C and D are to a lesser or greater extent 'unsatisfactory' in this regard. For example, the main characteristic of Classes B and C waters is eutrophication which may interfere with the amenity, abstraction or fisheries uses of such waters. Eutrophication is typically found in the recovery zones below seriously or moderately organically polluted reaches or it may arise as a consequence of the run-off of nutrients from agricultural or forestry land.

Waters assessed as Q3-4 (slightly polluted - Class B) are essentially transitional between the satisfactory Class A and the unsatisfactory Classes C and D. It is considered prudent, however, that these slightly polluted waters should also be classified as unsatisfactory in the analyses set out in this report because of the potential risk to wild game fish populations of nocturnal dissolved oxygen (DO) depletion which may occur in such waters, particularly in times of low flow and elevated temperature.

In Class D waters excessive organic loading leads to deoxygenation and may produce 'sewage fungus' growths; as a consequence, most beneficial uses may be severely curtailed or eliminated. Table I.1 in Appendix I sets out some of the principal characteristics of the four water quality classes and the relationship between these and the biotic indices (Q1 to Q5).

SAMPLING PROCEDURE

The freshwater reaches of rivers and streams are surveyed from an upper 'survey limit' to their confluences with other rivers or to their tidal limit. The survey limit is a point in the headwaters above which biological sampling is impracticable, usually because of lack of flow. Sampling sites are typically located at 5 km intervals with extra stations located in some reaches to reflect better the effects of point discharges or of other known or potential pollution sources. In order to determine the channel lengths in the various water quality classes it has been necessary to interpolate conditions between the individual sampling points: this procedure has been carried out in a systematic and standardised fashion having regard to typical or expected patterns of water quality recovery in rivers affected by waste discharges. River lengths quoted in the text refer to the surveyed, freshwater reaches, exclusive of lakes.

SURVEY RESULTS: MAIN FINDINGS

River Quality: National Status

On the basis of the 2001-2003 biological surveys, the national river channel baseline is classified as under:

Class A	**9163 km**	**(69.2%)**
Class B	**2370 km**	**(17.9%)**
Class C	**1637 km**	**(12.3%)**
Class D	**76 km**	**(0.6%)**
Total	**13,246 km**	

(Note this baseline has been adjusted to take account of the 6 km not surveyed in the current period; it has been assumed that this unsurveyed channel has retained the water quality status assigned in 1998-2000 (See Table 2.2). Note also that total length examined in 1998-2000 was 13,243 km and in 1995-1997 was 13,084 km.)

The results indicate that the bulk of surveyed rivers/stream channel length is in a satisfactory quality condition but a considerable length is affected by slight or moderate pollution; some 18 per cent (2370 km) is classed as slightly polluted/eutrophic, a further 12 per cent (1637 km) is being moderately polluted but less than 1 per cent (76 km) is currently subject to a serious degree of pollution. This length of seriously polluted channel is the smallest on record since the early 1990s.

An analysis based on the ***numbers of sampling locations*** surveyed is given below:-

Class A	**1830**	**(60.0%)**
Class B	**622**	**(20.4%)**
Class C	**548**	**(18.0%)**
Class D	**49**	**(1.6%)**
Total	**3049**	

River Quality in the River Basin Districts

The Water Framework Directive (EP and CEU, 2000) which came into force on 22nd December 2000 and which is incorporated into Irish legislation via a statutory instrument (Minister for the Environment, Heritage and Local Government, 2003) (see Chapter Six), rationalises and updates existing water legislations and provides for water management on the basis of River Basin Districts (RBDs). As pointed oput in Chapter One, the island of Ireland has been divided into eight such districts for management purposes (See Fig. 6.1). These are, for the most part, based on existing Hydrometric Areas as were the Water Resource Regions (WRRs) used for reporting at regional level in previous reports. Table 2.1 summarises the overall river quality situation in each of the seven River Basin Districts wholly or partly within the State. On the basis of the percentage of surveyed channel in Class A, these may be ranked as under (Figures in brackets are for the previous (1998-2000) period):

TABLE 2.1

Biological quality classification of river channel surveyed in each River Basin District in the 2001-2003 period.

River Basin District		Channel Length (km) in Class A	B	C	D	Total km
Neagh-Bann IRBD	**km**	**188.5**	**51.5**	**102.5**	**0.5**	**343.0**
(HA 03 & 06)	***%***	*55*	*15*	*30*	*0.1*	
(1998-2000)	%	*54*	*24*	*22*	*0*	
Eastern RBD	**km**	**468.5**	**321.0**	**342.5**	**21.5**	**1153.5**
(HA 07, 08, 09 & 10)	***%***	*41*	*28*	*30*	*1.9*	
(1998-2000)	*%*	*42*	*26*	*28*	*3.5*	
South-Eastern RBD	**km**	**1471.0**	**712.0**	**337.5**	**16.0**	**2536.5**
(HA 11, 12, 13, 14, 15, 16 & 17)	***%***	*58*	*28*	*13*	*0.6*	
(1998-2000)	*%*	*62*	*24*	*13*	*1*	
South-Western RBD	**km**	**1981.0**	**180.5**	**58.0**	**1.5**	**2221.0**
(HA 18, 19, 20, 21 & 22)	***%***	*89*	*8*	*3*	*0.1*	
(1998-2000)	*%*	*83*	*14*	*3*	*0*	
Shannon IRBD	**km**	**2109.0**	**709.0**	**493.0**	**19.0**	**3330.0**
(HA 23, 24, 25, 26, 27 & 28)	***%***	*63*	*21*	*15*	*0.6*	
(1998-2000)	*%*	*67*	*18*	*14*	*1*	
Western RBD	**km**	**1852.0**	**240.5**	**118.0**	**6.5**	**2217.0**
(HA 29, 30, 31, 32, 33 & 34 & 35)*	***%***	*84*	*11*	*5*	*0.3*	
(1998-2000)	*%*	*84*	*9*	*7*	*0*	
North-Western IRBD	**km**	**1099.0**	**149.5**	**179.0**	**11.5**	**1439.0**
(HA 01, 36, 37, 38, 39 & 40)*	***%***	*76*	*10*	*12*	*0.8*	
(1998-2000)	%	74	11	14	*1*	
Total Length (km) surveyed this cycle	**km**	**9169**	**2364**	**1630.5**	**76.5**	**13240**
Percentages (2001-2003)	**%**	***69***	***18***	***12***	***0.6***	
Percentages (1998-2000)	*%*	*70*	*17*	*12*	1	

*Drowes and Duff Rivers totals transferred from HA35 to HA36 to agree with RBD definitions.

South Western RBD	**89%**	(83%)
Western RBD	**84%**	(84%)
North Western IRBD	**76%**	(74%)
Shannon IRBD	**63%**	(67%)
South Eastern RBD	**58%**	(62%)
Neagh Bann IRBD	**55%**	(54%)
Eastern RBD	**41%**	(42%)

As expected the less densely populated and less developed regions have the higher proportions of unpolluted channel while those on the eastern and south-eastern seaboard are most affected by water quality degradation.

River Quality: Hydrometric Area Analysis

By agreement between the hydrological agencies in the State and in Northern Ireland, the island is divided into 40 Hydrometric Areas (HA), each of which comprises a single large river catchment or a group of smaller catchments (see map accompanying river data tabulations on accompanying CD ROM). Table 2.2 sets out the year(s) in which each area was surveyed (in the current period) and the lengths of channel in the four Biological Quality Classes A, B, C and D and also the national totals and percentages; these latter may be taken as the ‘national averages' against which each area might be compared. This analysis also shows that the cleanest waters are to be found in the more remote, less developed, less populated areas along the southern, western and north-western seaboards with the most polluted rivers and streams, generally speaking, in the east and south-east.

RIVER WATER QUALITY TRENDS

1971 Baseline (2,900 km)

Fig. 2.1 depicts quality trends in a 2900 km baseline established in 1971 when the first ever national survey of river quality was carried out (Flanagan and Toner, 1972). The objective of this survey was to assess the water quality situation in the 'main' rivers and their principal tributaries concentrating on known and potential sources of pollution, mainly from towns and industries (i.e., point sources). As a consequence, many of the cleaner, more remote rivers and streams were not included and, in general, smaller streams were considerably under-represented.

Surveyed eight times since its initiation, this baseline shows that while serious, mainly point source pollution had been virtually eliminated by the mid 1990s, the proportion of unpolluted channel had also fallen (from 84 per cent in 1971 to just 51 per cent in 1997) due to a substantial increase in slight and moderate pollution. The two recent surveys show, however, a clear reversal of this downward trend with Class A channel increasing by a six per cent (to 2000) and by a further 3 per cent (to 2003). This trend is mirrored by a two per cent reduction in the extent of moderate pollution and a

TABLE 2.2

Analysis by Hydrometric Area (HA) of the 2001-2003 surveys showing year and Channel length surveyed and the estimated lengths in the four biological classes. For trend analysis see end of table.

HA No.	Hydrometric Area	Year Surveyed	Channel Length (km) in Class A	B	C	D	Total km
01	Foyle	2001	150.0	27.0	21.5	0.0	198.5
03	Bann	"	33.5	2.0	42.5	-	78.0
06	Newry, Fane, Glyde & Dee	2003	155.0	49.5	60.0	0.5	265.0
07	Boyne	"	109.5	221.0	148.5	-	479.0
08	Nanny - Delvin	"	11.0	28.0	80.0	3.0	122.0
09	Liffey & Dublin Bay	"	165.5	32.0	81.0	7.0	285.5
10	Avoca - Vartry	"	182.5	40.0	33.0	11.5	267.0
11	Owenavorragh	2001	26.5	9.5	35.0	2.0	73.0
12	Slaney & Wexford Harbour	"	305.5	120.0	23.0	-	448.5
13	Ballyteige - Bannow	2002	71.0	12.0	3.0	-	86.0
14	Barrow	2003	278.0	189.5	139.5	9.5	616.5
15	Nore	2001	249.0	217.5	47.5	4.0	518.0
16	Suir	2002/03	477.5	144.0	84.0	0.5	706.0
17	Colligan - Mahon	2001	63.5	19.5	5.5	-	88.5
18	Blackwater (Munster)	2003	693.5	83.5	29.5	1.0	807.5
19	Lee, Cork Hbr & Youghal Bay	2001	341.0	34.0	13.0	0.5	388.5
20	Bandon - Ilen	2003	271.5	18.0	3.5	-	293.0
21	Dunmanus - Bantry - Kenmare	2003	320.5	16.5	1.0	-	338.0
22	Laune - Maine - Dingle Bay	2001/02	354.5	28.5	11.0	-	394.0
23	Tralee Bay - Feale	2001/02	236.5	41.0	23.0	*	300.5
24	Shannon Estuary South	2002/03	80.5	117.5	113.5	2.5	314.0
25	Lower Shannon	2002/03	650.0	275.0	154.0	11.5	1090.5
26	Upper Shannon	"	775.5	231.0	136.5	3.5	1146.5
27	Shannon Estuary North	"	209.0	31.0	55.0	1.5	296.5
28	Mal Bay	2003	157.5	13.5	11.0	-	182.0
29	Galway Bay South East	"	117.0	19.0	33.5	5.5	175.0
30	Corrib	"	343.5	93.0	31.5	0.0	468.0
31	Galway Bay North	2002/03	73.5	16.0	1.5	0.0	91.0
32	Erriff - Clew Bay	"	215.5	26.0	13.0	0.0	254.5
33	Blacksod - Broadhaven	2002/03	185.0	19.5	9.0	0.0	213.5
34	Moy and Killala Bay	2001/02	519.5	49.0	26.0	1.0	595.5
35	Sligo Bay and Drowes	2003	398.0	18.0	3.5	0.0	419.5
36	Erne	2001	251.5	84.5	130.0	1.0	467.0
37	Donegal Bay North	2002	192.0	14.5	5.0	0.5	212.0
38	Gweebarra - Sheephaven	2003	258.0	7.0	4.0	4.5	273.5
39	Lough Swilly	2001	150.0	16.5	16.0	-	182.5
40	Donagh - Moville	"	97.5	-	2.5	5.5	105.5
Total Length (km) surveyed this cycle			9169.0	2364.0	1630.5	76.5	13240.0
Adjustments*			6.5	-6.0	-6.5	0.0	-6.0
Baseline : Current Status (km)			**9162.5**	**2370.0**	**1637.0**	**76.5**	**13246.0**
Percentages			*69.2*	*17.9*	*12.4*	*0.6*	
Baseline : Previous Status. (km)**			**9237.5**	**2259.5**	**1636.5**	**112.5**	**13246.0**
Percentages			*69.7*	*17.1*	*12.4*	*0.8*	
Changes since Previous Survey (km)			**-75.0**	**110.5**	**0.5**	**-36.0**	**0.0**

* Adjustments : Deduct the 'extras' (+), add the 'shortages' (-) shown in right hand column. (Explanation in text)
** Table 2.2 McGarrigle et al 2002

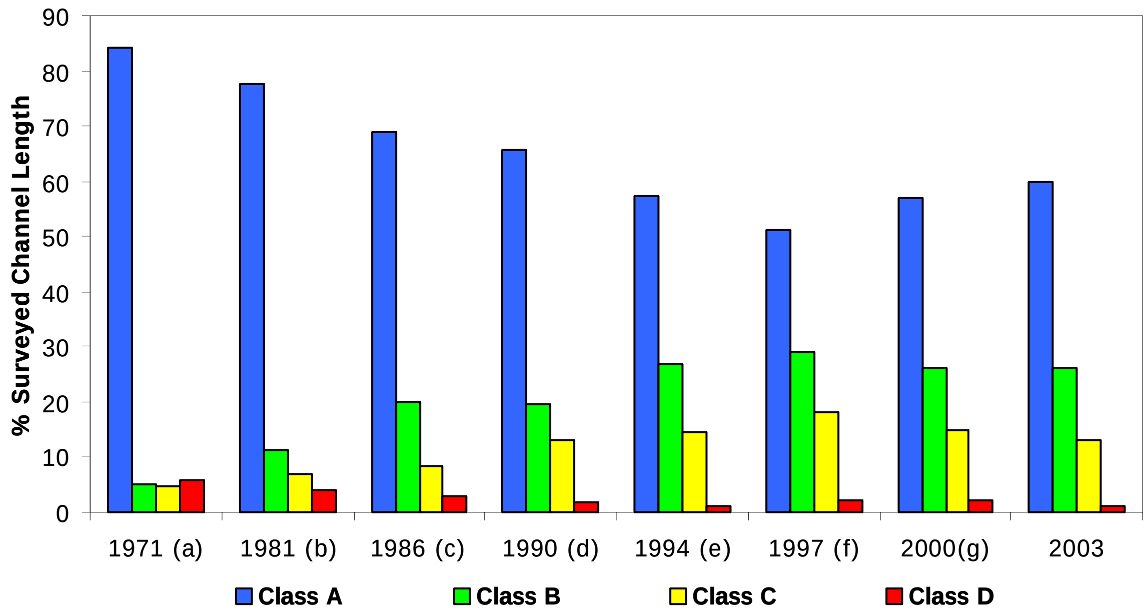


Fig. 2.1 Long-term trends (2,900km baseline) showing the percentage of surveyed channel length in four Biological Quality Classes:- A Unpolluted, B Slightly Polluted, C Moderately Polluted and D Seriously Polluted. Historic data from :- (a) Flanagan & Toner 1972, (b) Clabby *et al*. 1982, (c) Toner *et al*. 1986, (d) Clabby *et al*. 1992, (e) Bowman *et al*. 1996, (f) Lucey *et al.* 1999 and (f) McGarrigle *et.al.* 2002.

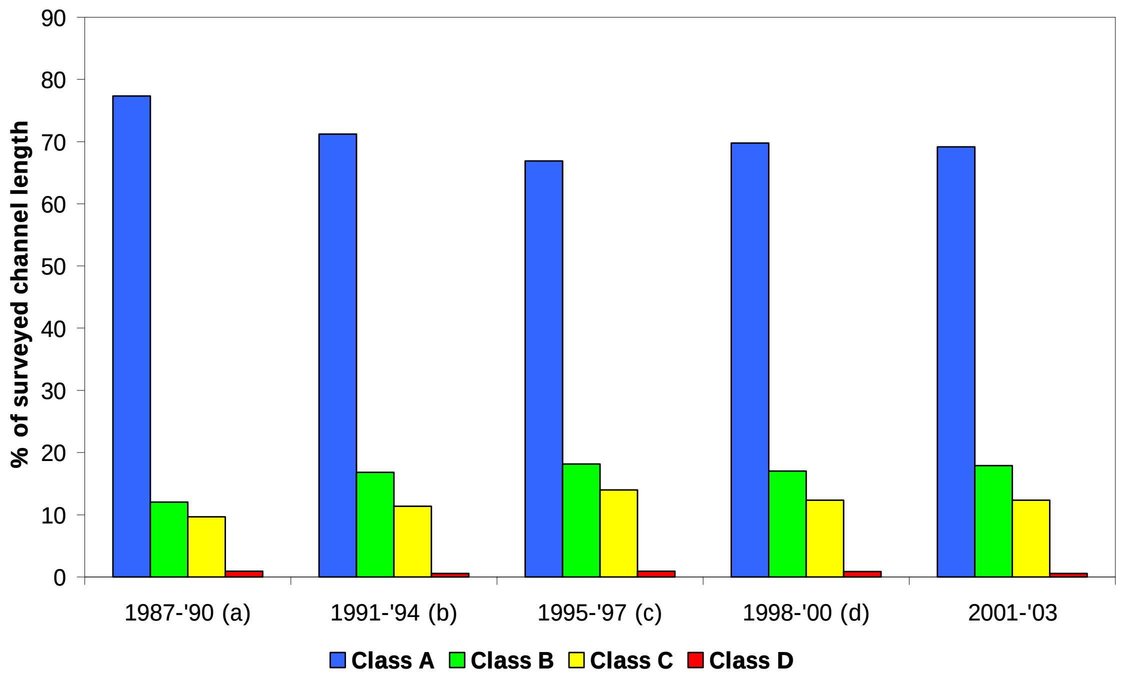


Fig. 2.2 Recent Trends in the 13,200 km baseline showing the percentage of surveyed channel length in four Biological Quality Classes : A Unpolluted, B Slightly Polluted, C Moderately Polluted and D Seriously Polluted. Historic data from (a) Clabby *et al.* 1992, (b) Bowman *et al.* 1996, (c) Lucey *et al.* 1999 and (d) McGarrigle *et. al.* 2002.

recent halving of serious pollution which now affects some 30 km (1%) of surveyed channel, a substantial improvement in comparison to the 1971 situation when 174 km (6%) were seriously polluted.

1987 Baseline (13,200 km)

Because of the intentional bias of the 1971 survey towards rivers and streams with potential pollution problems, the 2900 km baseline was not representative of river quality nationally and so the scope of the biological surveys was gradually extended so that by 1990 a much larger baseline had been established. This (13,000 km) baseline survey includes virtually all of the rivers and streams depicted on Ordnance Survey map entitled Irish Rivers and their Catchment Basins (1958) and is, therefore, regarded as representative of river quality nationally for the more significant channel.

Trends in this baseline (Fig. 2.2) follow a similar pattern to the above: throughout the 1990s the proportion of channel in Class A declined by 10 per cent (from 77% to 67%) due to the spread of slight and moderate pollution which increased by a similar percentage. Since then the two most recent surveys show that this situation appears to have improved: the proportion of channel in Class A is now of the order of 70 per cent of the total while less than one per cent of channel (76 km) is currently polluted at the serious level.

Recent Water Quality Trends in the River Basin Districts: (See Table 2.1)

Neagh-Bann IRBD

The bulk (77%) of surveyed channel in the State in this international RBD is in Hydrometric Area 06. With just 55 per cent of surveyed channel assessed as satisfactory (Class A) this RBD ranks second last in the national ratings based on the extent of unpolluted channel (see above). A 9 per cent reduction in slight pollution is offset by a recent, significant (8%) increase in the extent of moderate pollution while serious pollution, not recorded in 1998-2000 was recorded in a short stretch of the Ballymascanlan river in 2003.

Eastern RBD

While there has been a further small reduction in Class A channel which now stands at just 41 per cent of the total surveyed – the lowest in the country - the extent of serious pollution has been almost halved (to just 22 km). However, a considerable proportion (30%) of channel continues to be moderately polluted and a similar proportion has been assessed as slightly polluted.

South Eastern RBD

There has been a significant reduction in the extent of serious pollution in this RBD and in the Suir catchment (HA16), in particular, between the two recent survey periods: the Anner, Ara, Drish and Moyle, seriously polluted (in places) in 1998-2000, were free of this pollution in 2002/3. Slight pollution/eutrophication continues to affect a significant length of channel (28%), however, and this has increased by 4 per cent since the previous survey period. The extent of moderate pollution has remained unchanged at 13 per cent.

South Western RBD

An overall improvement is noted in this District where the proportion of channel in Class A has increased by six per cent: this is due to a similar reduction in slight pollution. Moderate pollution is unchanged (3%) and serious pollution, not recorded since 1987, was recorded in 2003 in the Brogeen (1 km) and the Bride (Lee) (0.5 km) rivers.

Shannon IRBD

An overall deterioration is indicated by increasing slight and moderate pollution which has brought about a 4 per cent reduction in Class A channel in recent years. Serious pollution was recorded in nine rivers in the period under review; these were the Lee (Tralee) in 2001, the Brosna below Mullingar, the Tullamore below the town, the Jiggy (Hind) below Roscommon, the Rhine below Granard, the Ahavarraga Stream below Drumcolliher, the lower Broadford, and the Loobagh below Kilmallock, all in 2002, and the Graney below Scarriff in 2003.

Western RBD

The bulk (84%) of surveyed channel in this District continues to be of a satisfactory standard (Class A) and there has been a two per cent overall reduction in moderate pollution. However, serious pollution has re-appeared in the RBD: this was in the Loughnaminoo Stream below Balla in 2001 while the Owendalulleegh river was seriously impacted by the Derrybrien landslide in October 2003. Slight pollution has also increased somewhat also (by 2%).

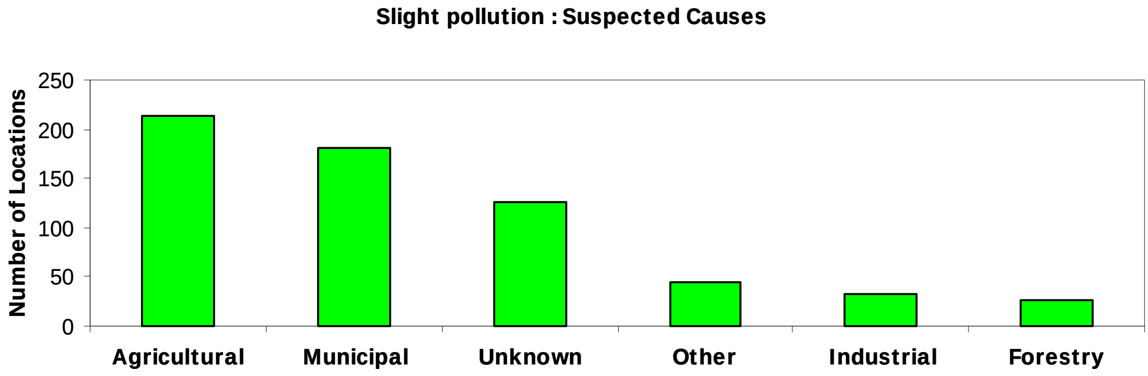
North Western IRBD

All levels of pollution decreased somewhat in the period under review resulting in a 2 per cent increase in Class A channel in this RBD. However, serious pollution was recorded below Smithboro' in 2001, in the lower Tullinteane river in 2002 and in the Aighe, upper Tullaghobegley, lower Murlin rivers and, for the first time, in the Keel Lough Stream in 2003.

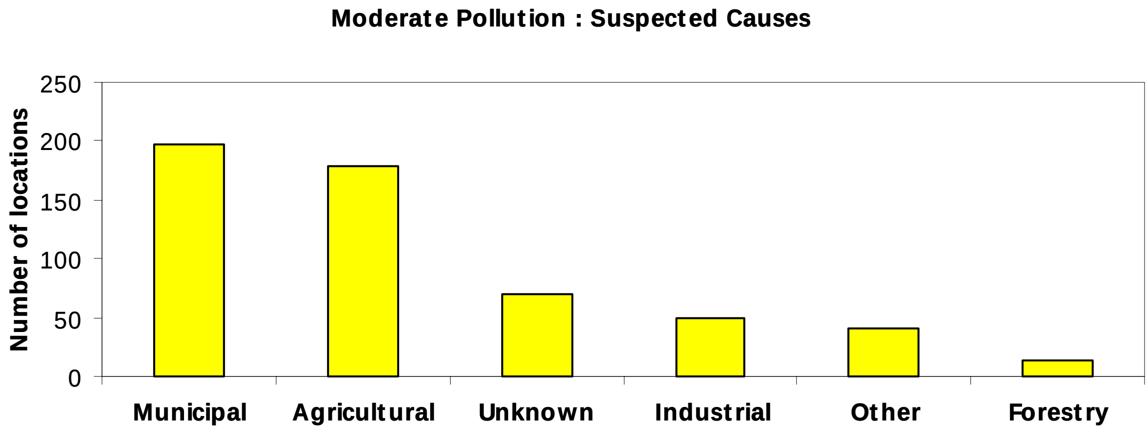
POLLUTION CAUSES

General Considerations

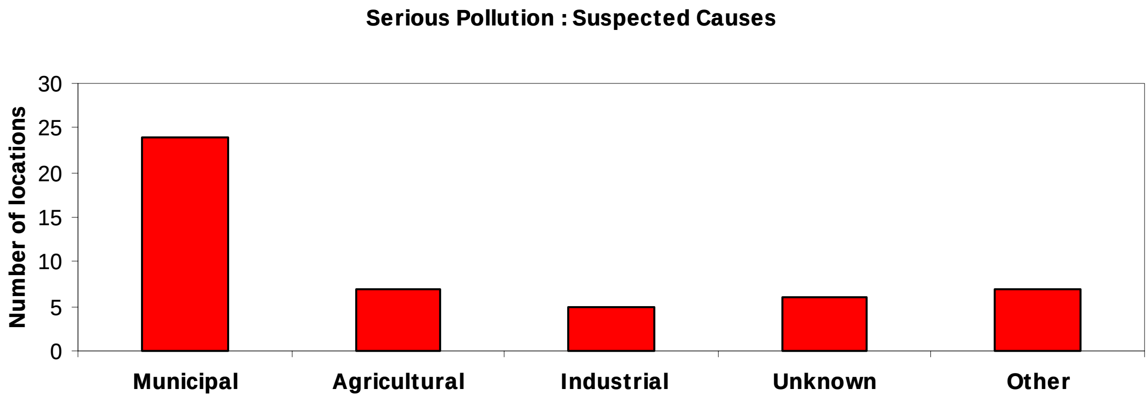
As for previous reports, an attempt has been made to determine the causes of the pollution observed in the rivers surveyed. While these causes have not been specifically proven, it is quite clear in most cases what they are likely to have been. The term 'suspected' is used in order to indicate the circumstantial nature of the analysis carried out in this report. The suspected causes of all observed pollution are summarised in Fig 2.3. In the figure, the heading 'Agriculture' includes the various



'Municipal' includes sewage (158), water treatment plant effluents (6) and diffuse urban runoff (16). *Other includes Siltation (15), Dredging (9), Lake Effects (13), Fish farm (2), Quarry (1), Landslide (1), Groundwater (1), Land clearance (1) & Domestic (1).



'Municipal' includes sewage (174),water treatment plant effluents (4) and diffuse urban runoff (20). *Other includes Siltation (10), Domestic (7), Dredging (4), Lakes (4), Fish-farm (4), Quarry (2), Landfill (4), Civil Works (3), Livestock Mart (1) & Oil (1).



'Municipal' includes sewage (22),water treatment plant effluents (1) and diffuse urban runoff (1). *Other includes: Mines leachate (3), Livestock Mart (1), Landslide (1), Fish farm (1) & Oil (1).

Fig. 2.3 The numbers of surveyed locations which were polluted either slightly, moderately or seriously in the period 2001-2003 grouped by suspected cause.

adverse effects of organic pollution and eutrophication caused by diffuse and point sources of agricultural wastes while 'Municipal' includes sewage, waterworks effluent, septic tank effluent and diffuse urban inputs. 'Lake Effects' indicates where rivers and streams are being enriched by the outflows from eutrophic lakes.

A total of 1218 surveyed locations were assessed as polluted, 622 slightly, 548 moderately and 49 seriously, in the period 2001-2003.

Slight pollution

Fig. 2.3 indicates that the bulk (214) of the recorded instances of slight pollution can be attributed to agriculture, with municipal sources (mostly sewage discharges) also featuring prominently (180 instances). The main effect of these sources is eutrophication (i.e., greatly enhanced plant and algal growth) caused by the plant nutrients nitrogen and phosphorus contained in farmland runoff and sewage effluents. Another frequently encountered effect is siltation where the more sensitive species are much reduced by the smothering effects of inert or organic silt from the above mentioned sources but also from such activities as quarrying, dredging, bog or forestry development and civil works. Eutrophic lake outflows have a marked effect on the downstream biota commonly resulting in the severe depletion or elimination of sensitive species.

Moderate Pollution

The bulk of recorded instances of moderate pollution can be associated with Municipal and Agricultural sources (198 and 179 instances respectively) and the main effects are intense eutrophication often accompanied by heavy bottom siltation. The majority of instances attributed to 'municipal' sources are locations downstream of towns or sewage discharges but there were also 20 instances attributed to diffuse urban runoff and four to water treatment plant effluent. Watering animals, farmyard runoff and inappropriate slurry spreading (or dumping) are the more commonly encountered causes of moderate pollution from agriculture. The 'Other' category includes instances due to other sources of siltation and to septic tanks, dredging, highly eutrophic lake outflows, fish-farms, quarries, landfills, civil works, livestock marts and oil pollution.

Serious Pollution

A total of 49 locations were assessed as seriously polluted in the 2001-2003 period of which 17 were new instances (Table 2.3). Suspected municipal (mostly sewage) discharges account for half of the recorded instances of serious pollution; most of the affected locations have been polluted for a considerable time but in some instances the deterioration is a recent phenomenon.

The Donagh River has been seriously polluted below Carndonagh on each occasion surveyed since 1971, ranking it as the most long standing instance on record. Other long standing instances are in

TABLE 2.3

Seriously polluted river locations in 2001-2003 grouped by suspected cause

River Name	Code	St. No.	Station Location	This Survey	1st record*
			SUSPECTED CAUSE : MUNICIPAL		
ST JOHNSTON[1]	01S01	0280	Second Bridge u/s Foyle River	2002	1985
NANNY (MEATH)	08N01	0040	Folistown Br	2001	2001
AUGHBOY (WEXFORD)	11A02	0180	Br NE of Middletown Ho	2001	1995
FIGILE	14F01	0050	Br S of Ticknevin Br	2003	1989
SLATE	14S01	0020	Quigley's Br	2003	2003
TULLY STREAM	14T02	0390	Soomeragh Br	2003	2003
GLORY	15G01	0045	0.1 km d/s Br N of Kilmaganny	2001	1995
NORE	15N01	2305	Thomastown Br (LHS)	2001	1987
BLACKWATER (MUNSTER)	18B02	2200	Fermoy Br (LHS)	2003	2003
BRIDE (LEE)	19B04	0610	Br at Crookstown RHS	2003	1997
AHAVARRAGA STREAM	24A02	0400	Br 0.5 km d/s Priests Br	2002	1989
LOOBAGH	24L01	0400	North Br d/s Kilmallock	2002	2002
BROSNA	25B09	0100	Butler's Br	2002	1971
GRANEY (SHANNON)	25G04	0400	400 m d/s Scarriff Br	2003	2003
TULLAMORE	25T03	0400	Br near Ballycowan Br	2002	1971
RHINE	26R04	0200	Br N of Cartron	2002	1987
LOUGHNAMINOO STREAM	34L04	0200	Br 600 m d/s Samp Stat 0100	2001	1984
TUBBERCURRY	34T02	0050	Br 1 km W. of Tubbercurry	2001	1980
ERNE	36E01	1410	Kilconny Belturbet (LHS)	2001	2001
KEEL LOUGH STREAM	38K01	0200	1.2 km u/s Crolly Bridge	2003	2003
MAGGY'S BURN[1]	39M01	0300	Just u/s Lough Fern	2001	1973
BREDAGH	40B02	0400	Moville Bridge	2001	1987
DONAGH	40D01	0300	1.5 km d/s Carndonagh Br	2001	1980
DONAGH	40D01	0400	Corvish Bridge	2001	1971
			SUSPECTED CAUSE : AGRICULTURAL		
GOWRAN	14G03	0020	Br E of Freneystown	2003	2003
HALFWAY HOUSE STREAM	16H02	0300	Br to NW of Halfway Ho	2003	2003
BROGEEN	18B06	0100	Br N of Islandav	2003	2003
MURLIN	38M03	0300	Gannew Bridge	2003	2003
MURLIN	38M03	0400	Straid Bridge	2003	2003
ROOSKY	40R01	0200	Second Bridge u/s Lough Foyle	2001	1987
ROOSKY	40R01	0300	First Bridge u/s Lough Foyle	2001	1987
			SUSPECTED CAUSE : INDUSTRIAL		
CAMAC	09C02	0500	Camac Close Emmet Rd	2002	1981
SANTRY	09S01	0300	Clonshaugh Rd Br	2002	1988
TULLY STREAM	14T02	0300	Kilberrin Br	2003	1986
MAGHERARNEY	36M01	0200	Magherarney Br	2001	1982
AIGHE	38A03	0150	Br NNW of Cashel	2003	1997
			SUSPECTED CAUSE : UNKNOWN		
PAINESTOWN[1]	09P01	0300	Bridge in Kill Village	2002	2002
CAPPANACLOGHY	15C06	0400	Br E of Clooncullen	2001	1987
CAPPANACLOGHY	15C06	1100	Br S of Coole	2001	1987
LEE (TRALEE)	23L01	0030	Ahnambraher Br (RHS)	2001	1996
BROADFORD	27B02	0500	Scott's Bridge	2001	2001
TULLINTEANE	37T01	0400	Just u/s Oily River confl	2002	1999
			SUSPECTED CAUSE : OTHER		
BALLYMASCANLAN	06B02	0100	Jonesborough Br	2003	2003
AVOCA	10A03	0700	Avoca Bridge	2002	1971
BARNACULLIA STREAM[1]	25B14	0100	Bridge at Barnacullia	2003	1982
SILVERMINES STREAM[1]	25S10	0100	d/s Silvermines complex	2002	1974
JIGGY (HIND)	26J01	0090	Br S.W. of Old Workhouse	2002	1987
OWENDALULLEEGH	29O01	0500	Ford at Tooraglassa	2003	2003
TULLAGHOBEGLY	38T01	0100	Ford 1.5 km d/s Lough Altan	2003	1997
TOTAL NO. OF LOCATIONS		**49**			

*1st Record is the year in which serious pollution was first recorded at location in question
[1] Indicates non-baseline streams

the Bredagh below Moville (since 1987), the Figile in the Ticknevin area (since 1989) and the Aughboy in Courtown (since 1995) while the Tubbercurry, St. Johnston, Rhine and Ahavarraga Stream have been seriously polluted on most occasions surveyed. The Brosna (below Mullingar) and Tullamore rivers also have a long history of heavy or serious pollution and although both had been slowly improving in the eighties and nineties they had reverted to a condition assessed as serious in 2002. Other recent reversions include the Tully Stream below Kildare, the Glory below Kilmaganny, the Nore at Thomastown, the Bride (Lee) at Crookstown, the Loughnaminoo Stream below Balla and the Maggy's Burn below Milford. New instances of serious municipal pollution include locations on the Nanny, Slate, Blackwater (Munster), Graney, Erne and Keel Lough Stream.

Agriculture is suspected as the source of seven cases of serious pollution, most of which are new: the exception is the Roosky river which has a long history of serious pollution.

A seriously polluted status is also long standing at the five locations affected by suspected industrial discharges and also in the case of the Avoca (See Box), Barnacullia and Silvermines streams which are being polluted by leachate from worked out lead and zinc mines.

Restoration of the Avoca River

The pollution of the Avoca River is of very long standing but until recently the possibility of redressing the situation had not been seriously considered. In response to an initiative by the Eastern Regional Fisheries Board, the University of Newcastle was contracted to undertake a scoping study in order to develop outline costings for remediation measures to restore the river to the status of a salmonid fishery. The study (Doyle et. al. 2003) concluded that it is indeed feasible to restore the river and proposes a further programme of work before the solution could be designed in detail. In angling terms alone it is estimated that the restored river has the potential to generate at least €750,000 per annum as well as greatly enhancing tourist and amenity value to the local community.

A total of 36 locations had recovered from serious pollution recorded in the previous period (Table 2.4). The majority (24) continued to be moderately polluted, a few (4) achieved 'slight pollution' status but only three have fully recovered: these are the Finn below Stranorlar, the Liffey below Osberstown and the upper reaches of the Yellow (Ballinamore). In the cases of the Finn and Liffey the recovery is attributed to much better sewage treatment whereas in the Yellow river the severe acid effects noted in 1998 were no longer apparent in 2001.

As previously stated there has been a major reduction in the length of channel assessed as seriously polluted – from 112 km in 1998-2000 to 76 km currently and as Fig 2.4 shows the improvements, of the order of a 50 per cent, are fairly evenly spread across the main suspected causes. The most striking improvement, however, is in the Municipal sector and this is attributed mainly to better sewage treatment plant performance. The increase in the 'Other/Unknown' category is largely due to the devastation of the Owendalulleegh by a landslide in 2003 and to a lesser extent to the reversion to serious pollution of the Tullaghobegley below a fish farm downstream of Lough Altan and to worsening oil pollution of the Ballymascanlan at Jonesborough.

TABLE 2.4

Baseline rivers in which serious pollution has recently (2001-2003) abated or partially abated, also showing current status.

River Name	EPA Code	Length km	Location	Class D In year:	Class in 2001-03
Finn (Donegal)	01F01	2.0	Br S of Stranorlar	1998	A
Liffey	09L01	1.0	d/s Osberstown STW	1998	A
Yellow (Ballinamore)	36Y01	4.0	Stralongford area	1998	A
Owenadoher	09O01	0.5	Lowermost reaches	1998	B
Dunhill	17D02	0.5	Ballyphilip	1998	B
Cauteen	25C04	0.5	d/s Gortnacoolagh Br	1999	B
Clodiagh (Tullamore)	25C05	0.5	Just u/s Clonaslee Br	1999	B
Blackwater (Kells)	07B01	1.5	Drumbannan area	2000	C
Boyne	07B04	4.0	d/s Edenderry	2000	C
Broadmeadow	08B02	3.0	u/s Ratoath	1998	C
Broadmeadow	08B02	3.0	Br in Ratoath	1998	C
Broadmeadow	08B02	3.5	d/s Ashbourne	1998	C
Camac	09C02	2.5	Br N of Brownsbarn	1998	C
Mayne	09M03	2.0	Hole in the Wall Rd Br	1998	C
Tolka	09T01	1.0	Rusk Br, Dunboyne	1998	C
Daingean	14D06	1.5	d/s Daingean	2000	C
Greese	14G04	1.5	Dunlavin area	2000	C
Triogue	14T01	3.0	d/s Portlaoise	2000	C
Tully Stream	14T02	1.5	d/s Kildare	2000	C
Anner	16A02	2.0	Drangan area	1999	C
Ara	16A03	4.0	d/s Tipperary	1999	C
Drish	16D02	1.0	Castletown area	1999	C
Moyle	16M01	4.0	Mocklerstown area	1999	C
Deel (Newcastlewest)	24D02	1.0	d/s Castlemahon	1999	C
Coos	25C08	2.0	Lower reaches	1999	C
Black (Westmeath)	26B05	1.5	Ballymahon Rd Br, Mostrim	1999	C
Feorish (Tarmonbarry)	26F03	1.0	Ballymoylin area	1999	C
Hind	26H01	7.5	4 points in & d/s Roscommon	1999	C
Laurencetown Stream	26L07	3.5	Br E of Sycamorehill	1999	C
Doonaha	27D01	0.5	Upper reaches	2000	C
Malin Stream	40M01	2.5	3 points in lower reaches	1998	C
Totals		**67.5**	**kilometres**		
		36	**locations**		

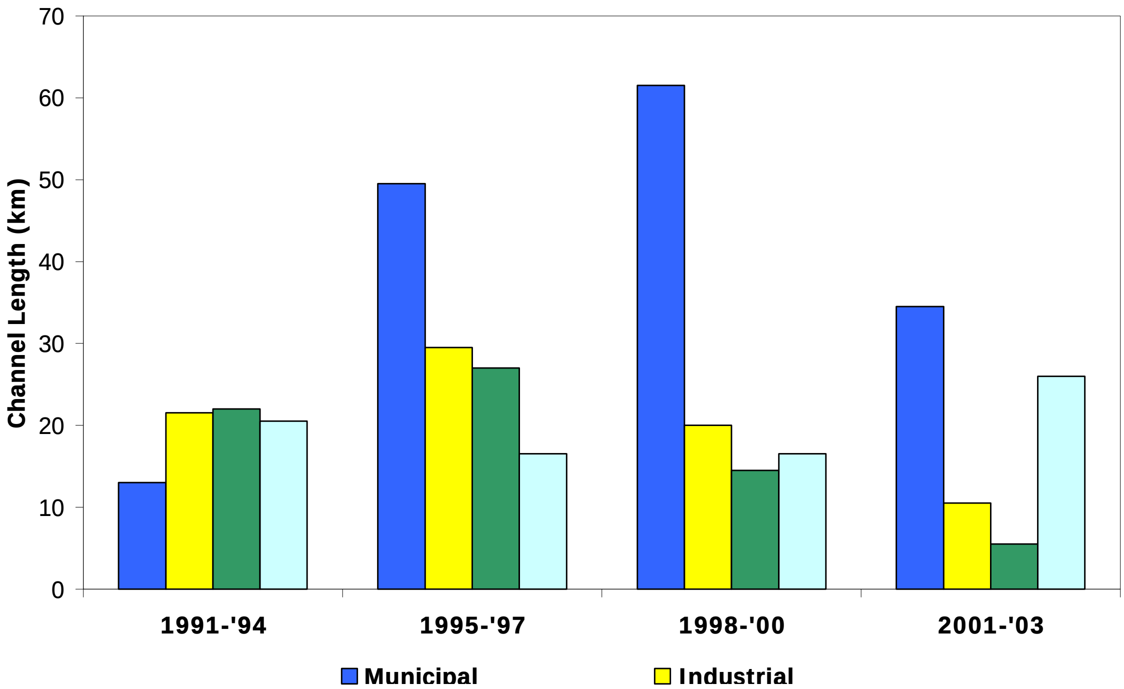


Fig. 2.4 Serious Pollution - Trends and suspected sources in four survey periods. Total channel lengths: 77, 122, 112.5 and 76.5 km respectively.

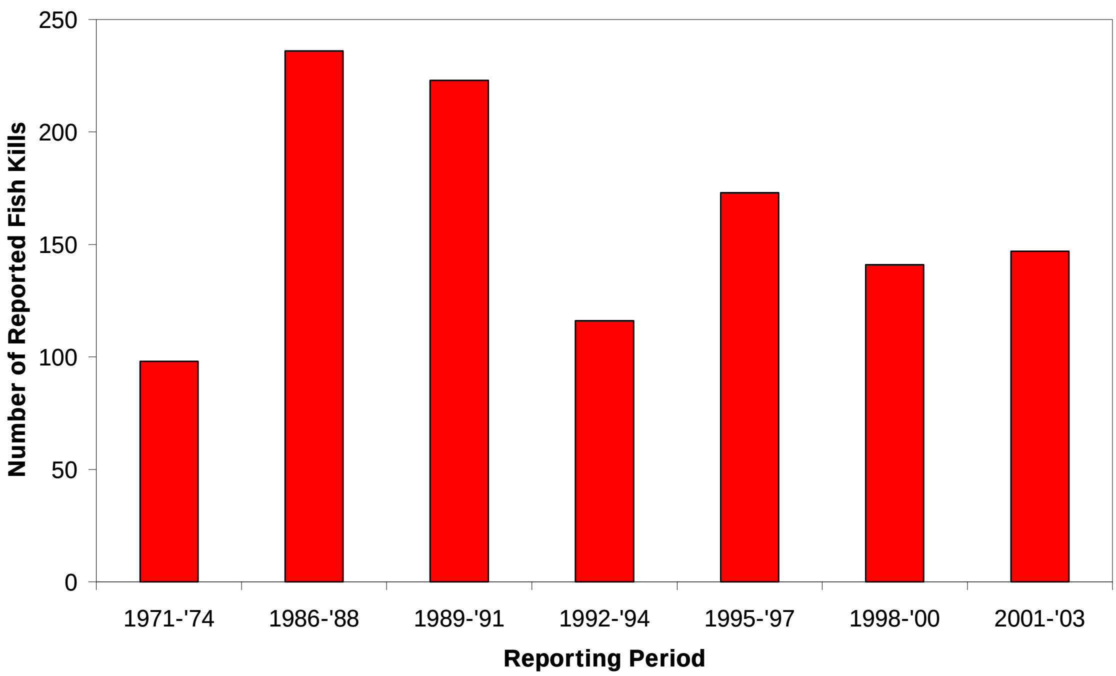


Fig. 2.5 The total number of fish kills reported by the Central Fisheries Board in the period 2001-2003 contrasted with totals from previous three and four-year periods. (See also Table 2.5).

FISH KILLS

Dead fish are only reported as “kills” if there is a strong suspicion that the death is pollution related or otherwise unnatural: for example older salmon die naturally after spawning and such deaths are not counted as kills. The total numbers of reported fish-kills in freshwaters (rivers and lakes) in the period under review is 147, broadly similar to the previous period (T. Champ, Central Fisheries Board (CFB) pers. comm.). A comparison with data from previous periods is given in Fig 2.5. In Table 2.5 reported kills in each period are grouped under seven main headings denoting the likely causes. The category ‘Other’ here includes seven instances attributed to acid mine drainage to the Avoca River, a river not included in previous CFB returns.

As it seems reasonable to assume that most if not all enrichment and deoxygenation is likely to be of anthropogenic origin, figures under these headings have been proportionally re-distributed (in the lower part of Table 2.5) to the most obvious primary sources (agriculture, sewage and industry). On the basis of this assumption it is possible that in the period under review, agriculture might have been responsible for some 48 fish kills, with 20 attributable to industry and 17 to sewage.

The historic data show a marked upsurge in kills between the 1970s and late 1980s/early 1990s, which was largely attributed to an eight fold increase in kills attributed to agriculture. In response to this alarming situation a nationwide public information campaign was launched by government in the late eighties and a campaign of vigorous enforcement was undertaken by local authorities and by the Central and Regional Fisheries Boards. These measures were primarily aimed at the agricultural sector and were very successful in combating the problem as the figures for the early nineties show: thus, between the 1989-91 and 1992-94 periods, the kills attributed to agriculture dropped by roughly one third (35%) but those due to industry fell by twice this rate (61%) and to sewage by even more (79%).

This encouraging trend was reversed in 1995-97, however, when total reported kills increased by 50 per cent. Since then there have been further improvements with totals in the region of 140 being reported for the current and previous period. Although the situation seems to have stabilised the number of reported fish-kills remains unacceptably high and demands a renewal of radical measures to redress the situation.

QUALITY IN DESIGNATED SALMONID WATERS

This section presents an overview of the quality of salmonid waters monitored in the context of the European Communities (Quality of Salmonid Waters) Regulations of 1988 (Minister for the Environment, 1988a). These regulations implement the Freshwater Fish Directive (CEC, 1978) and specify a range of water quality parameters to be monitored in the following designated waters:

TABLE 2.5

Numbers of fish kills reported in 2001-2003 and in six previous periods. Current statistics Courtesy of Central Fisheries Board (T. Champ, pers. comm.). Earlier data from CFB, McCarthy (1988) and Moriarty (1996).Note: In the lower part of the table, CFB categories "Enrichment" and "Deoxygenation" have been apportioned to the three most likely causes, viz Agriculture, Sewage and Industry

Period		Agriculture	Industry	Sewage	Enrichment	Deoxy.	Other*	Unknown	Total
1971-'74	No.	15	37	25			0	21	98
	%	*15*	*38*	*26*			*0*	*21*	
1986-'88	No.	145	40	5	6	1	10	29	236
	%	*61*	*17*	*2*	*3*	*0.4*	*4*	*12*	
1989-'91	No.	71	39	13	21	35	19	25	223
	%	*32*	*17*	*6*	*9*	*16*	*9*	*11*	
1992-'94	No.	45	15	3	30	1	14	8	116
	%	*39*	*13*	*3*	*26*	*1*	*12*	*7*	
1995-'97	No.	52	20	13	43	17	15	13	173
	%	*30*	*12*	*8*	*25*	*10*	*9*	*8*	
1998-'00	No.	41	19	7	31	1	7	35	141
	%	*29*	*13*	*5*	*22*	*1*	*5*	*25*	
2001-'03	No.	28	12	10	35	0	47	15	147
	%	*19*	*8*	*7*	*24*	*0*	*32*	*10*	

If the categories 'Enrichment' and 'Deoxygenation' are apportioned to the most likely causes of these conditions i.e., 'Agriculture', 'Industry' and 'Sewage' the figures which emerge would be as under:-

Period		Agriculture	Industry	Sewage	Other*	Unknown	Total
1971-'74	No.	15	37	25	0	21	98
	%	*15*	*38*	*26*	*0*	*21*	
1986-'88	No.	150	41	5	10	29	236
	%	*64*	*18*	*2*	*4*	*12*	
1989-'91	No.	103	57	19	19	25	223
	%	*46*	*25*	*8*	*9*	*11*	
1992-'94	No.	67	22	4	14	8	116
	%	*58*	*19*	*4*	*12*	*7*	
1995-'97	No.	89	34	22	15	13	173
	%	*51*	*20*	*13*	*9*	*8*	
1998-'00	No.	61	28	10	7	35	141
	%	*43*	*20*	*7*	*5*	*25*	
2001-'03	No.	48	20	17	47	15	147
	%	*32*	*14*	*12*	*32*	*10*	

* Other includes Acid Mine Drainage, Forestry, Poaching and Dredging.

Aherlow, Argideen, Munster Blackwater, Boyne, Bride (Waterford), Brown Flesk, Castlebar, Corrib (including Lough Corrib), Corroy, Dargle, Deel (Crossmolina), Feale, Fergus, Finn (Donegal), Glashagh (Lower), Glashagh (Upper), Glore (Mayo), Gweestion, Leannan, Lee (Cork), Lurgy, Maggy's Burn, Maine, Manulla, Moy, Mullaghanoe, Nore, Owengarve (Sligo), , Slaney, Spaddagh, Swilly, Trimoge, Vartry and Yellow (Foxford).

The parameter list covered by the Salmonid Regulation is shown in the Box below. A fuller discussion of the Freshwater Fish directive is given in Clabby *et al.,* (1992.)

Parameters required to be measured under the Salmonid Waters Regulations	
Temperature	Dissolved Oxygen
pH	Suspended Solids
BOD_5	Nitrites
Phenolic Compounds	Petroleum Hydrocarbons
Non-ionised Ammonia	Total Ammonium
Tot. Res. Chlorine	Total Zinc
Dissolved Copper	

Information pertaining to the 2001-2003 period is available for the for most of the specified parameters with the exceptions of phenols, petroleum hydrocarbons and residual chlorine. These parameters would normally be associated with discrete pollution events, which would be recorded separately and, generally speaking, it is unlikely that the designated waters would suffer from these pollutants. Data for suspended solids were generally not available and consequently this parameter is not dealt with here. ***The information below should not be taken, however, as indicating a definite compliance or non-compliance under the Regulations as it is based on a composite 3-year data set rather than on an annual set as would be provided by local authorities when making their official returns under the Freshwater Fish Directive.*** It is, rather, an indication of waters that are most likely to have breached the Regulations on the basis of the data supplied for the three-year period.

Table 2.6 summarises the overall situation in 2001-2003 showing those rivers which were or were not compliant for the parameters shown. Details as to the specific river locations where standard limits were exceeded are given in Appendix II. As indicated in the Table, 12 of the designated rivers (ten of which are in County Mayo) were likely to have been in compliance with all of the parameters for which sufficient data are available; these rivers are the Corrib, Corroy, Deel (Crossmolina), Glore (Mayo), Gweestion, Leannan, Manulla, Moy, Mullaghanoe, Spaddagh, Trimoge and Yellow (Foxford).

Exceedances of the prescribed limits were recorded for pH in just one river, DO in four, BOD in nine, Total Ammonium in three, Un-ionised Ammonia in one, Nitrite in 19 and Dissolved Copper in four

TABLE 2.6

Summary of numbers of recorded parameter exceedances in the 34 designated salmonid rivers in the period2001-2003. Exceedances were not recorded in those rivers shown in bold typeface. Further details in text.

River	pH	DO	BOD	Total Ammonium	Un-ionised Ammonia	Nitrites	Dissolved Copper
Aherlow			4			9	
Argideen						5	
Blackwater (Munster)						17	
Boyne		2		1	1	12	
Bride (Blackwater)						6	
Brown Flesk							4
Castlebar			1				
Corrib							
Corroy							
Dargle						1	
Deel (Crossmolina)							
Feale			2			3	1
Fergus						2	
Finn (Donegal)			1			8	3
Glashagh (Lower)						1	
Glashagh (Upper)						1	
Glore (Mayo)							
Gweestion							
Leannan							
Lee (Cork)						6	
Lurgy			1	1		2	
Maggy's Burn			1	1		2	
Maine		1				7	
Manulla							
Moy							
Mullaghanoe							
Nore		2	2			27	
Owengarve (Sligo)			1				
Slaney	2	1				15	
Spaddagh							
Swilly			3			58	1
Trimoge							
Vartry						1	
Yellow (Foxford)							
No. of exceedances. (Total 220)	**2**	**6**	**16**	**3**	**1**	**183**	**9**
% of exceedances	*1*	*3*	*7*	*1*	*0.5*	*83*	*4*
No. of rivers breaching parameter	**1**	**4**	**9**	**3**	**1**	**19**	**4**

rivers. The bulk (83%) of the 220 recorded exceedances was in relation to Nitrite (NO_2); as pointed out in previous reports, the level specified in the Directive is probably too low for Irish conditions and many rivers, considered unpolluted on the basis of other chemical and biological criteria, would have nitrite values in excess of the Regulation value (0.05 mg/l NO_2). BOD exceedances accounted for 16 per cent of the total and in virtually every case these were due to known point sources of pollution. Many were associated with other exceedances, for example of the ammonia and dissolved oxygen limits.

Copper exceedances were relatively infrequent – nine in just four rivers and all rivers were in compliance with the standard for zinc. It should be noted that both copper and zinc have sliding threshold values under the Regulations depending on the hardness range of the water since toxicity reduces as water hardness increases. Thus, it is necessary to have accompanying hardness values in order to evaluate the true situation regarding compliance with the Regulations. In some cases hardness values had to be estimated due to lack of data and this may have affected the final number of 'exceedances'.

THE IMPACT OF SELECTED SEWAGE TREATMENT PLANTS

One of the more important and practical uses of any water quality monitoring programme is in providing information on the success or otherwise of measures taken to reduce or eliminate pollution. Historically the discharge of poorly treated sewage and other wastes has been a major source of serious pollution in this country. Over the past forty years the various local authorities have been making great efforts to redress this situation and, as Figure 2.1 indicates, these efforts have been successful in significantly reducing the recorded incidence of serious pollution. In the mid 1980s, in order to get some idea of progress in combating sewage pollution, several of the then new or recently upgraded sewage treatment plants were selected for ongoing study (Toner *et. al.,* 1986). The objective was to record the rate of recovery of the polluted receiving waters and the most recent results of this ongoing exercise are presented in Table 2.7 below.

The results show that, relatively quickly after upgrading of the Carrickmacross, Castlebar, Mullingar and Tipperary treatment plants, serious pollution was eliminated in the receiving waters. Such substantial improvement was not immediately apparent in the cases of the Cashel, Mountmellick or Portlaoise treatment works but serious pollution eventually (i.e., in 1987-90) also disappeared from their receiving waters.

The initial (1984) striking improvement in the Proules river below Carrickmacross was not maintained, serious pollution reappearing in 1990 and again in 1997. Currently, although oxygen (DO and BOD) and ammonia results are quite satisfactory, average phosphorus values indicate a degree of eutrophication and the 2003 Q value indicates the likelihood of intermittent pollution not reflected in

TABLE 2.7

Median and extreme values for chemical parameters and the biotic indices (Q) recorded below sewage treatment plants pre upgrading and in six subsequent periods. N/a data not available

Town, River, Code	Survey	D.O.		B.O.D		Total Ammonia		o-Phosphate		
Sampling Station &	Period	% Saturation		mg/l O2		mg/l N		mg/l P		Q
year STW upgraded		Med.	Min.	Med.	Max.	Med.	Max.	Med.	Max.	(year)
Carrickmacross	pre 1978	n/a		n/a		n/a		n/a		1 (76)
Proules River	1983-85	80	66	2.3	4.5	0.18	0.80	0.34	1.06	3-4 (84)
	1987-90	79	60	4.2	11.3	1.03	7.14	0.46	4.31	1-2 (90)
06P01-0300	1991-94	86	38	4.1	14.1	0.25	11.50	0.15	1.60	2-3 (94)
(1978)	1995-97	84	15	5.0	24.3	0.71	6.49	0.26	2.84	2 ('97)
	1998-'00	87	77	2.3	8.0	0.11	1.79	0.17	0.79	2-3 ('00)
	2001-'03	94	81	2.6	5.0	0.1	0.41	0.05	0.20	2-3 ('03)
Cashel	pre 1983	n/a		n/a		n/a		n/a		2 (80)
Black Stream	1983-85	65	20	3.7	9.3	0.70	2.40	0.38	0.86	2 (85)
16B05-0100	1987-90	64	16	2.5	7.1	0.27	3.20	0.48	1.40	2-3 (89)
(1983)	1991-94	52	19	1.7	28.5	0.14	4.94	0.42	2.10	3 (93)
	1995-97	66	35	1.6	8.6	0.09	2.82	0.42	1.31	n/a
	1998-'00	75	32	1.0	6.1	0.04	1.14	0.08	1.05	2-3 ('99)
	2001-'03	84	37	0.8	2.6	0.04	0.17	0.03	0.08	2-3 ('02)
Castlebar	1979-80	66	11	6.9	14.0	0.60	3.10	0.20	0.50	1 (80)
Castlebar River	1983-85	85	60	1.8	4.6	0.05	0.40	0.11	1.20	3 (84)
34C01-0200	1987-90	95	70	2.0	5.7	0.04	0.25	0.07	1.00	3 (89)
(1981)	1991-94	88	64	2.1	5.2	0.04	0.33	0.04	0.66	3 (93)
	1995-97	91	71	1.7	4.3	0.04	0.18	0.01	0.09	3 ('95)
	1998-'00	89	67	1.7	6.4	0.06	0.42	0.04	0.13	3 ('98)
	2001-'03	93	76	1.4	6.9	0.08	0.52	0.04	0.08	2-3 ('01)
Mountmellick	pre 1981	n/a		n/a		n/a		n/a		1-2 (78)
Owenass River	1983-85	106	16	3.9	9.3	0.52	0.75	0.09	0.54	2 (84)
14O01-0300	1987-90	n/a		n/a		n/a		n/a		3-4 (89)
(1981)	1991-94	119	95	2.2	3.4	0.05	0.18	0.18	0.66	3-4 (93)
	1995-97	98	78 *	1.8	6.1 *	0.04	0.54 *	0.05	0.25 *	3-4 ('97)
	1998-'00	99	91	1.3	2.5	0.03	0.08	0.14	0.54	3-4 ('00)
	2001-'03	101	86	1.7	7.3	0.14	3.58	0.08	0.98	3-4 ('03)
Mullingar	pre 1979	n/a		n/a		n/a		n/a		1 (74)
Brosna River	1983-85	73	25	2.2	8.5	0.41	3.50	0.08	0.56	2-3 (84)
25B09-0100	1987-90	84	26	2.0	5.0	0.40	1.25	0.35	1.00	2-3 (90)
(1979)	1991-94	72	22	1.9	6.7	0.21	1.00	0.12	0.35	2-3 (93)
	1995-97	90	66	1.5	2.4	0.24	0.61	0.09	0.25	3 ('96)
	1998-'00	64	30	1.6	3.1	0.06	0.27	0.11	0.23	2-3 ('99)
	2001-'03	n/a		n/a		n/a		n/a		2 ('02)
Portlaoise	pre 1983	n/a		n/a		n/a		n/a		1 (81)
Triogue River	1983-85	97	48	7.1	18.1	2.0	6.0	0.35	1.45	2 (85)
14T01-0200	1987-90	n/a		n/a		n/a		n/a		2-3 (89)
(1983)	1991-94	86	55	3.9	10.3	0.9	3.2	0.24	1.90	3 (93)
	1995-97	84	43	4.6	9.0	1.1	3.6	0.49	1.62	2 ('97)
	1998-'00	86	28	4.8	8.9	1.6	4.6	0.17	1.28	2 ('00)
	2001-'03	86	50	2.3	8.0	0.3	1.8	0.12	0.63	3 ('03)#

Continued/

TABLE 2.7 Continued

Town, River, Code Sampling Station & year STW upgraded	Survey Period	D.O. % Saturation Med.	Min.	B.O.D mg/l O2 Med.	Max.	Total Ammonia mg/l N Med.	Max.	o-Phosphate mg/l P Med.	Max.	Q (year)
Thurles	pre 1982	n/a		n/a		n/a		n/a		3 (80)
Suir River	1983-85	81	55	2.5	17.1	0.10	1.30	0.06	0.48	3 (85)
16S02-1000	1987-90	90	61	1.9	50.0	0.08	0.62	0.07	0.43	3 (88)
(1982)	1991-94	96	57	1.4	4.7	0.06	0.33	0.06	0.33	3-4 (92)
	1995-97	96	63	1.7	5.1	0.03	0.20	0.07	0.40	3 (96)**
	1998-'00	89	55	1.3	3.3	0.06	0.51	0.07	0.31	3-4 ('99)**
	2001-'03	94	78	1.4	3.5	0.06	0.13	0.04	0.23	3-4 ('02)**
Tipperary	1979-80	64	22	6.0	8.7	0.84	2.40	0.24	0.39	1 (79)
Ara River	1983-85	78	38	2.7	14.6	0.21	0.74	0.18	1.10	3 (85)
16A03-0400	1987-90	79	46	2.4	24.6	0.20	1.50	0.24	1.50	3 (89)
(1981)	1991-94	84	55	2.3	26.0	0.17	0.90	0.28	1.17	3 (92)
	1995-97	78	53	2.3	8.6	0.18	0.97	0.30	2.12	3 (96)***
	1998-'00	75	36	1.9	56.0	0.18	5.40	0.19	1.02	3 ('99)***
	2001-'03	87	55	1.5	4.0	0.07	0.71	0.15	0.28	3-4 ('03)***

Recently upgraded treatment plants, pre (1998-2000) and post (2001-2003) upgrading

Ballyjamesduff	1998-'00	94	46	3.0	6.0	0.06	0.23	0.16	0.21	3 ('99)
Mountnugent River	2001-'03	96	79	<2.0	2.0	0.03	0.10	0.03	0.16	4-5 ('02)
26M02-0200										
Osberstown	1998-'00	94	88	n/a		0.1	1.81	0.11	0.38	2 ('98)
Liffey	2001-'03	97	82	2.6	9.3	0.05	1.45	0.17	0.40	4 ('02)
09L01-1200										
Edenderry	1998-'00	73	10	n/a		0.8	4.94	0.25	1.92	1-2 ('00)
Boyne	2001-'03	77	6	n/a		0.4	7.37	0.17	202	3 ('03)
07B04-0300										
Ashbourne	1998-'00	90	65	7.2	13.0	0.76	2.28	0.48	1.7	1 ('98)
Broadmeadow	2001-'03	105	90	2.6	9.3	0.05	1.45	0.17	0.40	2-3 ('01)
08B02-0500										

* Refers to St. 0220 1.3 km u/s 0300.
# Refers to St. 0300 4.5 km d/s 0200.
**Refers to St 1100 2 km d/s 1000
***Refers to St. 0440 2 km d/s 0400

the chemical results. In this case the poor re-aeration capacity of the receiving water in the reach immediately upstream of Lough Naglack is a significant factor militating against the achievement of fully satisfactory ecological conditions.

As indicated by occasional low DO values, high phosphate maxima and the 2002 biotic index the Black Stream continues to be significantly polluted below Cashel. The median values for most quality parameters, however, indicate that the pollution is most likely episodic and likely to be due to plant overload in flood conditions and/or to other, un-intercepted source(s) of pollution.

The initial (1984) major improvement in the Castlebar River eliminated serious pollution and following the installation of phosphorus reduction facilities in 1997 all of the chemical quality parameters indicated satisfactory conditions. The more recent data indicate increasing pollution again and this is tentatively attributed to storm overflows and un-intercepted wastes. A major programme is under way to upgrade the sewerage system in the town and to ensure that storm overflow problems are minimised.

While the most recent biological survey (2003) indicated only a minor degree of impairment in the Owenass below Mountmellick the occasionally high BOD, ammonia and orthophosphate results point to occasional plant overload, possibly in flood conditions and perhaps also to some un-intercepted intermittent waste sources.

Chemical data for the Brosna below Mullingar are unavailable for the period under review but the biological survey of August 2002 indicated a return to seriously polluted conditions. A dissolved oxygen reading of 43 per cent saturation was recorded at that time. The poor re-aeration capacity of the river is undoubtedly a factor but it seems likely that plant overload is more relevant. While treatment plant deficiencies are suspected it should be borne in mind that the river remains significantly polluted and highly eutrophic upstream of the sewage discharge.

The gradual improvement recorded in the Triogue below Portlaoise following sewage works upgrading in 1983 was reversed in the 1995-1997 period when serious pollution was again encountered; this level of pollution was again evident in the 1998-2000 review period. Since then the situation has improved; however, while chemical and biological data indicate a lessening of pollution, the river remains in an unsatisfactory condition.

Since the renovation of the Tipperary and Thurles sewage treatment facilities in 1981/2 there has been a fairly progressive improvement in the receiving waters of the Ara and Suir respectively and currently each is assessed as just slightly polluted. This is indicated by the 2003 biotic indices and also by the occasionally depressed DO minima and the elevated ammonia and orthophosphate maxima recorded.

In summary, although none of the receiving waters in question has recovered to a fully satisfactory and indeed most continue to be significantly polluted, the Owenass, Suir and Ara rivers have shown marked and sustained improvement so that each is currently just slightly polluted downstream of Mountmellick, Thurles and Tipperary respectively.

In recent years, waste treatment facilities have been upgraded in many other towns throughout the country including Ballyjamesduff, Co. Cavan, Naas/ Newbridge (Osberstown), Co. Kildare and Edenderry Co. Offaly. Data for the receiving waters of these plants are also given in Table 2.7 and show that in each case water quality has significantly improved. In the former two cases the receiving waters have been restored to a 'satisfactory' (Q4) condition but in the latter two recovery has been partial only. As pointed out elsewhere, plant overload, un-intercepted waste and/or urban runoff may be significant in these cases.

Despite these improvements, it is important to note that 24 locations continue to be seriously polluted by 'municipal' discharges, while 200 others are being very considerably affected (i.e., "moderately" polluted) below towns and villages throughout the country (Fig. 2.3).

Smaller rivers and streams are particularly susceptible to the adverse effects of even well treated sewage effluents. Such waters are liable to become eutrophic or hypertrophic because phosphorus – the main limiting nutrient - is not sufficiently removed by the standard secondary treatment process. This is borne out by the number of locations (circa 180) below towns and villages which were assessed as being slightly polluted and/or eutrophic as a result of suspected sewage discharges in the period under review (Fig. 2.3).

As regards the particular rivers being considered above, further recovery is unlikely in the absence of phosphorus removal and, even this step may not be successful:

a) where un-intercepted waste inputs continue,
b) where the treatment plant fails to perform consistently to specification,
c) where the plant is frequently overloaded or subject to breakdown or,
d) where upstream water quality is already degraded by other waste sources.

In this connection, it should be noted that the performance of urban waste water treatment plants with population equivalents in excess of 500 persons is assessed and reported on every two years by the EPA, as part of the Agency's statutory obligations. In particular, the composition of the effluents from the plants is compared with the requirements set out in the Urban Waste Water Treatment directive (CEC, 1991a) and the corresponding national Regulations. The report for the two year period 2002-2003 (Smith et al., 2004) shows that the limits set for the basic parameters of plant performance stipulated in the directive are exceeded in the effluents from several of these plants. In other cases, the level of sampling falls below the minimum frequency required, thus lessening the representativeness of the data obtained. The recently formed Office of Environmental Enforcement within the EPA will be using the additional powers conferred on the Agency by the Protection of the Environment Act, 2003, to address such deficiencies in the operation of sewage treatment plants by the local authorities.

OXIDISED NITROGEN/NITRATE LEVELS

Nitrate contamination of waters has been receiving much public notice recently due to the proceedings taken against the State by the EU Commission alleging non-implementation of some aspects of the Nitrates directive (CEC, 1991b). The directive, which is intended to control nitrate contamination of waters arising specifically from agricultural activities, was adopted in 1992. It requires Member States either to draw up action plans to counteract the loss of nitrate from farming lands to waters on the basis of a localised potential for contamination (i.e. in relation to vulnerable zones) or else to formulate and apply such plans at national level. Following wide consultation, the DEHLG decided on a State-wide approach and prepared a draft national action plan in 2004; this is being negotiated currently with the Commission but it is expected that Regulations implementing the directive, and incorporating the action plan, will be in force by the end of 2005.

High nitrate levels in surface and groundwaters used as sources of supply constitute a public health risk. In order to minimise this risk a limit of 50 mg/l of nitrate (equivalent to 11.3 mg/l nitrate-nitrogen) has been adopted in EU directives and corresponding national regulations dealing with the quality of drinking water sources and of the water in supply. The application of the same limit for source and supply waters reflects the fact that conventional treatment of water does not remove nitrate. Excess nitrate is also of concern in relation to eutrophication, especially in marine waters where it may act as the growth limiting nutrient. However, even in freshwaters, where phosphorus usually has the latter role, the more excessive growths of algae and other plants are likely to reflect increased inputs of both nutrients. In this context it is important to note that proper management of farm wastes to reduce the risk of pollution will simultaneously restrict the input to waters of both nitrates and phosphorus whereas in the treatment of sewage an individual approach to each of the nutrients is required to effect large-scale removal.

Agricultural fertilisers and farmyard wastes have been identified as the chief causes of nitrate enrichment of waters in many countries in Europe and in the United States, thus prompting the adoption of the Nitrates directive by the EU. Direct waste discharges, such as sewage, may also contribute significantly to such contamination and the EU Directive on urban waste treatment (CEC, 1991a) provides for the removal of nitrogen from such waste in certain circumstances.

In certain areas of the country, e.g. the south-east, where there is a greater than average proportion of the ploughed land, the possibility of excess nitrate loadings on surface waters and groundwaters is increased. Neill (1989) has shown a positive correlation between the nitrate levels in the rivers in this area and the proportions of ploughed land in their catchments. This correlation is due both to the relatively intense application rates of fertilisers in such areas and to the relative ease with which nitrate is leached from arable land. As in previous reports, an assessment of the current significance of nitrate contamination in Irish surface waters is presented here (Fig. 2.6) on the basis of a comparison of the total oxidised nitrogen (TON)[*] levels in the larger rivers in the south-eastern with those in the western part of the country as these areas may be considered, respectively, as areas where waters are at high and low risk of contamination.

The data illustrated in the figure compare the means and maxima recorded in the Clare, Moy and Suck with those in the Barrow, Nore and Suir rivers in the period 2001-2003. They thus give a general overview of the levels of the compound to be expected in the larger rivers in the two areas. The figure clearly shows the contrast between the two regions with values in the south east being significantly higher than in the Western and Shannon RBDs where maximum values are generally typical of un-impacted or just slightly impacted waters (viz. from 1 to 3 mg/l N). As noted in previous reviews, the higher nitrate levels in the rivers of the south-east reflect the differences in respect of land use, particularly the extent of tillage in the two areas.

In order to track nitrate trends in the south east as representative of an area where contamination is significant, the average median and maximum values recorded over the period 1979-2003 in four of the larger rivers in the region are presented in Fig. 2.7. In this figure, the 3-year rolling averages are used in order to smooth out year to year variations. The data come from the sampling stations surveyed by EPA showing the highest concentrations in each year. The data show that while average median concentrations have not exceeded EU Guideline limit values at any time the recorded maxima have exceeded this limit on occasion in the Barrow and Slaney. The trend which emerges is one of a gradual increase in average concentrations in each of these rivers until the 1996-1998 period when values started to fall and, with the exception of the Barrow, this downward trend continued in the present (2001-2003) period.

In summary the most recent oxidised nitrogen data indicate that while individual breaches of EU guideline limit have been recorded in the period under review, nitrate concentrations in Irish surface waters are generally well within the mandatory limit set for abstraction and drinking waters. Furthermore it is clear that levels are continuing the downward trend which became apparent in the mid-nineties in the major rivers of the south east.

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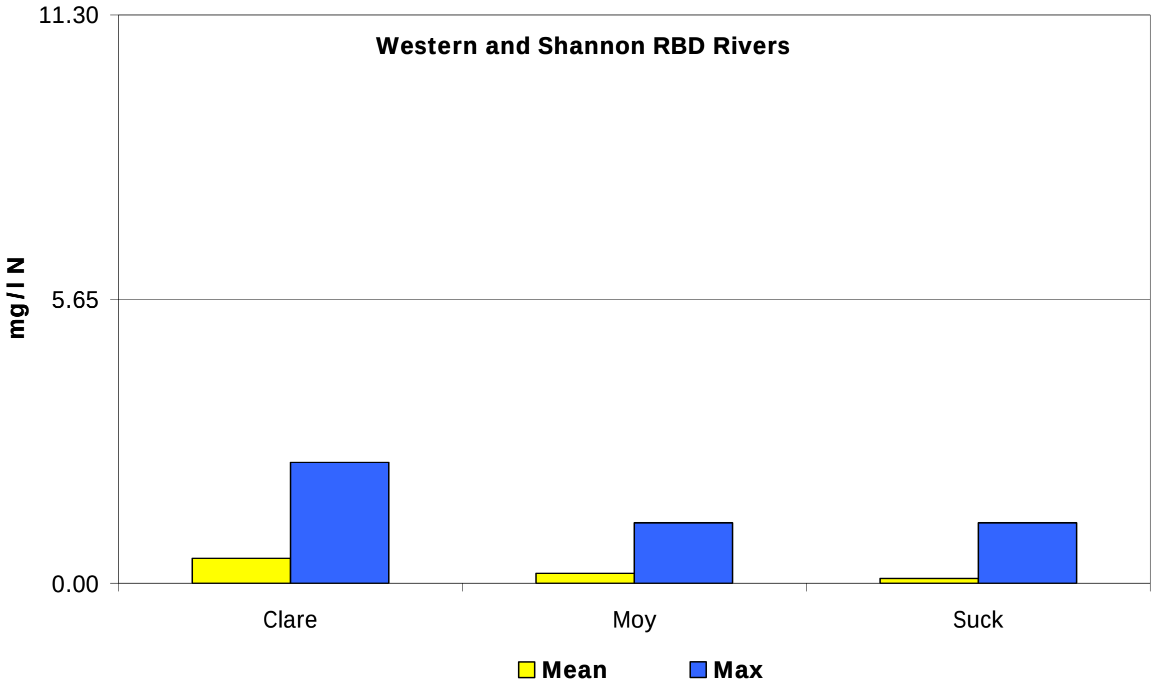
[*] TON is the sum of nitrate and nitrite but because nitrite is usually present in only very small concentrations, the TON value can be taken as approximating the nitrate concentration. For analytical convenience measurements are usually confined to oxidised nitrogen unless specific information is required on nitrite.



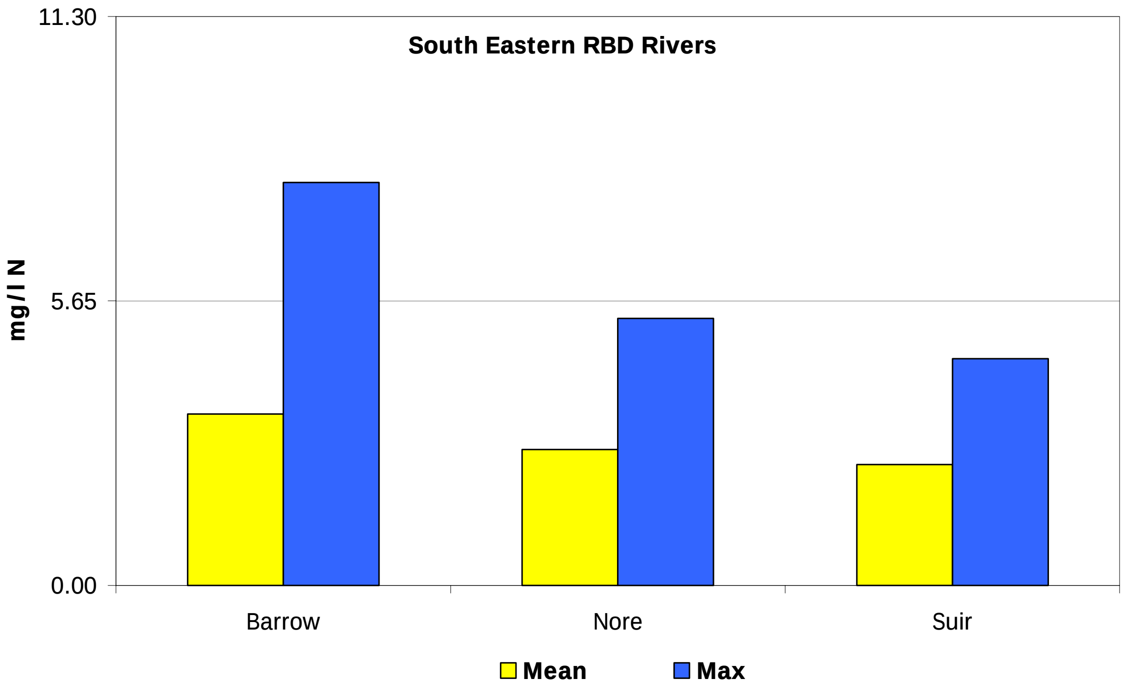


Fig. 2.6 Oxidised Nitrogen concentrations (mg/l N) in the larger Western and South Eastern RBD rivers compared. Data are the means and maximum values recorded by EPA in the period 2001-2003. The EU maximum and guideline limits for nitrate in abstractions is shown for reference.

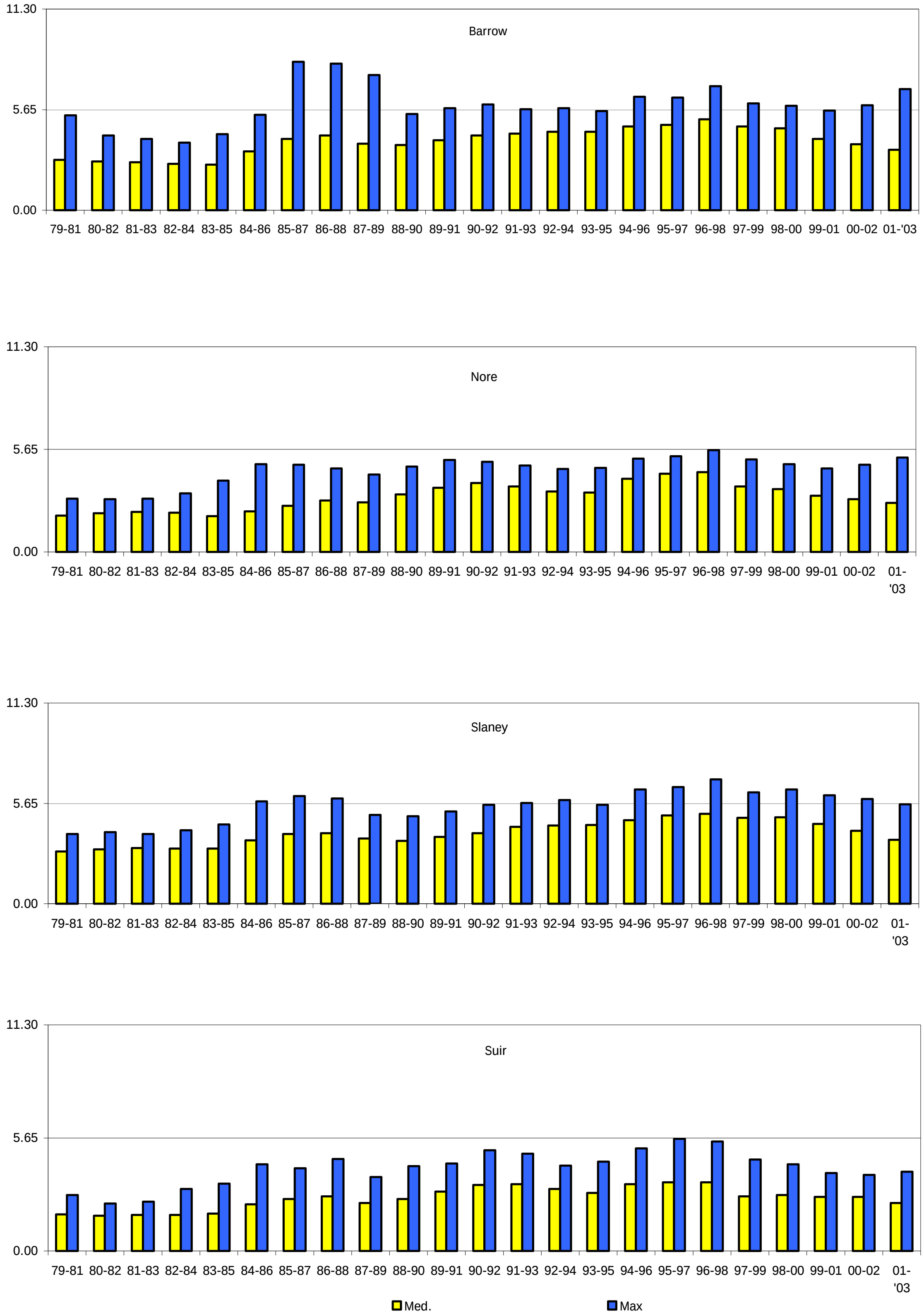


Fig. 2.7 Three year rolling averages of the annual median and maximum concentrations of oxidised nitrogen in the main rivers in the south-east in the period 1979 to 2003 in relation to the EU maximum (11.3 mg/l N) and guideline (5.65 mg/l N) limits for nitrate. Data are for the sampling stations showing the highest values for these annual statistics in each case.

TOXIC CONTAMINANT LEVELS IN FRESH WATERS

Background

Much concern has been expressed in recent years regarding the potential for environmental contamination by toxic and bioaccumulative substances, arising from the growing number of synthetic chemical compounds in daily use in the industrial, agricultural and domestic sectors (EEA, 1999). *Inter alia*, this situation has led to the EU proposal (REACH) for a scheme to register, evaluate, authorise and restrict the use chemicals as well as an agency to oversee the implementation of the scheme. The new regulation is intended to replace all of the approximately 40 existing regulations and directives in this area. In addition to man-made substances, there is a risk of loss to the environment of harmful substances, particularly metals, of natural origin, due to mining and other activities.

In regard to water, EU controls on the potential for contamination by dangerous substances were introduced as long ago as 1976 with the adoption of the Dangerous Substances directive (CEC, 1976a). This directive was intended to eliminate the discharge of the more toxic substances (List I) and to restrict the discharge of other harmful substances (List II). Subsequently, a total of 17 List I substances were made the subject of daughter directives and these were adopted into Irish law by regulation. National regulations dealing with some of the List II substances in the parent directive were adopted in 1998 (phosphorus) and 2001 (metals, organics and others) (Minister for the Environment and Local Government,1998, 2001). The Water Framework directive provides for the eventual repeal of the Dangerous Substances directive but incorporates a new policy to prevent contamination by these substances; in this context a “priority” list of substances has been identified for elimination from waters.

Monitoring of Irish waters for such substances has been relatively limited over the last 30 years. This arose from an assessment that the threat of contamination was relatively limited due to the lack of many of the main industrial and other activities giving rise to dangerous substances. To some extent this assessment is borne out by the low levels of contamination found in shellfish and other commercially exploited living resources in tidal waters (see Chapter Four). However, expansion of industrial activity and the wider range of substances used in domestic products now means that there is an increased potential for trace levels of some of these substances in discharges to waters, even from sewerage systems.

Measurements of Dangerous Substances in Irish Waters

In the mid 1990s, the EPA, in order to make an assessment of the position, commenced measurements in river waters of selected substances, including those on List I of the Dangerous Substances directive. The first series of surveys (Stephens, 2001) focussed on locations and parameters of likely concern and involved sites below the main inland towns and in some arable farming areas. In general these surveys indicated that the incidence of contamination was low, the main exception being metal levels in some rivers affected by past mining activities. However, the sampling frequency was low in these surveys and the possibility could not be ruled out that higher concentrations of the measured substances occurred under conditions different to those pertaining at the times of sampling. In order to clarify the position, a further series of surveys were carried out in 2002-2003 with an enhanced sampling frequency. The results of these surveys are summarised below.

The 2002-2003 surveys involved 22 sites for a total of 102 substances. The list of substances analysed for was a selected range of metals, pesticides, PCBs and volatile organic compounds (VOCs) and also encompassed the relevant substances from the Water Quality (Dangerous Substances) Regulations, 2001 (Minister for the Environment and Local Government, 2001). Fifteen sites were analysed for the full suite of 102 determinants and two were selected for metals only (Table 2.8). The latter are downstream of mining areas and not expected to be impacted by other substances. From the majority of sites, between 12 and 16 samples were taken over the two- year period giving rise, altogether, to 19,626 analyses on a total of 265 samples.

The overall findings of the 2002-2003 measurements (see Appendix III) confirmed the assessment based on the earlier survey that the levels of dangerous substances in Irish waters are, in general, very low.

Metals

The most serious case of metal pollution was found in the Avoca which continues to be seriously polluted with copper, zinc and to a lesser extent lead with all 16 samples taken exceeding the Dangerous Substances Regulations limit for at least one of the above metals (Table 2.9).

In the case of the Barrow, there was one exceedance each, both in the same sample in 2002, for chromium and zinc with concentrations, respectively, of 54 µg/l and 260 µg/l. However, the mean annual limit value was not exceeded for either metal in the Barrow in 2002 or 2003.

Organic Substances

With the exception of some isolated instances, there was little or no evidence of pollution from any of the targeted pesticides or other organic substances. The vast bulk of analyses were below the detection limit for these compounds although some significant concentrations were detected for Atrazine and Simazine in a small number of cases (Appendix III). These herbicides are included in the Dangerous Substances Regulations list and the limit value for both is 1.0 µg/l. In addition, trace levels of some PCB congeners were found in few instances. This is to be expected and the concentrations were too low to be of significance.

TABLE 2.8

Sites sampled in the surveys of dangerous substances in rivers 2002-2003

River	Location	Nos of samples 2002-2003
Sites where analyses included the full suite of 13 substances to be measured under the Regulations:		
BARROW	Graiguenamanagh Br	16
NORE	Brownsbarn Br.	16
SLANEY	New Br., Enniscorthy	14
BLACKWATER (MUNSTER)	Lismore Br	15
FEALE	Finuge Br.	14
LEANE	Beaufort Br.	14
LEE	Leemount Br.	14
SHANNON	Athlunkard Br.	14
CASTLEBAR	Br. 2.5 km d/s Castlebar	16
CORRIB	Quincentennial Br.	13
SHANNON	Lanesboro Br.	12
LIFFEY	Knockmaroon Footbridge	14
TOLKA	Violet Hill Drive Finglas	14
BOYNE	Old Bridge	14
BROADMEADOW	Br. W of Lissenhall	14
Heavy Metals only Sites:		
AVOCA	By-pass Br. d/s IFI	16
BLACKWATER (KELLS)	Pollboy Br. (Slane Rd) Navan	14

TABLE 2.9

Results of measurements (ug/l) of copper, zinc and lead in samples taken from the Avoca River in 2002-2003.

Year	**No. of samples**	**Statistic**	*Limits:*	Copper *5*	Zinc *50*	Lead *5*
2002	9	**mean**		18	190	7.9
		maximum		28	390	28
		minimum		12	62	1
2003	5	**mean**		21	185	6
		maximum		26	242	8
		minimum		9	81	5

In the metropolitan section of the Tolka, two (7.9 µg/l and 1.3 µg/l) out of 14 samples exceeded the Regulations limit for Atrazine and one sample (2.0 µg/l) exceeded the limit for Simazine. Measurable concentrations of both Atrazine and Simazine, although below the limit, were also found in a number of other samples taken from the Tolka. It should be noted, however, that formal legal compliance with the Regulations is determined by reference to the mean annual concentration for the particular water body. For 2002 the mean values (of 10 samples) for Atrazine and Simazine in the Tolka were, respectively, 0.90 µg/l and 0.29 µg/l, both below the above limit. In 2003, however, the mean annual concentration limit was exceeded for Atrazine (2.23 µg/l) at but not for Simazine (0.61 µg/l) (4 samples in each case). It should be noted that in calculating the mean values, the full detection level was assumed for cases where concentrations were below this level. This is a conservative approach which probably slightly overestimates the true mean values.

There was one other single exceedance (4.2 µg/l) of the limit for Atrazine, this being recorded on the Liffey, again in an urban location. However, evidence from other samples indicated that this sample, which was taken during the summer period, was probably an isolated instance. The annual mean values for Atrazine or Simazine in the Liffey did not exceed the limit.

Endocrine Disrupting Chemicals (EDCs) Research Programme

Further potential effects of some of these dangerous substances is the inducement of cancers and, as has come to light in more recent times, interference with hormonal functions in animals, leading in particular to reproductive anomalies. The most noteworthy occurrence of the latter type of effect is the feminisation of male fish which has been noted in some rivers in Europe and the US. This effect results from the ability of some synthetic chemical compounds, referred to as *endocrine disrupting chemicals (EDCs)*, to mimic or interfere with the activity of the female reproductive compound, oestrogen and has led to concerns that there is a risk of similar impacts in humans due to exposure through drinking water.

An EPA-funded project, managed by the Cork Institute of Technology, intended to investigate the occurrence of EDCs in the Irish aquatic environment, was recently concluded (Tarrant et al., in press). This is the first field study on the effects of EDCs in Irish waters and the bulk of the measurements were carried out in 2003. The main objective of the study was to determine the level of oestrogenic effects in fish populations in a number of selected rivers and lakes. The study also examined the oestrogenic potential of selected wastewater treatment plant (WWTP) effluents and their receiving waters in a number of sites in the South and East of Ireland, using a quantitative Yeast Estrogen Screen (YES) bioassay developed by Glaxo Wellcome PLC.

Phosphorus and Dangerous Substances Regulations

The Phosphorus Regulations, 1998, is a legislative measure aimed at reducing eutrophication in rivers and lakes. The targets set by the Phosphorus Regulations are designed to prevent deterioration of waters of good quality and to improve waters of unsatisfactory quality to a specified standard. The Regulations require that each local authority must submit an Implementation Report to the Agency every two years detailing measures it is taking to meet the specified standards. The Agency has published a number of national reports on implementation of the Regulations and on progress towards meeting the targets (e.g., Clenaghan, 2003).

The Local Authorities have proposed or implemented a wide range of measures aimed at protecting and improving water quality. Progress has been made by a number of local authorities, e.g., in the introduction of agricultural bye-laws, in reviewing discharge licences, in conducting farm surveys and misconnection surveys, and in implementing Geographical Information Systems to manage and interrogate water quality related information. The development of teams within certain local authorities to tackle water quality issues and in particular the Phosphorus Regulations is welcome. While availability of resources is still an issue for many local authorities there appears to have been some improvement in this regard, which should enable more effective implementation of measures.

The installation of phosphorus removal at certain inland wastewater treatment plants has proved successful in improving water quality. However, problems remain at a number of wastewater treatment plants despite upgrading due to, for example, overloading and storm water overflows. Smaller wastewater treatment plants appear to pose a particular threat to water quality in many areas and are not performing as well as many of the larger plants. A number of local authorities report that many single house treatment systems are not installed or maintained properly. Considerable effort is required to rectify this situation. Increased co-operation between Planning and Environment sections in local authorities is required. Water quality issues need to be a key consideration in the preparation of County Development Plans. Greater efforts are also required in the enforcement of local authority discharge licences.

Few local authorities are using nutrient management planning powers available to them under the Water Pollution Act. A relatively small number of local authorities have introduced bye-laws to control agricultural activities. As agriculture can pose a serious threat to water quality in many catchments it is important that local authorities address pollution threats from this sector adequately. Measures that have proven successful include REPS uptake, farm surveys and nutrient management planning. Involvement of farming organisations and the general public in water quality initiatives (such as introduction of bye-laws or catchment farm surveys) has also proved successful. It is to be hoped that national implementation of the Water Framework Directive, Nitrates Directive and of cross-compliance (linking farm payments to legislative environmental requirements) will also yield benefits in terms of water quality protection.

The Dangerous Substances Regulations, 2001, prescribe water quality standards in respect of 14 dangerous substances in surface waters, e.g., rivers, lakes and tidal waters. The substances concerned include pesticides (atrazine, simazine, tributyltin), solvents (dichloromethane, toluene, xylene) metals (arsenic, chromium, copper, lead, nickel, zinc) and other substances (cyanide, fluoride). They were selected primarily on the basis of their high priority internationally and also having regard to their likely use or presence in Ireland and their potential impacts on waters by virtue of toxicity, persistence and bioaccumulation. Water quality targets set in the Regulations must be met by 2010 and, where the existing condition of waters does not meet a particular standard, there must be no disimprovement in water quality in the meantime. The local authorities are required to submit two-yearly reports to the EPA, outlining the measures they aim to take to prevent water pollution from dangerous substances so as to meet the standards set by the Regulations. The Agency must publish a National Report on Implementation of the Regulations every two years from 2005.

A range of analytical techniques, including blood and histological examination, were used on the sampled fish in order to provide as clear a picture as possible. The results of the survey (Table 2.10) showed that histological examination of the gonads in wild fish did not yield any evidence of intersex (defined as the simultaneous presence of male and female tissue) in any of the waterbodies surveyed. However, one instance of elevated levels of the lipoprotein vitellogenin, a widely used biomarker of fish exposure to oestrogens, was found in a number of brown trout sampled below the Osberstown wastewater treatment plant on the River Liffey. This is indicative of at least some degree of exposure of fish to oestrogenic compounds downstream of the Osberstown plant. This conclusion is supported by the evidence from the effluent study where the highest oestrogenic equivalent concentration (17.2 ng/l) was found in the Osberstown effluent. (Table 2.11). This value is approximately six times greater than that found at the Leixlip WWTP, also discharging into the Liffey and with a comparable influent loading. However, since histological examination showed no evidence of intersex at this location and as the half-life of vitellogenin is relatively short, the exposure to EDCs at Osberstown may

TABLE 2.10

Survey of Male Wild Brown Trout
Incidence of Intersex and Vitellogenin Synthesis

Capture Site	Sample (male)	Population Equivalent for WWTP	Incidence of Intersex	Incidence of Vitellogenin Synthesis
River Liffey				
Upstream Osberstown WWTP	72		None	1 of 72
Downstream Osberstown WWTP	57	68, 490	None	15 of 57
River Bandon				
Ardcahane (source waters)	13		None	None
Upstream Bandon WWTP	52	6,200	None	None
Downstream Bandon WWTP	26		None	None
River Lee				
Ballyvourney (source waters)	12		None	None
Upstream Ballincollig WWTP	07	18,700	None	None
Downstream Ballincollig WWTP	11		None	None
Killarney Lakes				
Guitane, Black Valley, Leane	14	34,784	None	None

TABLE 2.11

Yeast Estrogen Bioassay (YES)
Estrogenicity of STW Effluents and Receiving Waters

STW	PE	Effluent E2 eq (ng/l)	Receiving Waters	Receiving Water E2 eq (ng/l)
Ringsend	2,186,808	16.0 ± 5.6	Dublin Bay	-
Kilkenny	110,000	6.8 ± 0.2	Nore	-
Osberstown	66,100	17.2 ± 3.8	Liffey	U/S 0.9 ± 0.4 D/S 1.3 ± 0.8
Leixlip	64,539	2.8 ± 1.4	Liffey	0.9 ± 0.1
Tralee	24,633	5.7 ± 0.4	Tralee Bay	-
Clonmel	40,000	2.9 ± 1.0	Suir	1.7 ± 0.8
Killarney	32,814	3.7 ± 1.8	L. Leane	1.8 ± 1.5
Carlow	36,000	1.1 ± 0.2	Barrow	-
Fermoy	12,960	5.0 ± 1.1	Blackwater	2.9 ± 2.4
Ballincollig	15,000	3.2 ± 1.1	Lee	1.5 ± 0.6

have been relatively transient. *The high YES result from the Ringsend outfall should be treated with caution since it was reported that the plant was not operating properly at the time.*

Since Osberstown was the sampling point representative of sewage inputs from the highest inland population of those assessed directly for impacts on fish, it was not a surprising outcome, especially in view of similar international evidence on the effects of sewage discharges (EA, 1996). As a follow-up to this study, it is clear that further investigations are warranted both at this site and at other locations with similar sewage inputs. These studies should also include testing, identification and quantification of the substances apparently causing the oestrogenic effects. Such an analytical programme, because of its great complexity, should be confined to locations where biological or oestrogenic effects are indicated.

WATER QUALITY OF CANALS AND THEIR FEEDER STREAMS

Background

The canals were constructed between the mid 18th and early 19th centuries as a means of transport; although there are some smaller representatives, as well as canalised river stretches, the two main canals are the Royal and Grand with the offshoots of the latter known as the Barrow Line and Naas Line. For the purposes of the Water Framework Directive, for which monitoring programmes must be in place by 2006, canals are classified as artificial water bodies (see Chapter Six).

A short account of the chief characteristics of the Irish canal system was given in Lucey *et al.* (1999). The ownership of the canals passed from *Córas Iompair Éireann* (CIE) to the Office of Public Works (OPW) in 1986 and thence to *Dúchas* - The Heritage Service. Waterways Ireland, the largest of the North/South Implementation Bodies set up on foot of the British-Irish Agreement, is now responsible for the management, maintenance, development and restoration of the inland navigable waterway system throughout the island, principally for recreational purposes. It is currently responsible for the Barrow Navigation, the Erne System, the Grand Canal, the Lower Bann Navigation, the Royal Canal, the Shannon-Erne Waterway and the Shannon Navigation.

Water quality monitoring of the canals in the Republic of Ireland is undertaken, on behalf of Waterways Ireland, by the Central Fisheries Board (CFB). The first systematic water quality survey of the major canals was undertaken in the 1990-1994 period (Caffrey and Allison, 1998) and sampling has been continued since then by the CFB. An assessment of the water quality of Irish canals has been included in the previous two national reports on water quality covering the periods 1995-1997 (Lucey *et al.*, 1999) and 1998-2000 (McGarrigle *et al.*, 2002), based on the results of this monitoring. An assessment of the current position in the major canals, i.e. the Royal and Grand including the Naas and Barrow Lines of the latter, is given below, based on reports to Waterways Ireland from CFB (Nicola O'Gorman, pers. comm.) for the year 2003.

Surveys and Assessment

The canals can be divided into a number of sections based primarily on water flow from summit points. In the case of the Royal Canal, sites were sampled east and west of the summit level in Mullingar. In the case of the Grand Canal the water quality was monitored at sites east and west of its summit level at Lowtown. Thus, for sampling purposes, the canals are divided into the following six sections:

1. Royal Canal - Mullingar to Dublin
2. Royal Canal - Mullingar to Ballybrannigan Harbour
3. Grand Canal - Lowtown to Dublin
4. Grand Canal - Lowtown to Shannon Harbour
5. Naas Line
6. Barrow Line (Lowtown to Athy).

A total of 78 canal sites and 38 feeder stream sites were sampled in 2003 at the same locations as in the previous two reporting periods. Sampling on the canals and their feeder streams was carried out during four periods: February-March, May-June, August-October and November-December. The three main parameters used in the assessment of water quality of the canals were Molybdate Reactive Phosphorus (MRP), Total Phosphorus (TP) and Faecal Coliforms. Phosphorus is the nutrient directly linked to plant productivity in the canals and MRP is a measure of the phosphorus species or component that is most readily available for uptake by plants. The following limits, above which eutrophication may occur in canals, have been tentatively set, by the CFB, for phosphorus: 0.02mg/l MRP and 0.063mg/l TP. Additionally, the CFB reports use the limit set for faecal coliforms in the Quality of Bathing Water Regulations, 1992 (Minister for the Environment, 1992) as a surrogate for the conditions necessary for the protection of secondary-contact recreational activities (e.g. boating, angling and canoeing). This stipulates that bathing waters must conform to a standard of 1000 or less faecal organisms per 100 ml of water in 80 per cent or more of samples.

Royal Canal – Mullingar to Dublin

Good water quality was recorded in this section during all sampling periods with no breaches of nutrient or faecal coliform threshold limits at any of the sampling sites. Elevated TP and faecal coliform levels were, however, recorded at four of the feeder sites. At Lock No.1 elevated TP was measured during February but levels were satisfactory on being re-sampled and again in the May sampling run. Chambers Bridge, near Kilcock, had elevated levels of MRP and TP and, on one occasion (May 2003), faecal coliform numbers exceeded EU bathing water limits. That site was also re-sampled and coliform levels were within the accepted limits. When sampled during October, Kilcock Harbour displayed threshold breaches for faecal coliforms but on re-sampling later in the month all parameters were below the set threshold limits. During sampling in November faecal coliforms numbers were again elevated. At that time TP was also in breach of threshold limit. This feeder site was due to be intensively investigated in early 2004 in an effort to isolate the source of contamination.

Royal Canal – Mullingar to Ballybrannigan Harbour

Overall, generally good water quality was recorded in this section of the Royal Canal with TP and MRP threshold levels exceeded at just one site each in the earlier sampling period of 2003. Ballynacargy Harbour displayed an elevated MRP concentration during the February sampling period but was satisfactory when sampled in May; Belmont Bridge showed a nutrient threshold limit breach for TP but was satisfactory on subsequent sampling. Apart from one elevated total coliform count, recorded at a feeder stream site, all bacteriological values were below the prescribed limits.

Grand Canal – Lowtown to Dublin

Water quality was generally satisfactory in this section of the Grand Canal in 2003; just one site exceeded the faecal coliform limit on one sampling occasion while the target value for TP was breached at two sites, including Hazelhatch Bridge, in February. Breaches of the TP and MRP limits were recorded in the feeder streams. The feeder site 40 m d/s of Cock Bridge displayed elevated levels of TP and MRP in the February sampling but the site was dry when revisited in May. The Monread feeder near Sallins displayed a threshold breach of MRP in February and, although nutrient levels measured in May were satisfactory, both TP and MRP were again elevated in November.

Grand Canal – Lowtown to Shannon Harbour

No breaches of the recommended limit for faecal coliform were recorded at canal sites between Lowtown and Shannon Harbour in 2003 although there were exceedances at some of the feeder sites, e.g. Newtown Feeder and Derrycooley Supply in August. Nutrient threshold levels were exceeded at a number of canal and feeder sites. A number of breaches of nutrient threshold levels were recorded on this section of the Grand Canal during February, e.g. at Bond Bridge and Lock 20, the majority of which could be traced to enriched feeders. In the feeders, nutrient limits were exceeded on some sampling occasions, viz. in the Toberdaly inflow (TP), the Ballylennon feeder (MRP) and the Ballymullen Feeder (TP and MRP); the last of these would appear to be chronically enriched, e.g. in 2000, a high MRP concentration (0.184 mg/l) was recorded (McGarrigle *et al.*, 2002).

Naas Line

Results for the Naas Line in 2003 indicated generally good water quality although three TP breaches and one MRP breach occurred during the February monitoring period. In the May sampling period all nutrient and bacteriological results were satisfactory but in the September survey TP and faecal coliforms were raised, respectively, at a canal and feeder site. In October all sites were satisfactory but in the following month an elevated level of TP was measured at one site, upstream of Lock 2.

Barrow Line

Results for the Barrow Line indicated reasonably good water quality conditions between Lowtown and Athy although faecal coliform numbers at a canal and feeder site exceeded the limit. In addition there were ten breaches of MRP and six of TP in canal and feeder sites in samples analysed throughout 2003. Based on these results there would appear to have been some deterioration in water quality compared with the previous reporting period.

Overall Water Quality of Canals and their Feeder Streams

While the major canals continue to have generally good water quality, which benefits all recreational users, they are nonetheless subject to some pressures. The majority of cases of phosphorus enrichment or faecal contamination of canal waters can be attributed, for the most part, to the incoming feeder streams. It is noted in some cases where feeder streams dry out during the summer months, that the water quality of the particular receiving canal waters improves at such times.

The monitoring programme of the canals and their feeder streams, carried out by the CFB for Waterways Ireland, has among its objectives to identify sources of enrichment or microbiological contamination and to eliminate these where possible. The monitoring programme for these artificial water bodies will have to be expanded to include biological elements, such as phytobenthos, macrophytes and fish, in order to meet the needs of the Water Framework Directive.

Chapter Three

WATER QUALITY OF LAKES

INTRODUCTION

The results of the water quality monitoring carried out on Irish lakes during the three-year period 2001-2003 are described in this chapter. A classification of the lakes is presented based on the total numbers and total surface areas falling into each trophic category. In addition, an analysis of trophic status by lake size, region and WFD River Basin District is presented, along with data showing trends over the past 25 years in selected lakes. Data for the individual lakes are tabulated in summary form on the attached CD ROM.

During the 2001-2003 period 492 lakes were examined; this represents a 61 percent increase over the previous reporting period and is due, largely, to the commencement of the National Lakes Monitoring Programme in 2000 and to the investigations carried out as part of an EPA ERTDI Fellowship Project which commenced in 2001. The 2001-2003 lake database describes the quality of approximately 1100 km^2 or 73 percent of the surface area covered by lakes in the State and as such is quite representative of such waters. Included are all of the larger lakes (surface area >7.5 km^2) wholly in the State and Loughs Melvin and MacNean which are shared with Northern Ireland. The lakes examined are principally located in the counties along the western seaboard and in the north midlands, reflecting the higher number of lakes in these areas. Relatively few lakes are located in the eastern and southern areas of the country.

Current data arising from the long term monitoring programme of selected acid sensitive surface waters are also summarised. Biannual physico-chemical and biological examinations are carried out in this programme on three lakes - Loughs Veagh (Donegal), Maumwee (Galway) and Glendalough Lake Upper (Wicklow) and their inflowing streams - which are representative of the principal acid-sensitive areas of the country. These waters were the subject of a detailed investigation, to examine the impact of acid precipitation, in the period 1987-89. In addition data arising in the reporting period from a physico-chemical examination of a further 80 acid-sensitive lakes in these areas and in Co. Clare, which had been examined initially in the period 1987-89, are also presented.

Information on the compliance of the bacteriological quality at each of the designated freshwater bathing areas, with the standards set out in the EU Bathing Water Regulations, is also supplied in this chapter for the period under review.

Information on these lakes is derived from investigations carried out by Local Authorities, EPA and the Central and Regional Fisheries Boards. Information on the large western lakes - Loughs Arrow, Carra, Conn, Corrib and Mask and on Loughs Bunerky Sheelin, Gowna, Garadice, Glore, Oughter, White, Sillan, Annamakerrig, Lavey, na Bach, Lene, Mount Dalton and Derravaragh was derived in whole or in part from investigations carried out by the Central and Regional Fisheries Boards (Champ *et al.*, 2004). Data for Loughs Sillan, Ramor, Kinale Mullagh, Nadreegeel and additional data for Loughs Gowna, Oughter, and Sheelin were supplied by Cavan County Council (C. O'Callaghan pers. comm.). Other results of the investigations on the water quality of lakes was supplied by Clare County Council (M. Burke pers. comm.); Cork County Council (C. Deasy pers. comm.); Donegal County Council (D. Casey and H. Kerr pers. comm.); Galway County Council (P. Dagg pers. comm.) Kerry County Council (D. Lenihan pers. comm.); Leitrim County Council (M. Coultry pers. comm.); Limerick County Council (T. Tarpey and C. Gleeson pers. comm.); Longford County Council (A. Brady pers. comm.); Louth (S. Callaghan pers. comm.); Meath (G. Duggan pers. comm.) Monaghan County Council (B. O'Flaherty pers. comm.); Roscommon County Council (J. O'Gorman pers. comm.); Sligo County Council (P. Bergin and R. Morrissey pers. comm.); Waterford County Council (P. Carroll pers. comm.); Westmeath County Council (A. Bonner and B. Keogh pers. comm.) and Wicklow County Council (T.Griffin and J Sexton pers. comm.). In addition, data from some 200 lakes examined by ERTDI Research Fellows (G. Free, R. Caroni, D. Tierney, K. Donnelly and R. Little) are included in the assessments.

EUTROPHICATION OF LAKES

Eutrophication has long been the principal pressure on lake water quality in Ireland. This form of pollution is caused by the inputs of nutrients, especially compounds of phosphorus and/or nitrogen, either directly to lakes or more commonly through the inflowing rivers, at concentrations in excess of natural levels. Eutrophication results in accelerated growths of planktonic algae, Cyanobacteria (formerly known as blue-green algae) and higher forms of plant life; the increased biomass may produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned. These growths can cause a marked reduction in light penetration through the water column and also lead to oxygen depletion in the deeper layers, during periods of stratification, as the dead cells to sink to the bottom and decay. In addition, increased growths of rooted macrophytes and attached algae, on or near shorelines adjacent to waste inputs, may also occur.

In freshwaters, phosphorus concentrations and to a lesser extent nitrogen compounds, are the important factors controlling algal, cyanobacterial and other plant growth. Phosphorus is naturally less abundant than nitrogen relative to plant needs and its concentration in water is often reduced to very low levels by plant uptake during the growing season. Thus, it can frequently be the "growth limiting" factor regulating plant development. In extreme cases of enrichment, such as in hypertrophic lakes, where both phosphate and nitrogen compounds are present in abundance, the ensuing luxuriant plant growths may be limited by other factors such as poor light penetration (self-shading), or reduced silica or trace element concentrations.

The principal sources of phosphate and nitrogen compounds in Ireland are losses from agricultural activities and municipal and industrial waste discharges. These sources are commonly classified according to the manner of the discharges as “point” and “non-point” sources. The former includes sewage discharges and the direct run-off from farmyards, while the latter category covers diffuse losses from land resulting from the excessive and/or ill-timed application of natural and artificial fertiliser as well as other diffuse sources such as septic tanks percolation. A high proportion of the phosphate in inputs to water derived from these sources is in a chemical form which is readily available for uptake by plants.

Phosphate and nitrogen compounds in water are also derived through natural erosion of rock and soils, though the small amounts of phosphorus derived in this manner are largely in a form that is unavailable for plant growth. A further source, generally of lesser significance except in the case of oligotrophic waters, is from rainfall and dry deposition.

ASSESSMENT OF EUTROPHICATION AND LAKE CLASSIFICATION

Lake water quality is widely assessed by reference to a scheme (Table 3.1) proposed by the OECD (OECD, 1982). The traditional trophic categories are described in this scheme by establishing boundaries for the three key indicator parameters, total phosphorus, chlorophyll and water transparency in assessing the level of eutrophication and its effects. Inputs of phosphorus to freshwaters commonly result in planktonic algal and Cyanobacterial growth, which are most easily quantified by measurement of the algal pigment chlorophyll. Water transparency is an important aesthetic characteristic in lakes and frequently determines the suitability of a waterbody for such recreational pursuits as game fishing and swimming. It is reduced by the presence of suspended material, such as planktonic organisms, in the water column.

The usual frequency of sampling of lakes in Ireland does not generate sufficient data to permit the calculation of the annual mean values as specified in the OECD scheme. To allow classification of these lakes a modified version of the OECD Scheme is used in which the classifications are based on the annual maximum chlorophyll concentration. In addition, because of the wide limits set for the eutrophic category in the original OECD scheme, a sub-division of this category has been made. The lakes are classified, therefore, in six water quality categories by reference to the maximum levels of planktonic algae measured during the period. This arbitrary modification of the scheme is set out in Table 3.2 together with other indicators related to water quality and the probability of pollution.

TABLE 3. 1

Trophic classification scheme for lake waters proposed by the OECD (OECD, 1982).

Lake Category	Total Phos. mg/m³ Mean	Chlorophyll mg/m³ Mean	Chlorophyll mg/m³ Max.	Transparency m Mean	Transparency m Min.
Ultra-Oligotrophic	<4	<1.0	<2.5	>12	>6
Oligotrophic	<10	<2.5	<8.0	>6	>3
Mesotrophic	10-35	2.5-8	8-25	6-3	3-1.5
Eutrophic	35-100	8-25	25-75	3-1.5	1.5-0.7
Hypertrophic	>100	>25	>75	<1.5	<0.7

TABLE 3. 2

Modified version of the OECD scheme based on values of annual maximum chlorophyll concentration. Indicators related to water quality and the probability of pollution are also shown.

Classification Scheme			Category Description			
Lake Trophic Category		**Annual Max. Chlorophyll mg/m³**	**Algal Growth**	**Deoxygenation In Hypolimnion**	**Level of Pollution**	**Impairment of Use of Lake**
Oligotrophic (O)		<8	Low	Low	Very low	Probably none
Mesotrophic (M)		8-25	Moderate	Moderate	Low	Very little
	Moderately (m-E)	25-35	Substantial	May be High	Significant	May be appreciable
Eutrophic	Strongly (s-E)	35-55	High	High	Strong	Appreciable
	Highly (h-E)	55-75	High	Probably total	High	High
Hypertrophic		>75	Very High	Probably total	Very high	Very high

Where it is possible to carry out only a limited number of measurements on lakes these measurements are made during the summer and autumn months, periods when the maximum planktonic algal growth is likely to occur. The highest chlorophyll concentrations recorded during these months are taken as approximations of the annual maximum concentration. In the classification of lakes for the present review period these values are used to assign the trophic categorisation to the lake for each year in which it was surveyed. However, in the summary positions given below (Tables 3.3 and 3.4 and Figs 3.1 – 3.5 and the tabulations on accompanying CD ROM), *the average of the annual maxima for the period* has been used to assign an overall trophic status to each lake.

In most of the larger lakes sampling was carried out at several points along the main axes of the lake, in the major bays and at points adjacent to important inflowing rivers and waste discharges. In the small lakes single sampling points are considered to be adequate to describe the water quality. In order to investigate localised deteriorations, such as those occurring at locations adjacent to polluted inputs, examinations of shoreline conditions at several points on some of the larger lakes are also carried out to assess algal and macrophyte growth.

RECENT ASSESSMENT OF LAKE WATER QUALITY

National Position

Water quality data are available for 492 lakes for the period 2001-2003. The location of and quality assessment for each lake are shown on the Lake Quality Map on the accompanying CD ROM. The accompanying tabulation gives in the case of each lake: the sampling agencies; annual sampling frequency; surface area; annual data (where available) for the parameters required by the OECD classification scheme; the trophic status for each year based on the annual maximum chlorophyll concentration; the uses where known and changes, if any, in the water quality since the last review period and the overall trophic status assessment of the lakes for the three year period.

The level of planktonic algal growth measured in 402 (82%) of the 492 lakes investigated during the review period were consistent with a trophic status (oligotrophic or mesotrophic) reflecting low to moderate planktonic algal growth, indicative of a low probability of pollution and none or very little impairment of beneficial uses; these lakes are thus judged to have satisfactory conditions (Table 3.3). The remaining 90 lakes examined (Table 3.4) have been assigned a eutrophic or hypertrophic trophic status indicative of varying degrees of pollution and less than satisfactory water quality conditions. These lakes have substantial to very high planktonic algal growth and thus an increased and real potential for impairment of their beneficial uses.

The excessive growths of planktonic algae in these 90 lakes are mainly attributable to inputs of phosphorus above or well in excess of natural levels. Much of this phosphorus is likely to have arisen from agricultural activities but single point sources, such as the waste discharges from municipal and

TABLE 3.3

Trophic status of 492 lakes examined in the period 2001-2003 (percentage of total in parentheses)

Trophic Category		**Number of Lakes in Category**	**Surface Area in Category km^2**
Oligotrophic (O)		253 (51.5)	247.0 (22.8)
Mesotrophic (M)		149 (30.3)	738.5 (68.1)
	Moderately (m-E)	23 (4.7)	23.4 (2.2)
Eutrophic	Strongly (s-E)	35 (7.1)	30.8 (2.9)
	Highly (h-E)	20 (4.1)	28.5 (2.6)
Hypertrophic (H)		12 (2.4)	15.2 (1.4)

TABLE 3.4

Lakes for which recent estimates of the maximum chlorophyll concentration indicate a moderately eutrophic or higher trophic status consistent with being polluted.

Name	Location	Area km^2	Trophic Status
Ballydoolavaun	Co. Clare	0.01	H
Maherarney	Co. Monaghan	0.15	H
Drumsaul	Co. Monaghan	0.10	H
Oony	Co. Monaghan	0.10	H
Creeve Upper	Co. Monaghan	0.08	H
Ballagh	Co. Monaghan	0.04	H
Gangin	Co. Leitrim	0.08	H
Grove	Co. Monaghan	0.10	H
Oughter	Co. Cavan	13.00	H
Corbeagh	Co. Longford	0.30	H
Coumduala	Co. Waterford	0.05	H
Eigish	Co. Monaghan	1.24	H
Lambes	Co. Monaghan	0.10	h-E
Nadreegeel (East)	Co. Cavan	0.50	h-E
Ballagh	Co. Clare	0.01	h-E
Annagh	Co. Longford	0.40	h-E
Bunerky	Co. Cavan	0.77	h-E
White	Co. Monaghan	0.90	h-E
Mullanary	Co. Monaghan	0.40	h-E
Lavey	Co. Cavan	0.10	h-E
Cross	Co. Mayo	1.00	h-E
Drum	Co. Monaghan	0.10	h-E
Minor	Co. Monaghan	0.10	h-E
Corkeeran	Co. Monaghan	0.16	h-E
Rosconnell	Co. Clare	0.09	h-E
Driminidy	Co. Cork	0.05	h-E
Fenagh	Co. Leitrim	0.40	h-E
Nadreegeel (West)	Co. Cavan	0.45	h-E
Mullagh	Co. Cavan	0.28	h-E
Sillan	Co. Cavan	1.72	h-E
Ramor	Co. Cavan	7.50	h-E
Gowna	Co. Cavan	13.50	h-E
Ballybeg	Co. Clare	0.20	s-E
Curtins	Co. Clare	0.02	s-E
Meenish	Co. Monaghan	0.02	s-E
Skerrig Reservoir	Co. Monaghan		s-E
Derrybrick	Co. Cavan	0.52	s-E
Killone	Co. Clare	0.25	s-E
Ballin	Co. Cork	0.16	s-E
Whitewood	Co. Meath	0.24	s-E
Bran	Co. Leitrim	0.16	s-E
Muckno	Co. Monaghan	3.64	s-E
Farrihy	Co. Clare	0.30	s-E
Baraghy	Co. Monaghan	0.20	s-E
Balrath	Co. Meath	0.10	s-E
Corcaghan	Co. Monaghan	0.10	s-E
Feagh	Co. Monaghan	0.10	s-E
Crinkill	Co. Monaghan	0.10	s-E
Mount Dalton	Co. Westmeath	0.40	s-E

TABLE 3.4 Contd.

Name	Location	Area km^2	Trophic Status
Calloughs	Co. Leitrim	0.28	s-E
Tully	Co. Longford	0.20	s-E
Toghan	Co. Monaghan	0.10	s-E
Sheelin	Co. Cavan	17.71	s-E
Drumgole	Co. Monaghan	0.10	s-E
Inner	Co. Monaghan	0.65	s-E
Coolkellure	Co. Cork	0.05	s-E
Lisnahan	Co. Clare	0.10	s-E
Muckno Mill	Co. Monaghan	0.20	s-E
Allua	Co. Cork	1.36	s-E
Goller	Co. Clare	0.10	s-E
Drumlona	Co. Monaghan	0.53	s-E
Abisdealy	Co. Cork	0.68	s-E
Acres	Co. Leitrim	0.10	s-E
Rockfield	Co. Cavan	0.38	s-E
Annamakerrig	Co. Monaghan	0.36	s-E
Dromore	Co. Cavan	0.68	s-E
Drumlaheen	Co. Leitrim	0.74	s-E
Ballyshunnock	Co. Waterford	0.20	m-E
Castle	Co. Clare	0.28	m-E
Bawn	Co. Monaghan	0.40	m-E
Kinale	Co. Longford	2.40	m-E
Bracken	Co. Meath	0.08	m-E
Drumbrow	Co. Cork		m-E
Greagh	Co. Monaghan	0.20	m-E
Glaslough	Co. Monaghan	0.40	m-E
Carrowmore	Co. Mayo	9.60	m-E
Ballycullinan	Co. Clare	0.36	m-E
Gulladoo	Co. Leitrim	0.52	m-E
Shreelane	Co. Cork	0.16	m-E
Inniscarra	Co. Cork	5.20	m-E
Moanmore	Co. Clare	0.13	m-E
Major	Co. Monaghan	0.24	m-E
Glasshouse	Co. Cavan	0.68	m-E
Lickeen	Co. Clare	0.88	m-E
Monalty	Co. Monaghan	0.30	m-E
na Bach	Co. Longford	0.20	m-E
Bridget	Co. Clare	0.55	m-E
Killaneer	Co. Louth	0.03	m-E
Knappabeg	Co. Mayo	0.40	m-E
Morne	Co. Monaghan	0.16	m-E

industrial sewage treatment plants and septic tanks, may be totally or partly responsible for the enriched status of some other lakes in this group.

Regional and River Basin District Analysis

A regional analysis of the surveyed lakes according to their trophic status classification is shown in Fig. 3.1. Of the 291 lakes examined in the counties along the west coast of Ireland 276, (94%) were classified as being in the satisfactory oligotrophic or mesotrophic categories, while of the remaining 17, 14 in Clare and three in Mayo, showed evidence of being enriched. In the north-midland counties, 90 (59%) of the 152 lakes examined were assessed as being in a satisfactory state, while 51 of the remaining 62 lakes showed evidence of high or very high levels of enrichment . The remaining 11 lakes there were classified as being moderately enriched. The majority of significantly polluted lakes identified in the State during this review period were located in the north-midlands, including 10 of the 12 hypertrophic lakes. Of the 49 lakes examined in the rest of the country, 38 (77%) were in the unpolluted oligotrophic and mesotrophic categories while ten lakes in County Cork and one each in Waterford and Louth showed evidence of varying degrees of enrichment.

A further perspective on the trophic status of lakes is given by a consideration of the classification of those in each of the River Basin Districts (RBDs) (Fig. 3.2). As might be expected from previous remarks on the national distribution of lakes, most of these waters occur in the Western, North-Western and Shannon RBDs. Thus, the majority of the oligotrophic and mesotrophic lakes are located in the Western River Basin District (WRBD) and North Western International River Basin District (NWIRBD). However, as the latter RBD includes parts of counties of Leitrim, Cavan and Monaghan, it also contains a sizeable percentage of those lakes exhibiting a high degree of nutrient enrichment or pollution. In all Districts, the lakes of satisfactory status are in the majority.

Analysis by Size

Of the 1084 km^2 of lake surface area examined in the period 2001-2003 (Table 3.3), 986 km^2 (91 per cent) were classified as being in the oligotrophic or mesotrophic categories. Of the remaining 98 km^2 of lake surface area, 82.7 km^2 and 15.2 km^2 respectively were classified in the eutrophic sub-categories or in the hypertrophic category.

Only 100 Irish lakes (0.8%) have a surface area greater than 1 km^2 (100 ha), the majority of lakes in the State measuring less than 0.05 km^2 (5 ha). This size distribution is reflected in the group of lakes examined in the present review period (Fig. 3.3), 80 per cent (393) of those examined being less than 1 km^2. Of these 393 smaller lakes, 80 percent were assessed as being in the satisfactory oligotrophic or mesotrophic categories while 62 were classified in the eutrophic sub-categories and a further 10 in the hypertrophic category. In the case of the medium-sized lakes (1.0 – 7.5 $km^{2)}$, 89 per cent were classified as oligotrophic or mesotrophic.

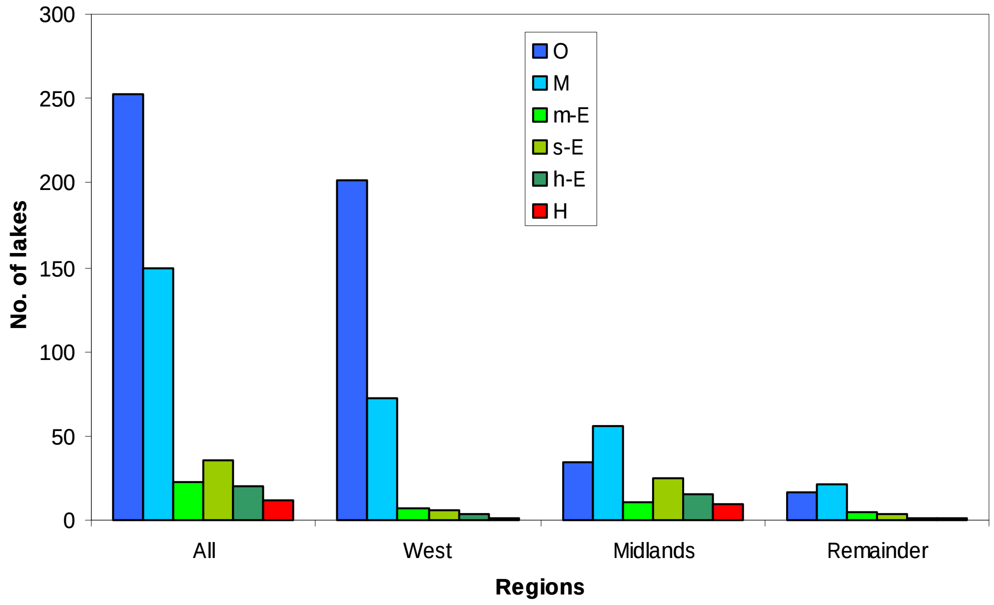


Fig. 3.1. Trophic Status of Lakes: Classification by Region

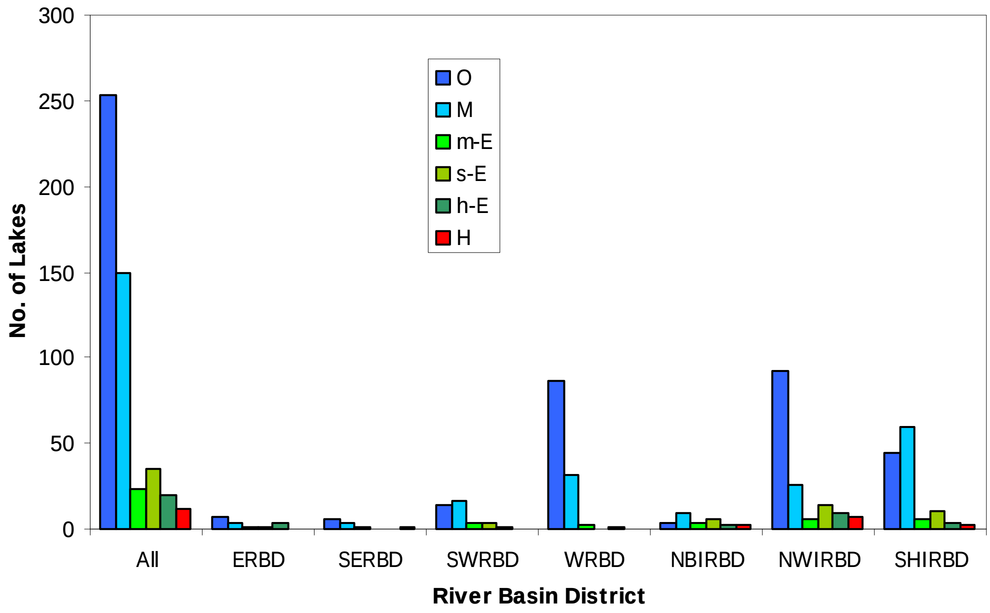


Fig. 3.2. Trophic Status of Lakes: Classification by River Basin District

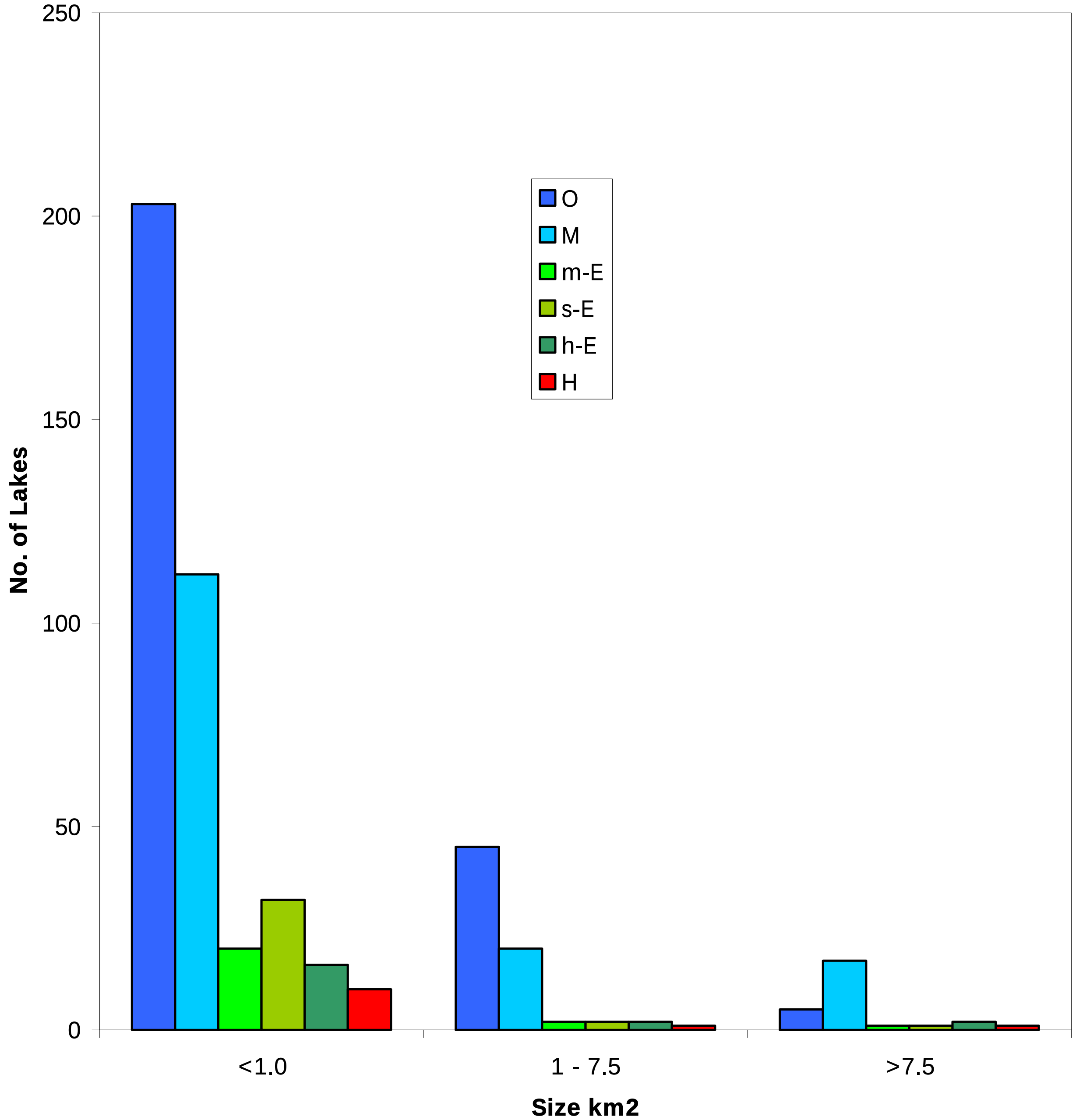


Fig. 3.3 Trophic Classification of lakes: Classification by Size

Assessment of Large Lakes

Information is available on the water quality of the 27 large lakes wholly or partly within the State with surface areas greater than 7.5 km^2 (Table 3.5); for 13 of these lakes, data, of sufficient detail to allow annual values to be calculated in addition to maximum values, were collected for all or part of the period under consideration. Of these large lakes 22 (81%) were in the satisfactory oligotrophic and mesotrophic categories while the remaining five exhibited a high degree of enrichment. Lough Carrowmore has been exhibiting substantial growths of cyanobacteria in recent years while Loughs Sheelin, Gowna and Ramor continue to exhibit the characteristics of seriously polluted lakes. Lough Oughter continues to be classified in the hypertrophic status.

The available data indicated an oligotrophic status for five of the large lakes viz. Loughs Allen, Melvin, Carra, Key and Derg (Donegal). However, there is evidence of increased algal production and nuisance cyanobacterial blooms in parts of Lough Melvin indicative of excessive localised nutrient inputs. A marked reduction in both the annual chlorophyll means and maxima was measured in Lough Carra compared with the previous review period when the lake was categorised as mesotrophic.
The key indicator of nutrient enrichment, phytoplankton growth as measured by chlorophyll, indicates a mesotrophic status in the open waters of a further 16 of these large lakes. This group includes Loughs Corrib, Mask, Conn and Cullin in the west of Ireland. Widespread concern about the welfare of these salmonid fishery lakes has arisen as a result of declining angling returns and excessive growths of shoreline plants and algae in recent years, suggesting localised nutrient enrichment. In addition, long-term data sets for these lakes, collected over the past 30 years, indicate an upward trend in the annual mean values for chlorophyll as well as in phosphorus inputs (Champ pers. comm.). Notwithstanding the satisfactory conditions measured in the open waters of these lakes, the above changes highlight the need for the implementation of measures to reduce phosphorus losses to watercourses in their catchments before major ecological damage occurs.

Satisfactory mesotrophic conditions were again recorded in the large, midland brown trout (*Salmo trutta* L.) fishery lakes viz. Owel and Derravaragh. While the maximum chlorophyll concentration indicated a marked increase of the trophic status of Lough Ennell in 2002, lower concentrations in the other two years of the period meant that the lake retained its average mesotrophic status. Open water plankton growth in Lough Arrow was of an order consistent with mesotrophic conditions, notwithstanding increased maximum chlorophyll values. However, the slightly increased annual mean chlorophyll values recorded during the current period would period place the lake in the eutrophic category according to the unmodified OECD classification scheme, while heavy shoreline algal and macrophyte accumulations attest to localised enrichment consistent with the latter status. Recent intensive monitoring of Lough Currane, in response to local concerns about the water quality of the lake, indicates chlorophyll concentrations consistent with a mesotrophic status.

TABLE 3. 5

The trophic status of the 27 large Irish lakes (>7.5 km^2) indicating any recent changes in their water quality. The lakes are listed according to their trophic status determined as the mean of the annual maxima of the chlorophyll concentrations measured during the current period. Their surface area (km^2) is shown in parentheses.

Lake	Trophic Status	Recent Change
Allen (35)	Oligotrophic	None
Melvin (23)	Oligotrophic	Reduced Phytoplankton Growth
Carra (15)	Oligotrophic	Reduced Phytoplankton Growth
Currane	Oligotrophic	
Key (9)	Oligotrpphic	Reduced Phytoplankton Growth[1]
Derg (Donegal) (8.8)	Oligotrophic	None
Corrib (170)	Mesotrophic	Increased phytoplankton growth in Upper basin
Derg (117)	Mesotrophic	None[1]
Ree (105)	Mesotrophic	Reduced Phytoplankton Growth[1]
Mask (80)	Mesotrophic	Reduced Phytoplankton, increased filamentous growth
Conn (50)	Mesotrophic	Increased phytoplankton growth
Leane (19.7)	Mesotrophic	Reduced Phytoplankton in lake and TP in Ross Bay
Gill (14)	Mesotrophic	None[1]
Ennell (14)	Mesotrophic	Increased phytoplankton growth
Arrow (12.5)	Mesotrophic	Increased phytoplankton growth
Derravaragh (11)	Mesotrophic	Slightly reduced Phytoplankton Growth
Poulaphouca (12)	Mesotrophic	
Cullin (11)	Mesotrophic	Increased phytoplankton growth
Gara (11)	Mesotrophic	None
MacNean (10.2)	Mesotrophic	
Owel 9.5)	Mesotrophic	None
Carrigadrohid (9.0)	Mesotrophic	Increased phytoplankton growth
Carrowmore (9.6)	Moderately Eutrophic	Increased phytoplankton growth
Sheelin (18.8)	Strongly Eutrophic	Reduced Phytoplankton Growth[1]
Gowna (12.9)	Highly Eutrophic	Increased phytoplankton growth
Ramor (7.5)	Highly Eutrophic	Increased phytoplankton growth
Oughter (13)	Hypertrophic	Slight reduction in excessive plankton growths

[1] Major Zebra mussel infestation

Monitoring carried out on the Shannon lakes since 1997 indicate that the key symptoms of eutrophication, viz. high chlorophyll concentration and reduced water transparency, have been improved significantly (Bowman, 1998 and 2000). These improvements have coincided with the infestation of the River Shannon system by the Zebra mussel and also the introduction of a comprehensive catchment management plan which included the completion of a major programme of remedial measures at the 17 larger waste treatment works in the catchment. However, the reduction of phosphorus concentrations in the lakes has not been significant and is still at a level sufficient to sustain populations of phytoplankton comparable with those which existed during the peak of eutrophication in the early 1990s. This constitutes strong evidence that Zebra mussels and not nutrient reduction are now controlling the size of populations of planktonic algae and Cyanobacteria in these lakes.

Zebra Mussel

The Zebra mussel (*Dreissena polymorpha*), first recorded in lower Lough Derg and the River Shannon upstream of Limerick in 1997 (McCarthy *et al.*, 1997), had, by 1998, become established throughout the navigable reaches of the Shannon system as far north as Lough Key (Lucy and Sullivan, 2000). However, a mussel population has not been established in Lough Allen.

The species has now extended beyond the River Shannon to other suitable adjoining waters (Frances Lucy, Sligo IT, pers.comm.). Zebra mussels, sustained by filtering particulate matter, including planktonic algae, from the surrounding water, have the effect of reducing the concentrations of such material in a lake. In this manner the phosphorus concentration in the lake water is also reduced, as that fraction of the element that is contained in the algae and other suspended material is removed through the filtering process and is transferred to the sediments as faecal matter. The removal of the suspended material from the water results in an improvement in water transparency. Thus the presence of Zebra mussels has an important influence on the concentration of the nutrient causing eutrophication and also on the parameters, chlorophyll and water transparency, used to measure the extent of this development in lakes.

Thus, while Loughs Derg, Ree and Key and the smaller lakes in the Shannon system viz. Drumharlow, Oakport, Boderg, Bofin, Forbes and the “Inner Lakes” of Lough Ree - Coosan, Killinure and Ballykeeran - are classified as being in a satisfactory mesotrophic status based on chlorophyll concentrations, a higher trophic status, in line with the phosphorus concentrations, might be more appropriate for some of these waters. Evidence of significant localised enrichment was observed at a number of shoreline sites examined on these lakes further, supporting the high trophic status designation for these waters.

No significant change in the trophic status of Lough Gill in Sligo is indicated by the data collected in the 2001-2003 period. However, the lake has been heavily infested by Zebra mussels in the past two years (Frances Lucy, Sligo IT, pers.comm.).

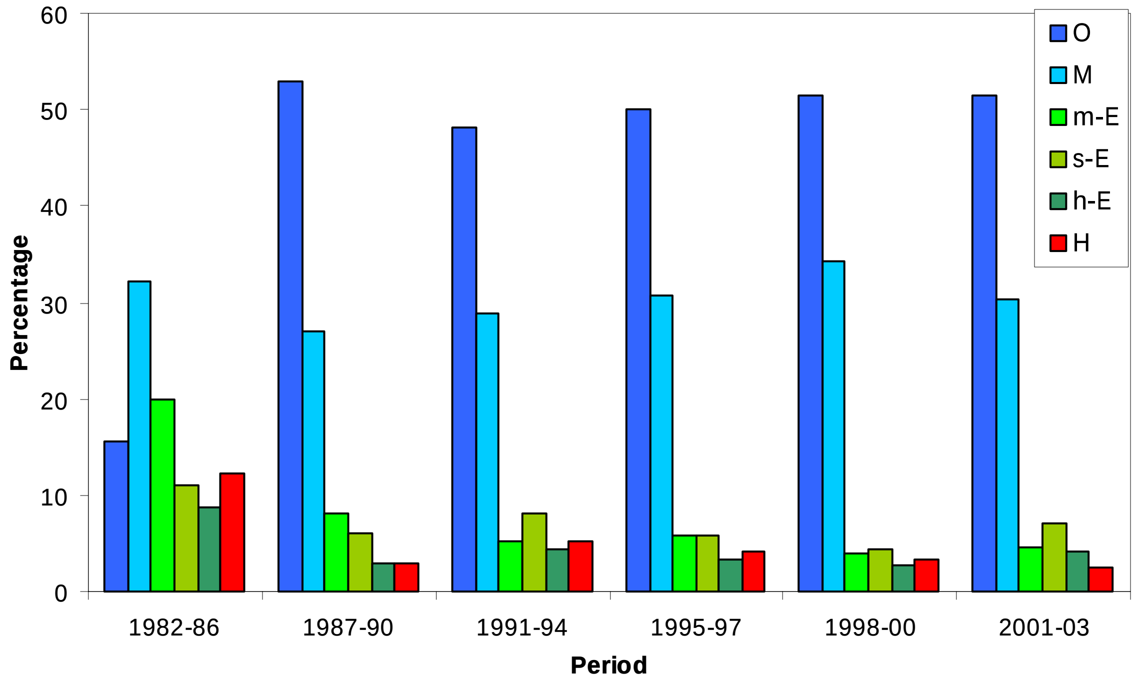


Fig 3.4 Recent Changes in Trophic Status: Numbers of Lakes

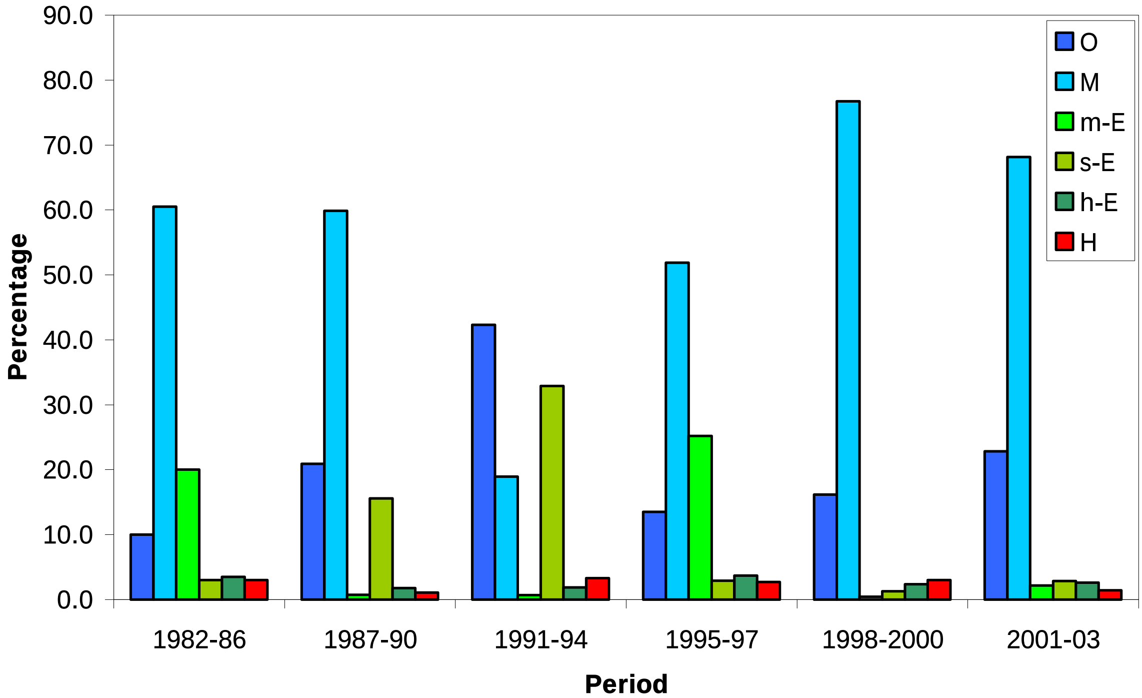


Fig 3.5 Recent Changes in Trophic Status: Combined Surface Areas of Lakes.

While considerable fluctuations in the annual mean total phosphorus concentrations and annual mean and maximum chlorophyll levels were measured in Lough Leane during the current review period, these values remained within the boundaries of the mesotrophic status. The annual mean total phosphorus concentration measured in the Ross Bay area of the lake in the current period showed a marked reduction compared to the levels recorded in 1998-2000 although, paradoxically, this corresponded with chlorophyll values marginally higher than those recorded during the previous review period.

Data on Poulaphouca Reservoir in Co. Wicklow and Lough MacNean Upper in Counties Sligo, Leitrim and Fermanagh indicate mesotrophic status; these lakes were not covered in the 1998-2000 surveys. Notwithstanding the elevated chlorophyll concentrations measured in 2002, the significant improvement in the trophic status of Carrigadrohid Reservoir on the River Lee system, compared to conditions recorded in the early 1990s, has been maintained during the current period. In contrast, the marked decline in the water quality of Carrowmore Lake, recorded in 2003 and with adverse effects on angling in the lake, is persisting. In addition, the decline in the water quality of Lough Sheelin, first noted nearly three decades ago, was again evident during this period. The unsatisfactory condition of the lake has been worsened by the introduction of Zebra mussels to this water in 2003 (T. Champ, Central Fisheries Board, pers. comm.).

TRENDS IN LAKE WATER QUALITY

The trends over the last 21 years in the trophic status of Irish lakes are shown in Figs 3.4 and 3.5. Despite the very large increase in the number of lakes examined in the current period compared with previously (Fig. 3.4) there are no significant changes in the percentages of the number of lakes falling into each trophic category since 1995. (It should be noted in this context that the data for the period 1982-86 are not strictly comparable with those for other periods as they include a disproportionate number of enriched lakes in Co. Cavan arising from detailed lake monitoring carried out in that county in 1982-3.) The most significant change during this 21 year period has been the reduction in the trophic status of Loughs Derg and Ree from strongly eutrophic in 1991-94 through moderately eutrophic in 1995-97 to a mesotrophic status since 1998. As already mentioned, these changes are due largely to the impact of the Zebra mussel infestation.

The percentage of lakes classified as oligotrophic in the current review period still remains in excess of 50 percent of the total, although a slight decline was noted in the percentage classified as mesotrophic. The high proportion of surface area in the latter category is partly due to the reduction in chlorophyll in the major River Shannon lakes which has given these waters a mesotrophic status. An anticipated fluctuation in the phytoplankton population in these lakes, as a result of instability in the Zebra mussel population, has not been noted. A small increase in the percentage of lakes classified as eutrophic, particularly as strongly eutrophic, was also noted while the decline in the percentage of lakes in the hypertrophic class continued.

The corresponding comparison based on the trophic status of lake surface area examined indicates an increase in the percentage surface area assigned to the oligotrophic category when compared with the two previous review periods. This change has come about principally as result of the additional large lakes examined during the current period and which were classified in the oligotrophic category but also due to the reassessment of Loughs Carra, Melvin and Key as oligotrophic compared to their previous mesotrophic status. These improvements in trophic status have contributed to a small decline in the percentage of lake area classified as mesotrophic despite the current mesotrophic classification of the formerly oligotrophic Loughs Gill and Cullin. The recovery in the trophic status of Lough Leane continues and, while the lake remains in a mesotrophic status, the abundance of phytoplankton in the lake has returned to the levels of 15 years ago.

In the period 1976-81 the water quality of 39 lakes was assessed (WPAC, 1983). Of these lakes, 21 have been re-examined in each subsequent review period while water quality data are available for a further six lakes during each of the last six of these periods (Table 3.6). The only lakes to have maintained a stable oligotrophic status since first examined are four acid-sensitive (see below) waters in Cos Wicklow and Galway (Glendalough Upr. Maumwee, Nahasleam West and Nafurnace) and Lough Lene, a hard water lake in Co. Westmeath. All of the other lakes have shown varying degrees of fluctuation in the levels of planktonic algal development. Some of these lakes viz Loughs Arrow, Conn, Corrib and Owel have shown limited fluctuation and remained within the mesotrophic category over the 27 year period; Lough Mask, apart from a period when the lake reduced from the mesotrophic to oligotrophic status, has also shown little fluctuation in recent years.

Loughs Derravaragh, Gortglass, Ennell and Leane and Inniscarra Reservoir have shown reduced phytoplankton development and improving water quality in recent years following earlier periods of enrichment. In the case of the latter three, the implementation of nutrient management plans has resulted in these significant improvements in water quality. Lough Muckno, however, following a period of recovery, has shown a marked decline in quality in the recent period. The water quality of Loughs Oughter, Ramor, Sheelin and Gowna has been consistently bad since monitoring commenced; while there has been significant variability in planktonic algal growth in these lakes, at best they have been classified at the upper end of the eutrophic scale and have frequently been in a hypertrophic state. Lough Kinale situated on the River Inny downstream of Lough Sheelin has shown marked variability in planktonic algal development in recent years, reflecting largely the conditions in the upstream Lough Sheelin. The introduction of the Zebra mussel to this system may account for the recent reduction in chlorophyll values. The improvement in the quality of Loughs Derg Ree, Key and Killinure has been discussed above in the context of the Zebra mussel infestation.

TABLE 3.6

The maximum chlorophyll concentrations in the 21 lakes for which data are available since the 1976-81 period and six lakes for which data are available since 1982-86 period. Values are the average of the annual maxima for each period.

Lake	Period of Examination						
	1976-81	1982-86	1987-90	1991-94	1995-97	1998-00	2001-03
Arrow	14	20	12	13	18	15	18
Carra	9	9	9	9	10 (28) [1]	15	7
Conn	17	10	11	13	10	11	14
Coosan	5	19	-	12	13	14	16
Corrib (Upper)	11	5	9	8	11	9	13
Corrib (Lower)	28	18	10	8	11	9	8
Derg	14	34	41	54[2] (72)[1]	27	12	10
Derravaragh	35	29	25	12	13	16	11
Ennell	47	28	19	23	16	17	21
Gowna	63	35	18	66	56	78	67
Inniscarra	34	-	61	137	43	16	29
Key	13	12	15	15	16	14	8
Killenure	16	9	-	13	11	9	6
Kinale	40	24	24	7	6	60	33
Leane (Open)	15	25	14	10	71[4]	24	15
Leane (Ross Bay)	63	57	23	17	41	30	32
Mask	12	5	7	6	11	13	12
Muckno	68	54	-	29	24	17	48
Oughter	537	99	68	158	132	104	86
Owel	11	7	8	12	11	12	11
Ramor	290	92	59	119	156	51	55
Ree	25	21	21	33	31	19	9
Sheelin	60	60	37	33 (66)[3]	48	65	44
Glendalough (Up'r)	-	3	3	1	1	2	2
Gortglass	-	4	21	8	34	28	15
Lene	-	5	6	7	8	8	8
Maumwee	-	3	5	1	3	3	3
Nafurnace	-	3	2	1	3	2	7
Nahasleam (West)	-	3	3	1	2	2	3

[1] Maximum individual value
[2] Maximum mean value recorded in Lough Derg during 1991-92 investigation (Bowman *et al*, 1993)
[3] Maximum value recorded in 1994
[4] Maximum value recorded in 1997

ACID SENSITIVE WATERS

Acid sensitive water bodies in Ireland are found in areas with base-poor bedrock formations e.g. granite, shale, gneiss and sandstone and associated soils. These geological features occur mostly along the Atlantic coastal counties and in Co. Wicklow. The surface waters in these areas are characterised by low alkalinity and consequently poor capacity to neutralise acid inputs. Such waters are therefore potentially at risk from acid-generating pollutants, such as sulphur dioxide, released into the atmosphere, leading to the “acid rain” phenomenon. This effect caused damage to the fauna and flora of sensitive surface waters in many areas of Europe and the US from the 1960s onwards and has only been arrested in recent years following international agreements to reduce emissions of the pollutants.

Investigations (Bowman, 1991) in the late 1980s showed that Irish waters were generally free of “acid rain” impacts, an expected position in view of the island’s location on the western fringe of the European continent. Subsequently, three of these lakes and their inflowing streams, viz Loughs Veagh (Donegal), Maumwee (Galway) and Glendalough Lake Upper (Wicklow), were selected for long-term monitoring in order to keep the situation under review. This regular monitoring, carried out in December and April each year and covering chemical and biological characteristics of the three lakes was continued during the review period. In addition, a physico-chemical examination was carried out of a number of other acid-sensitive lakes in these areas.

The level of acidity in the three lakes and their feeder streams is inferred from the biological “Raddum Index” (NIVA, 1987). This index is based on the sensitivity of individual species of the macroinvertebrate fauna to reduced pH and is used widely to describe the acid status of surface waters. Species are assigned an “acidification score” or index in accordance with the following scheme of sensitivity or tolerance to acidity:

Category	Min. pH tolerated by species	Score	Inferred Acidification Impact by Presence
A	5.5-6.0	1.0	None
B	5.0-5.5	0.5	Moderate
C	4.7	0.25	Serious
D	<4.7	0	Severe

The Raddum Index scores for the three lakes and their feeder streams derived from the data collected in the reporting period are given in Table 3.7.

TABLE 3.7

The acidification "score" calculated for Loughs Maumwee, Glendalough Lake Upper and Lough Veagh and their inflowing streams during the period 2001 - 2003.

Location	2001		2002		2003	
Lough Maumwee	**May**	**Nov.**	**May**	**Dec.**	**May**	**Nov.**
Lake Shore	1	1	1	1	1	1
Inflow No.1	1	1	1	1	1	1
Inflow No.2	1	1	1	1	1	1
Glendalough Lake Upper	**May**	**Dec.**	**June**	**Dec.**	**May**	**Dec.**
Lake Shore	0	0	0	0	0	0
Glenealo River	1	1	1	1	1	1
Lugduff River	0	0	0	0	0	0
Lough Veagh	**May**	**Nov.**	**May**	**Dec.**	**May**	**Nov.**
Lake Shore	1	1	1	1	1	1
Sruthnacoille R.	1	1	1	1	1	1
Derrybeg River	1	1	1	1	1	1
Owenveagh River	1	1	1	1	1	1
Glenlackburn R	1	1	1	1	1	1

The continuing presence of acid-sensitive (Category A) macroinvertebrate fauna in shoreline samples taken at Loughs Veagh and Maumwee and in their inflowing streams and in the Glenealo River, a tributary of Glendalough Lake Upper, confirm the absence of significant inputs of artificial acidity to these waters. Evidence of salmon and trout spawning, regularly observed in the western lake systems, along with the capture there and in the Glenealo River of young trout, which are most sensitive to increased acidity, further attest to the unimpaired state of these waters. In contrast, the absence of acid sensitive organisms at the sampling station on the Lugduff tributary of Glendalough Lake Upper and in the littoral fauna of the lake coupled, with the prominence of the acid tolerant Plecoptera (stoneflies) in the macroinvertebrate communities, is indicative of severe acidification at these locations.

The results of the physico-chemical analysis carried out on samples taken from Loughs Veagh, Maumwee and Glendalough Lake Upper systems in conjunction with the biological examinations during the period 2001-03, are summarised in Table 3.8. The near absence of buffering capacity in these systems and their high degree of sensitivity to acid inputs is confirmed by the very low alkalinity values recorded at the sampling points.

With the exception of those for the Derrybeg River at Lough Veagh, the pH values recorded at Lough Maumwee and Lough Veagh were considered to be within the natural range for waters draining areas with base-poor bedrock formations and associated soils and showed no evidence of inputs of artificial acidity to these systems. The cause of the greater acidity in the Derrybeg River, noted in earlier investigations (Bowman, 1991), is not apparent. However, the presence of acid-sensitive macroinvertebrate fauna in this stream suggests that the reduced pH values may also be the result of natural processes rather than artificial inputs.

At Glendalough Lake Upper on the east coast, low pH and high concentrations of aluminium were recorded in the Lugduff River, which drains the heavily afforested southern area of the lake catchment. The eastern area of the lake, adjoining the confluence with the Lugduff River, is adversely impacted by the levels of acidity in this inflowing river. In contrast, the water quality of the Glenealo River, which drains an unafforested catchment, remains unaffected by increased acidity or high metal concentrations.

The concentrations of non-marine sulphate, a measure of sulphate of anthropogenic origin, recorded during the period 2001-03, while, in general, slightly higher than the values measured in 1998-00 at the sampling sites, were substantially lower than the levels formerly noted. Similar reductions have been recorded at sampling sites in mainland Europe in the past decade and are attributed largely to reduced sulphate content in industrial emissions. The declining trend in concentrations of oxidised nitrogen also continued during the current period. The concentrations of total aluminium were

TABLE 3. 8

The minimum and median pH values, and the median concentration of alkalinity, total aluminium, non-marine sulphate and oxidised nitrogen in Loughs Maumwee, Glendalough Lake Upper and Lough Veagh and their inflowing streams during the period 2001 - 2003.

	pH		Alkal.[1]	Tot-Al	N-M SO_4 [2]	Ox-Nit.
Location	**Min.**	**Med**	**mg/l**	**ug/l**	**mg/l**	**ug/l N**
Lough Maumwee						
Lake Surface	5.95	6.61	5	26	0.5 8	10
Inflow No.1	6.12	6.30	9	44	0.58	10
Inflow No.2	6.04	6.66	7	32	0.39	15
Glendalough Lake Upper						
Lake Surface	6.04	6.30	4	128	2.28	170
Glenealo River	5.99	6.61	5	73	4.09	150
Inflow No.2	6.92	7.16	8	23	4.22	600
Lugduff River	5.02	5.40	3	171	2.54	205
Lough Veagh						
Lake Surface	6.08	6.45	4	82	0.55	50
Sruthnacoille R.	5.96	6.26	7	125	0.73	<10
Derrybeg River	5.18	5.90	5	110	0.39	<10
Owenveagh River	6.27	6.63	6	97	0.58	26
Glenlackburn R.	6.58	7.04	10	75	0.80	90
Inflow No. 5	5.80	6.34	7	106	0.62	10

[1] Expressed as $CaCO_3$

[2] Non-marine Sulphate calculated by reference to the Chloride concentration in sample

considerably lower than those formerly recorded at the Loughs Maumwee and Glendalough lake Upper sampling sites, but the showed no change at Lough Veagh.

Both the biological and chemical data recorded indicate that there are no significant impacts from artificial acidification in these acid sensitive waters, with the exception of the afforested Lugduff River catchment at Glendalough Lake Upper in Wicklow. Neither do the data suggest any marked change in the acidity status of these waters since first examined 20 years ago.

QUALITY OF DESIGNATED BATHING WATERS IN LAKES

A summary of the quality of bathing water results reported for freshwaters in the review period are presented in Table 3.9 and 3.10. The locations and compliance status of the bathing areas sampled in 2003 are shown in Fig. 4.2 in Chapter Four. The number of freshwater bathing sites designated under the EU directive concerning the quality of bathing water has remained at nine since 1994. Chapter Four gives further information on the provision of the EU Bathing Water Directive and the implementing National Regulations.

Over the review period the quality of the bathing water at all nine sites has continued to be of a very high standard. In each of the three years, all of the sites complied with the mandatory values laid down in the directive for the main parameters (total coliforms, faecal coliforms, mineral oils, surface active substances and phenols). In addition, eight out the nine sites (88.9 per cent) complied with the stricter guideline values in 2001 and all sites compiled with the these in the last two years of the review period.

TABLE 3.9

Compliance with Mandatory Standards for Freshwater Bathing Areas (2001-2003)

Parameters	2001 T[1]	2001 NC[1]	2002 T	2002 NC	2003 T	2003 NC
Microbiological						
Total coliforms	9	0	9	0	9	0
Faecal coliforms	9	1	9	0	9	0
Faecal streptococci[2]	8	2	8	0	8	0
Salmonella	3	0	1	0	0	-
Enteroviruses	0	-	1	0	0	-
Physicochemical						
PH	9	0	9	1	8	0
Colour	9	0	9	1	8	0
Mineral oils	9	0	9	0	9	0
Surface-active substances	9	0	9	0	9	0
Phenols	9	0	9	0	9	0
Transparency	9	2	9	0	9	1
Dissolved oxygen [2]	6	1	6	1	8	0
Floating materials [2]	9	1	9	1	9	0

[1]T = Number of locations sampled at required frequency
I = Number of locations not complying with the standards in the EU directive
[2]Guide values only

TABLE 3.10

Freshwater Bathing Water Quality Monitoring Results 2001-2003 showing Compliance with the Mandatory and Guide Values Specified in the EU Directive 76/160/EEC

Year	Number of Sampling Points	Compliance (%) Mandatory	Compliance (%) Guide
2001	9	100.0	89.9
2002	9	100.0	100.0
2003	9	100.0	100.0

CHAPTER FOUR

THE QUALITY OF ESTUARINE AND COASTAL WATERS

INTRODUCTION

The quality of Ireland's tidal waters is determined by the composition of the waters of the North East Atlantic which bathe our coasts and the degree to which this is altered by inputs of organic matter, nutrients and other materials from the land and from the atmosphere. Local impacts may also arise from marine-based activities associated with port and harbours, dredging, aggregates extraction and aquaculture. The quality of estuarine and coastal waters is monitored by a number of government and regulatory agencies, including the EPA, coastal local authorities, the Marine Institute, various arms of the Department of Communications, Marine and Natural Resources and the Radiological Protection Institute of Ireland. Monitoring of certain aspects is also carried out by non-governmental agencies (EPA, 2003). This chapter outlines the results of monitoring activities carried out by these agencies in the period 2001 to 2003 in relation to water quality and other environmental aspects of tidal waters.

As is the case with all categories of water, arrangements for the monitoring and assessment of the quality of estuarine and coastal waters are currently undergoing significant change due to the requirements of the Water Framework Directive.

EUTROPHICATION TENDENCY AND GENERAL QUALITY CONDITIONS IN ESTUARINE AND COASTAL WATERS

Background

Prior to the mid 1990s, water quality surveys of most estuarine and coastal areas in Ireland were infrequent and were generally intended to establish the effects of discharges of biodegradable waste from municipal or industrial sources. These investigations were mainly concerned with the management of waste water discharges to ensure the protection of beneficial uses of the waters, for example, the avoidance of nuisance to the public through odour or visual evidence of sewage and the maintenance of sufficient dissolved oxygen in receiving waters to facilitate the survival and migration of fish populations.

In more recent times, the associated release of nitrogen and phosphorus compounds has become a cause for increasing concern in relation to the potential for eutrophication. The problem of eutrophication was first identified in inland waters, primarily lakes, but in recent years there has been increasing global evidence that nutrient inputs are causing similar problems in estuarine and marine waters, resulting in significant changes in plant and animal communities. The deleterious effects of excessive nutrient enrichment include increases in the frequency and duration of blooms of algae, among them nuisance and toxic species, dissolved oxygen depletion with the potential to cause mortalities of fish and other biota, and alteration of the natural faunal and floral communities both in the water column and on the seabed. In addition, eutrophied waters may experience mass growth and strandings of algal material which typically produces very strong odours and visual impact as it degrades on beaches and shorelines.

The EU Directives on urban waste water treatment (CEC, 1991a) and nitrates from agricultural sources (CEC, 1991b) are among the most important measures in place to combat eutrophication of waters. In response to the former, considerable investment is currently being made in Ireland to provide new waste water treatment plants and to upgrade existing facilities in both inland and coastal areas and many estuaries no longer receive discharges of untreated sewage. Similarly, the risk of nutrient loss associated with agricultural activities is receiving considerable attention at present; Ireland is currently finalising its Nitrates Action Plan in line with the requirement of the Nitrates directive, which will hopefully redress situations where excessive and unsustainable losses of nitrogen and phosphorus to waters occur. Since surface waters ultimately drain to the sea, carrying the accumulating nutrient burdens that they pick up along the way, estuaries and coastal waters are uniquely vulnerable to nutrient related ecological disturbance, and are likely therefore to show most clearly both the adverse consequences of excessive enrichment and the benefits of measures taken to combat these problems.

It is worth stating here that, in addition to biodegradable organic matter and nutrients, other substances, including more serious pollutants, are generally present in discharges from waste water treatment plants or collection systems and in riverine inflows, and also arise from sources such as shipping and port activities. Since many of these pollutants are typically much more difficult to monitor in seawater, they are monitored by regular measurement of their presence in sediments or in shellfish or fish tissue rather than in the water itself (see next section). However, measuring the degree of disturbance to water quality due to eutrophication or the direct polluting effects of biodegradable organic matter serves as a highly efficient indirect indicator of the potential extent of pollution by less easily detectable but more environmentally significant contaminants. In particular, water bodies[*] which are found to be impacted by eutrophication or by organic enrichment are also more likely to exhibit contamination by potentially more serious contaminants than those which are not in this condition.

[*] "Water Bodies" in this context refer to the water management units developed for the purposes of implementing the WFD, and do not necessarily conform to natural water systems such as a recognised estuary or Bay, though some do. Large waterways have been partitioned into management units to fulfil the WFDs specification that "a (surface) water body is a discrete and significant element of surface water…" which is of uniform "ecological status". Thus, for example, the Shannon Estuary as normally understood comprises a total of seven water bodies, the Tidal Shannon River, the Upper Shannon Estuary and the Lower Shannon Estuary, the Maigue, Fergus and Deel Estuaries and the Mouth of the Shannon. Each of these is considered to warrant separate and individual attention when considering pressures on their ecological state and management measures required to address these pressures. See www.wfdireland.ie for more information on these developments.

Assessment of the Trophic Status of Estuaries, Bays and Adjacent Coastal Waters

General Approach

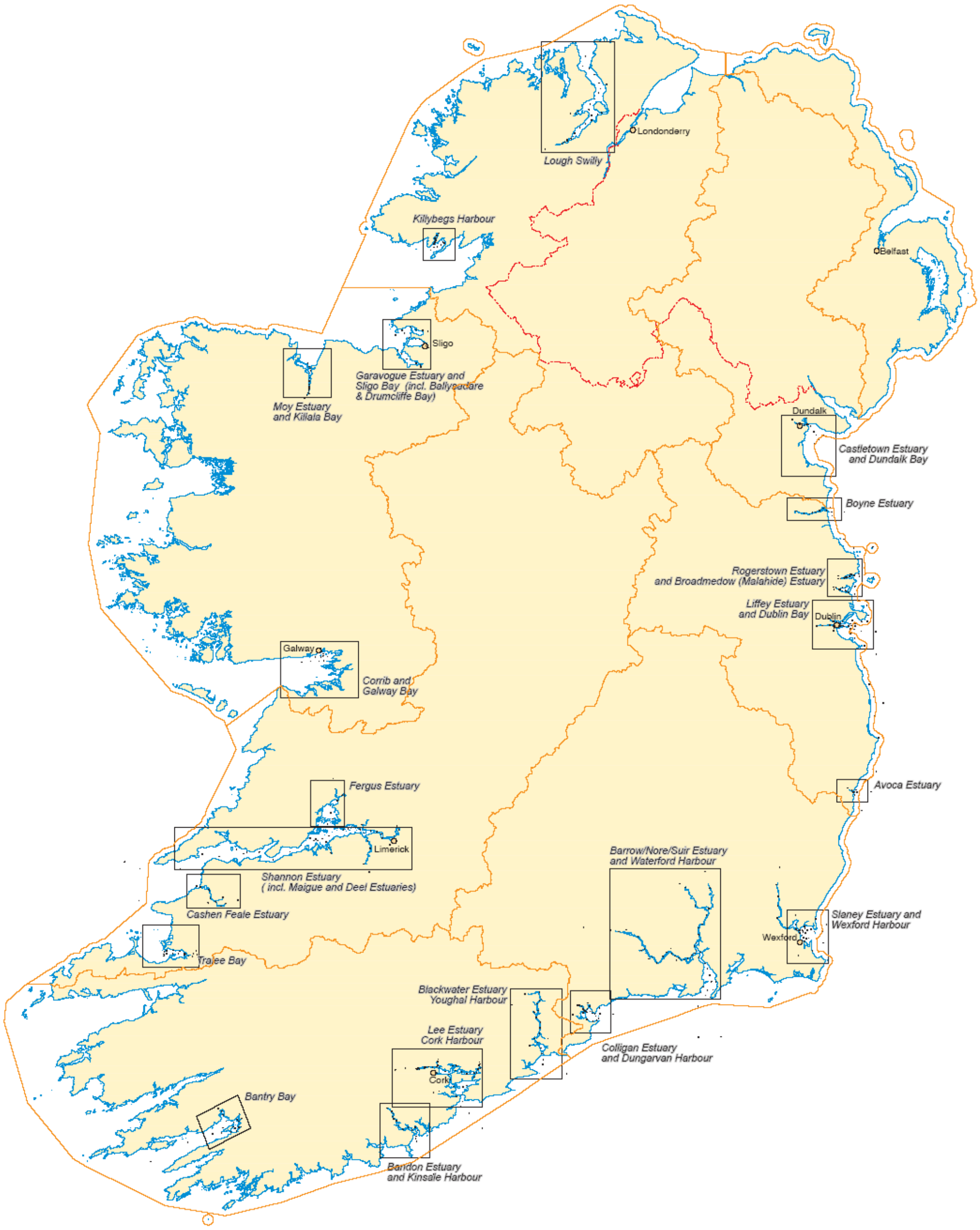
Partly to fulfil Ireland's obligations under the urban waste water treatment and nitrates directives, but with the more general objective of providing information on the quality of these waters, the current estuarine and coastal waters monitoring programme was initiated at a pilot scale by EPA in 1992/93. By 1995, this programme had been expanded to include the majority of Ireland's more important estuaries, bays and inshore coastal waters. The programme also incorporates the monitoring activities of local authorities, the Marine Institute and the Radiological Protection Institute of Ireland (EPA, 2003). The water bodies currently included in the Estuarine and Coastal Water Quality Monitoring Programme are shown in Map 4.1.

A system for the Assessment of Trophic Status of Estuaries and Bays in Ireland (ATSEBI) was developed in 2001 for the analysis of the available data and information with the primary purpose of establishing the trophic status of tidal waterbodies and their sensitivity to eutrophication*, with a view to prioritising measures to combat this problem. The ATSEBI system comprises two main elements, the first, and most developed, being based on water quality, and the second being based on observed distribution and abundance of macroalgae, particularly the green algae, such as *Enteromorpha* and *Ulva*.

To date, the macroalgae element has been an informal and qualitative process based on simple observations, because a proven quantitative scheme does not yet exist, nor has a dedicated monitoring programme been put in place. Similarly, another aspect of the ecological response to eutrophication, the alteration of the frequency and duration of algal blooms, is only included indirectly within the water quality element. Formal classification tools for macroalgae and phytoplankton are currently under development by a joint Ireland – UK Water Framework Directive working group; it is expected that these will provide a basis for expanding the ATSEBI scheme by establishing formal criteria for the assessment of macroalgal and plankton bloom dynamics as part of the WFD ecological monitoring programmes due to commence in 2007.

The water quality element of the ATSEBI system was developed on the basis of existing information on the nature of estuarine and coastal waters which were considered to be of good environmental quality. More specifically, it establishes the values of measurable characteristics or parameters, such

* 'Sensitive Areas' with regard to eutrophication are defined in the Urban Waste Water Treatment Directive as 'waters which are found to be eutrophic or may become eutrophic if protective action is not taken'. The Nitrates Directive which concerns agricultural sources of nitrogen only, is closely linked to that directive and equates Sensitive Areas with 'waters affected by (agricultural) pollution, whether inland or coastal'. Those areas of land which drain into such waters and which contribute to pollution may be designated as 'Vulnerable Zones'.



Map 4.1 Locations of Estuarine and Coastal Water Areas sampled in 2001-2003

as nitrogen and phosphorus concentrations, which are indicative of good environmental quality, against which values for the water body under consideration can be compared. In this regard, it anticipates some of the requirements of the Water Framework Directive (see Chapter Six) in its use of comparisons with unimpacted “Reference Conditions”, though it is not itself WFD-compliant in its current form.

The initial application of the ATSEBI system, covering the period 1995 – 1999, was completed in March 2001 (EPA, 2001a), and the results of the assessment were published in the previous report in this series (McGarrigle et al., 2002). On the basis of that assessment, a number of estuarine and coastal waters (See Box) were designated as Sensitive Areas under the Urban Waste Water Treatment directive (Minister for the Environment and Local Government, 2001b; Minister for the Environment, Heritage and Local Government, 2004).

Designated Sensitive Areas in Tidal Waters

Lee Estuary (Upper) (Tralee)	Owennacurra Estuary/North Channel
Broadmeadow Estuary (Inner)	Feale Estuary (Upper)
Liffey Estuary	Cashen/Feale Estuary
Slaney Estuary (Upper and Lower)	Killybegs Harbour
Barrow Estuary	Castletown Estuary (Dundalk)
Suir Estuary (Upper)	Blackwater Estuary (Upper and Lower)
Bandon Estuary (Upper and Lower)	Lee Estuary/Lough Mahon

The second Assessment of Trophic Status, based primarily on the results of surveys in the period 1999 –2003, is described here. While the majority of waters are common to both assessments, there is not a direct correspondence between the water areas examined, as the current list is based on the tidal water bodies identified for the purposes of the Water Framework Directive which was not available in 2001; also, a number of additional water bodies have been introduced to the assessment for which monitoring information has become available since 1999.

The Assessment of Trophic Status of Estuaries and Bays in Ireland (ATSEBI) System

The ATSEBI eutrophication classification scheme was designed to provide a means of identifying the occurrence of eutrophication in Irish estuarine and near shore waters based on relevant measures of water quality, and was therefore designed to address the issue of eutrophication as laid out in the two most relevant Directives:

The directive on urban waste water treatment defines eutrophication thus:

> ‘eutrophication’ means the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the

quality of the water concerned.

The definition of eutrophication as contained in the directive on nitrates from agricultural sources is along similar lines:

> 'eutrophication' means the enrichment of water by nitrogen compounds, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned.

These definitions recognise the complexity of the linkages between the causes and the responses of waterbodies to eutrophication. They require that, in order to be categorised as 'eutrophic', areas of water should have exhibited each of the following:

- enrichment by the stated nutrients, and
- accelerated growth of algae and higher forms of plants, and
- undesirable disturbance to the balance of organisms present and to the quality of the water concerned.

It follows that waters which exhibit only one or two of these effects do not meet the criteria for eutrophic waters. Certain waters may or may not exhibit high algal growth because they are naturally productive or rapidly flushed; they may equally be subject to other forms of pollution which do not involve nutrient enrichment, such as deoxygenation by the direct effects of high organic loading. Efforts to control nutrients in such waters could represent wasted effort, and may divert resources from the appropriate control measures to combat the actual problem.

In the development of the ATSEBI system, a broadly-based approach was taken to developing the classification scheme:

- the natural range and variability of water quality indicators in Irish estuarine, coastal and marine waterbodies, and their inflowing rivers, which clearly exhibited good environmental quality, and in particular low trophic status*, was established,

- the relevant European and international literature was consulted, and

- available information was collated on the experience to date of the international scientific and regulatory bodies, including the EU and OSPAR.

* The absence of any clear indication of eutrophication

From this body of information, a set of criteria was developed to provide a clear and transparent mechanism for evaluating the key features of eutrophication against which the water quality of each individual waterbody could be assessed. In line with the above definitions of eutrophication, there are three categories of criteria:

(a) criteria for nutrient enrichment,
(b) criteria for accelerated growth, and
(c) criteria for 'undesirable disturbance'.

In addition, observations of clearly excessive productivity of Macroalgae are considered, though no formal criteria are yet in place.

The detailed structure of the ATSEBI system is described in Table 4.1. Using these criteria, the following classification scheme has been devised for tidal waters in relation to their trophic status and tendency to eutrophication.

> *Eutrophic* waterbodies are those in which each of the criteria are breached, i.e. where elevated nutrient concentrations, accelerated growth of plants and undesirable water quality disturbance occur simultaneously.
>
> *Potentially Eutrophic* waterbodies are those in which two of the criteria are breached and the third falls within 15 per cent of the relevant threshold value/values.
>
> *Intermediate Status* waterbodies are those which do not fall into the Eutrophic or Potentially Eutrophic classes but in which breaches one or two of the criteria occur;
>
> *Unpolluted* waterbodies are those which do not breach any of the criteria.

The ATSEBI system is intended to be applied to estuaries, bays and the coastal waters where there is at least a risk of eutrophication due to the size of their drainage basins or to the presence of large towns, cities or industrial areas along their shorelines. It is not intended to provide criteria for enrichment or its effects in general coastal waters (EPA, 2001a).

The main rivers flowing into tidal waters, which bear substantial loads of nutrients into near shore waters, and the offshore waters into which land-derived nutrient loads will ultimately disperse, are also of interest for a full characterisation of eutrophication tendency in Ireland's tidal waters. While the ATSEBI system does not apply to rivers, the results of the analysis of the riverine inflows are useful in identifying those estuaries in which these inflows are significant in relation to trophic status.

TABLE 4.1

Criteria for Eutrophication in Irish Estuaries, Bays and Nearshore Coastal Waters

MODULE A WATER QUALITY

Parameter/ Waterbody Type	Numeric Criterion	Statistic	Period to which Criterion Applies[1]
Category A: Nutrient Enrichment			
Dissolved Inorganic Nitrogen (DIN) mg/l N[2]			
Tidal Fresh Waters	>2.6	Median	Winter or Summer
Intermediate Waters [3]	>1.4	Median	Winter or Summer
Full-Salinity Waters	>0.25	Median	Winter or Summer
Orthophosphate (MRP) µg/l P			
Tidal Fresh Waters	>60	Median	Winter or Summer
Intermediate Waters [3]	>60	Median	Winter or Summer
Full-Salinity Waters	>40	Median	Winter or Summer
Category B: Accelerated Growth			
Chlorophyll µg/l [4]			
Tidal Fresh Waters	>15	Median	Summer
	or >30	90 percentile	Summer
Intermediate Waters [3]	>15	Median	Summer
	or >30	90 percentile	Summer
Full-Salinity Waters	>10	Median	Summer
	or >20	90 percentile	Summer
Category C: Undesirable Disturbance [5]			
Dissolved Oxygen (D.O.) % saturation			
Tidal Fresh Waters	<70	5 percentile	Summer
	or >130	95 percentile	Summer
Intermediate Waters [3]	<70	5 percentile	Summer
	or >130	95 percentile	Summer
Full-Salinity Waters	<80	5 percentile	Summer
	or >120	95 percentile	Summer

MODULE B MACROALGAE

Pending the introduction of a formal classification scheme for macroalgae, the following procedure is used. Where the trophic status of a waterbody according to information on macroalgal distribution and abundance indicates a poorer condition than the water quality parameters, the water body is so downgraded pending further investigation. Thus, the overall status is determined by the poorer of the classes suggested by the water quality and macroalgal modules of the ATSEBI.

Notes

1 In relation to these criteria: **Winter** extends from October – March inclusive;
Summer extends from April – September inclusive.

2 Dissolved Inorganic Nitrogen (DIN) **is quantified as the sum of oxidised nitrogen (nitrate and nitrite) and ammonium. These are considered to represent the readily available nitrogen for uptake by plants.**

3 at Median Salinity 17 psu *(practical salinity units; see Appendix IV)*; because the variation in water quality characteristics of estuaries is primarily controlled by variation in the degree of mixing of fresh and marine waters, as reflected by salinity, it is necessary to scale the criteria accordingly. The applicable value of each criterion is established and used in the assessment process as follows:

(i) Obtain the Median salinity value for the waterbody being assessed;
(ii) Using this Median salinity, determine from the table below the applicable value of the criterion for each parameter;
(iii) Determine whether the value of the parameter for the waterbody exceeds the applicable value of the criterion or, in the case of deoxygenation, falls below it;
(iv) If the waterbody is non-compliant for **at least one** of the standards for each of the three categories of criteria, the waterbody is deemed to be Eutrophic.

For example, the DIN criterion is scaled from 2.6 mg/l N at 0 psu salinity (freshwater) to 0.25 mg/l N at 35 psu. Thus, for a Median salinity of 25 psu, the applicable DIN criterion has a value of 0.889 mg/l N. If the Median DIN value for the waterbody exceeds 0.889 mg/l N, this criterion is breached.

4 Chlorophyll: As there is a wide range of sampling, processing and analytical methods in use for this parameter, and therefore a degree of uncertainty about the comparability of results, the stated criteria should not be applied without careful evaluation to data generated by methods other that that employed by EPA.

5 Undesirable Disturbance to the oxygen regime caused by accelerated plant production may take the form of deoxygenation or of excess oxygenation, which is referred to as Supersaturation. Criteria are therefore defined for both of these effects; non-compliance in respect of either threshold is regarded as a breach of the criterion for Undesirable Disturbance.

The applicable values of each of the criteria over the full range of salinities are tabulated below.

Salinity Median psu	**DIN** Median mg/l N	**MRP** Median µg/l P	**Chlorophyll** Median µg/l	**Chlorophyll** 95 %ile µg/l	**Dissolved Oxygen % Saturation** 5 %ile	**Dissolved Oxygen % Saturation** 95 %ile
0	2.600	60	15.0	30.0	70	130
1	2.529	60	15.0	30.0	70	130
2	2.459	60	15.0	30.0	70	130
3	2.388	60	15.0	30.0	70	130
4	2.318	60	15.0	30.0	70	130
5	2.247	60	15.0	30.0	70	130
6	2.176	60	15.0	30.0	70	130
7	2.106	60	15.0	30.0	70	130
8	2.035	60	15.0	30.0	70	130
9	1.965	60	15.0	30.0	70	130
10	1.894	60	15.0	30.0	70	130
11	1.824	60	15.0	30.0	70	130
12	1.753	60	15.0	30.0	70	130
13	1.682	60	15.0	30.0	70	130
14	1.612	60	15.0	30.0	70	130
15	1.541	60	15.0	30.0	70	130
16	1.471	60	15.0	30.0	70	130
17	1.400	60	15.0	30.0	70	130
18	1.336	59	14.7	29.4	71	129
19	1.272	58	14.4	28.9	71	129
20	1.208	57	14.2	28.3	72	128
21	1.144	56	13.9	27.8	72	128
22	1.081	54	13.6	27.2	73	127
23	1.017	53	13.3	26.7	73	127
24	0.953	52	13.1	26.1	74	126
25	0.889	51	12.8	25.6	74	126
26	0.825	50	12.5	25.0	75	125
27	0.761	49	12.2	24.4	76	124
28	0.697	48	11.9	23.9	76	124
29	0.633	47	11.7	23.3	77	123
30	0.569	46	11.4	22.8	77	123
31	0.506	44	11.1	22.2	78	122
32	0.442	43	10.8	21.7	78	122
33	0.378	42	10.6	21.1	79	121
34	0.314	41	10.3	20.6	79	121
35	0.250	40	10.0	20.0	80	120

Results of the 2005 Assessment

The results of the latest application of the ATSEBI are summarised in Table 4.2 while the assessments in respect of individual water bodies are presented in Table 4.3 and illustrated on the map on the accompanying CD ROM. The outcome of the analysis in terms of individual statistics are detailed in Appendix IV. It is intended to make available on CD ROM at a later date all of the water quality data for each water body.

Changes in the period since the previous assessment covering the period 1995 – 1999 are indicated in Table 4.2; as the boundaries of a number of water bodies have been refined since the last assessment, that analysis has been repeated using the new water body boundaries, so the results presented here in respect of the 1995-1999 assessment are not identical to those originally reported (EPA, 2001a).

There has been an increase in the number of water bodies included in the assessment, from 60 to 69. Of these additional water bodies, four represent waters which were not considered in any manner in the last assessment (the Avoca Estuary and the Coastal Waters Adjacent to Arklow Harbour, and Inner and Outer Bantry Bay); the remaining additional water bodies represent portions of estuaries and bays for which little or no data were previously collected, such as the Upper Swilly Estuary in the vicinity of Letterkenny and the Rogerstown Estuary in North Dublin, and also includes the Argideen Estuary (Courtmacsherry Bay), Co Cork, which is of note due to macroalgal abundance over the last number of years.

The condition of almost two-thirds of water bodies has remained unchanged over the period between the assessments, and of the remainder approximately equal proportions have shown improvement and deterioration. The number of water bodies classified as Eutrophic has fallen from 15 to 12 since the 1995–1999 period, as has the proportion of waters in this category, down from 25 to 17 per cent. This is almost mirrored by the increase in the proportion of water bodies falling into the Intermediate category, and mostly results from a substantial improvement in at least one of the ATSEBI criteria for previously eutrophic water bodies.

Of a total of fifteen water bodies classed as Eutrophic in the previous assessment, only six have remained so, these being the Inner Broadmeadow Estuary, the Lower Slaney Estuary, Lough Mahon (inner Cork Harbour), both sections of the Bandon Estuary and the Upper Lee (Tralee) Estuary. The Broadmeadow Estuary, which is much used for recreational boating and other water contact sports, is particularly impacted by nutrient inputs, probably arising both from riverine and direct inputs, and action is urgently required to address the pollution of this water body. The previously eutrophic water bodies which have improved are Inner Dundalk Bay, the Liffey Estuary, the upper Slaney, Barrow and Suir Estuaries, the North Channel (Great Island) in Cork Harbour, both sections of the Cashen-Feale Estuary and Killybegs Harbour. The Castletown Estuary, Dundalk and South Wexford Harbour (south

TABLE 4.2

Summary results of trophic status assessments for tidal water bodies. Numbers and proportions of tidal water bodies falling into each trophic assessment class in the five-year periods 1999-2003 and 1995-1999

Trophic Class	1999-2003		1995-1999	
	Nos	Percentage	Nos	Percentage
Eutrophic	12	17.4	15	25.0
Potentially Eutrophic	3	4.3	3	5.0
Intermediate Status	28	40.6	18	30.0
Unpolluted	26	37.7	24	40.0
Total Numbers Assessed	69		60	

TABLE 4.3

Trophic classification of tidal water bodies in the periods 1995-1999 and 1999-2003 and indication of change in status between these periods. Note water body boundaries have been adjusted to conform with WFD designations, thus outcome here may differ for earlier 1995-1999 assessments (EPA, 2001a)

Water Body	Category	Assessment 1999 - 2003	Assessment 1995 - 1999	Change from 1995 - 1999
Argideen Estuary[1]	Estuary	EUTROPHIC	Not Assessed	
Bandon Estuary Upper	Estuary	EUTROPHIC	EUTROPHIC	Unchanged
Bandon Estuary Lower	Estuary	EUTROPHIC	EUTROPHIC	Unchanged
Blackwater Estuary Lower	Estuary	EUTROPHIC	Potentially Eutrophic	Disimprovement
Broadmeadow Estuary (Inner)	Estuary	EUTROPHIC	EUTROPHIC	Unchanged
Castletown Estuary	Estuary	EUTROPHIC	Intermediate	Disimprovement
Lee (Tralee) Estuary Upper	Estuary	EUTROPHIC	EUTROPHIC	Unchanged
Lough Mahon	Estuary	EUTROPHIC	EUTROPHIC	Unchanged
Owenacurra Estuary	Estuary	EUTROPHIC	Potentially Eutrophic	Disimprovement
Rogerstown Estuary[2]	Estuary	EUTROPHIC	Not Assessed	
Slaney Estuary Lower	Estuary	EUTROPHIC	EUTROPHIC	Unchanged
Wexford Harbour South	Estuary	EUTROPHIC	Intermediate	Disimprovement
Barrow Estuary	Tidal Fresh	Potentially Eutrophic	EUTROPHIC	Improvement
Blackwater Estuary Upper	Tidal Fresh	Potentially Eutrophic	Potentially Eutrophic	Unchanged
Boyne Estuary[3]	Estuary	Potentially Eutrophic	Intermediate	Unchanged
Bantry Bay Inner	Estuary	Intermediate	Not Assessed	
Bantry Bay Outer	Bay	Intermediate	Not Assessed	
Barrow Nore Estuary	Estuary	Intermediate	Intermediate	Unchanged
Barrow Nore Suir Estuary (Outer)	Estuary	Intermediate	Intermediate	Unchanged
Broadmeadow Estuary (Outer)	Bay	Intermediate	Unpolluted	Disimprovement
Cashen Feale Estuary	Estuary	Intermediate	EUTROPHIC	Unchanged
Colligan Estuary	Estuary	Intermediate	Intermediate	Unchanged
Cork Harbour	Bay	Intermediate	Unpolluted	Disimprovement
Deel Estuary	Estuary	Intermediate	Intermediate	Unchanged
Dundalk Bay Inner	Estuary	Intermediate	EUTROPHIC	Unchanged
Feale Estuary Upper	Tidal Fresh	Intermediate	EUTROPHIC	Unchanged
Fergus Estuary	Estuary	Intermediate	Intermediate	Unchanged
Garavoge Estuary	Estuary	Intermediate	Intermediate	Unchanged
Killybegs Harbour	Bay	Intermediate	EUTROPHIC	Improvement
Kinsale Harbour	Bay	Intermediate	Intermediate	Unchanged
Lee Estuary	Estuary	Intermediate	Intermediate	Improvement
Liffey Estuary	Estuary	Intermediate	EUTROPHIC	Improvement
Maigue Estuary	Estuary	Intermediate	Intermediate	Unchanged
McSwyne's Bay	Coastal	Intermediate	Unpolluted	Disimprovement
Nore Estuary	Tidal Fresh	Intermediate	Unpolluted	Disimprovement
Nth Channel, Cork Harbour	Estuary	Intermediate	EUTROPHIC	Improvement
Rogerstown Estuary Outer	Bay	Intermediate	Unpolluted	Disimprovement
Shannon River (Tidal)	Tidal Fresh	Intermediate	Unpolluted	Disimprovement

TABLE 4.3 CONTD.

Water Body	Category	Assessment 1999 - 2003	Assessment 1995 - 1999	Change from 1995 - 1999
Slaney Estuary Upper	Estuary	Intermediate	EUTROPHIC	Improvement
Suir Estuary Lower	Estuary	Intermediate	Intermediate	Unchanged
Suir Estuary (Upper)	Tidal Fresh	Intermediate	EUTROPHIC	Improvement
Swilly Estuary Upper	Estuary	Intermediate	Not Assessed	
Wexford Harbour North	Bay	Intermediate	Intermediate	Unchanged
Avoca Estuary	Estuary	Unpolluted	Not Assessed	
Avoca Estuary Adjacent Coastal	Coastal	Unpolluted	Not Assessed	
Ballysadare Bay	Bay	Unpolluted	Unpolluted	Unchanged
Boyne Estuary Plume Zone	Coastal	Unpolluted	Intermediate	Improvement
Broadmeadow Adjacent Coastal	Coastal	Unpolluted	Unpolluted	Unchanged
Corrib Estuary	Estuary	Unpolluted	Unpolluted	Unchanged
Dublin Bay	Bay	Unpolluted	Unpolluted	Unchanged
Dublin Bay Adjacent Coastal	Coastal	Unpolluted	Unpolluted	Unchanged
Dundalk Bay Outer	Bay	Unpolluted	Unpolluted	Unchanged
Dungarvan Harbour	Bay	Unpolluted	Intermediate	Improvement
Galway Bay North Inner	Bay	Unpolluted	Unpolluted	Unchanged
Killala Bay	Bay	Unpolluted	Unpolluted	Unchanged
Lee (Tralee) Estuary Lower	Estuary	Unpolluted	Intermediate	Improvement
Lough Swilly Lower	Bay	Unpolluted	Unpolluted	Unchanged
Moy Estuary	Estuary	Unpolluted	Unpolluted	Unchanged
Rogerstown Adjacent Coastal	Coastal	Unpolluted	Unpolluted	Unchanged
Shannon Estuary Lower	Estuary	Unpolluted	Unpolluted	Unchanged
Shannon Estuary Upper	Estuary	Unpolluted	Unpolluted	Unchanged
Sligo Bay	Bay	Unpolluted	Unpolluted	Unchanged
Sligo Harbour	Bay	Unpolluted	Unpolluted	Unchanged
Swilly Estuary Lower	Bay	Unpolluted	Unpolluted	Unchanged
Tralee Bay	Bay	Unpolluted	Unpolluted	Unchanged
Waterford Harbour Adjacent Coastal	Coastal	Unpolluted	Not Assessed	
Waterford Harbour Outer	Bay	Unpolluted	Intermediate	Improvement
Wexford Harbour Adjacent Coastal	Coastal	Unpolluted	Not Assessed	
Youghal Harbour	Coastal	Unpolluted	Unpolluted	Unchanged

[1]The Argideen Estuary was not classified by ATSEBI as no water qulity data are available for this water body, but it is considered Eutrophic arising from observations of macroalgal distribution and abundance; investigations are needed to confirm this conclusion.

[2]The Rogerstown Estuary was classed as Potentially Eutrophic according to the water quality module of the ATSEBI analysis, but is considered Eutrophic arising from observations of macroalgal distribution and abundance; investigations are needed to confirm this conclusion.

[3]The Boyne Estuary was classed as Intermediate according to the water quality module of the ATSEBI analysis, but is considered Potentially Eutrophic arising from observations of macroalgal distribution and abundance; investigations are needed to confirm this conclusion.

of the southern training wall) have deteriorated to Eutrophic Status, and another two, the Lower Blackwater Estuary and the Owenacurra Estuary, have been confirmed as eutrophic, having been classed as potentially eutrophic in the last assessment.

The proportion of water bodies classed as being unpolluted has remained practically unchanged at around 40 per cent of the bodies assessed. Deterioration was found in respect of a number of reaches which were classed as Unpolluted in 1995-1999, notably Outer Cork Harbour and McSwynes' Bay, adjacent to Killybegs Harbour. The tidal freshwater zones of the Shannon and Nore rivers also exhibited disimprovements to Intermediate condition, though the latter case arises mainly because more information is available for the current period. Conversely, four water bodies improved from Intermediate to Unpolluted; these are the Boyne Estuary Plume Zone (the coastal waters immediately outside the mouth of the Boyne), Outer Waterford Harbour, Dungarvan Harbour and the Lower Lee (Tralee) Estuary.

Macroalgae

As noted earlier, a formal system of classification of tidal waters based on the patterns of macroalgal growth and abundance is not yet available, so this is not yet formally incorporated into the ATSEBI. On site observations of macroalgal growth patterns made during water quality surveys in the period 1999–2003 were generally consistent with the assessments outlined above. In the case of two estuaries, the Boyne Estuary and the Rogerstown Estuary, the observations suggest excessive development of opportunistic green algal mats. Given that these water bodies are in breach of the nutrient criteria and, in the Rogerstown Estuary, both oxygen criteria (this water body was classed as Potentially Eutrophic on this basis), the productivity of green algal mats in these water bodies is probably sufficient to warrant considering the Boyne Estuary and the Rogerstown Estuary as Potentially Eutrophic and Eutrophic respectively for management purposes. In the absence of formal quantitative criteria giving thresholds for eutrophication in respect of macroalgal abundance, it is recommended that this aspect be the subject of further investigation in the first instance in each of these water bodies.

In a third case, the Argideen Estuary in West Cork, this water body has not to date been included in the EPA Estuarine and Coastal Water Quality Monitoring Programme, but several sources (Wilkes, 2005; Courtmacsherry Bay Environmental Partnership, pers. comm.) have clearly established that it is seriously impacted by annual overproduction of green algae, and should accordingly be considered as Eutrophic.

Specific Observations in Relation to Water Management

<u>Castletown Estuary and Inner Dundalk Bay</u>

The waste water treatment plant (WWTP) at Soldier's Point, Dundalk was commissioned in 2000, and so has been discharging biologically treated effluent for most of the period covered by the present assessment, whereas prior to 2000 discharges were treated only to primary screening level. The commissioning of the plant appears to have achieved a considerable reduction in the phosphorus levels in Inner Dundalk Bay, such that this water body no longer breaches any of the criteria relating to nutrients in the ATSEBI scheme. This water body remains in exceedance of the accelerated growth and oxygenation criteria, however, and there indications that the WWTP is discharging more biologically available inorganic nitrogen than it did prior to upgrading. In contrast to Inner Dundalk Bay, the trophic status of the Castletown Estuary, upstream of the Soldier's Point outfall, appears to have deteriorated since the last review, this time exceeding the criteria for nitrogen and phosphorus, both chlorophyll thresholds and, of probably most significance, exhibiting regular and marked deoxygenation.

Since both the Castletown Estuary and Inner Dundalk Bay are Sensitive Areas, the following should be investigated: whether there is a case for installing nitrogen removal in addition to the biological treatment currently in place, and for re-examining the performance of the WWTP in relation to organic loading discharging to the estuary. There should also be a review of the situation in relation to stormwater overflows.

Liffey Estuary and Dublin Bay

Water quality in the Liffey Estuary appears to have improved markedly in the period since the previous assessment, particularly in relation to Nitrogen, though winter phosphorus levels remain in breach of the respective criterion, as were oxygen supersaturation levels. Chlorophyll levels appear to have fallen since 1995-1999, though there is a slight degree of uncertainty associated with this observation; due to the use of an alternate analytical approach by Dublin City Council's Water Laboratory, the application of the ATSEBI criterion to assess these data is intended to be indicative only.

The observed improvement in water quality in the Liffey Estuary is clearly a result of the installation of significantly upgraded treatment facilities at the Ringsend WWTP, though further investigation is still required to track the change in nutrient levels as the full commissioning of the works proceeds (Carney, 2003). For example, there are indications that, while total and ammoniacal N concentrations are falling as a consequence of nitrification taking place within the system, this is being accompanied by increasing oxidised N levels. This should be kept under review in case it becomes a problem requiring further tertiary treatment to avoid the reoccurrence of excessive N availability in the estuary, which is a Sensitive Area under Urban Waste Water Treatment directive. Similarly, it is too early to tell whether the stranding of macroalgae on the beaches of Dublin Bay has been adequately addressed by the treatment processes already in place at Ringsend. It is clear, though, that the new WWTP has achieved a considerable improvement in the bacteriological quality of the Liffey Estuary and Dublin Bay, reflected in the results of bathing water monitoring at a number of locations in these water bodies (see Quality of Bathing Waters below), a development which is greatly welcomed.

Slaney, Barrow, Nore, Suir, and Blackwater Estuaries

The upper Slaney, Barrow and Suir Estuaries, each of which are essentially tidal freshwater habitats at the mouths of large rivers, were previously observed to be Eutrophic, but in the current assessment they have improved to Intermediate condition. In each of these, and in the Nore Estuary, for which data were not previously available, the criteria for nitrogen and oxygen disturbance were breached, but not the chlorophyll thresholds. However, it is prudent to consider these water bodies still at risk of eutrophication, at least partly given the abundant plant growth which is observed along their banks; this may be the main source of the elevated oxygen levels observed in these reaches in the current assessment period, as the riverine inflows did not exhibit these levels of supersaturation.

The Lower Slaney Estuary, the Lower Blackwater Estuary and the Upper and Lower Bandon Estuary were again classed as Eutrophic in the current period. The Upper reach of the Blackwater remained Potentially rather than formally Eutrophic. All of these are associated mainly with high nitrogen concentrations in the riverine inflows.

The southern portion of Wexford Harbour, south of the southern training walls, is indicated as Eutrophic in the current assessment, having previously been of Intermediate condition; the difference may lie only in the fact that winter nutrient data were not previously available for this water body. Since it is very shallow and relatively sheltered, with flushing rates probably much lower than those in main body of Wexford Harbour, the South Harbour may be naturally predisposed to high algal productivity. The main body of the Harbour, north of the south training walls, exhibits generally high water quality, though breaches of the nutrient criteria occurred in both the 1995-1999 and the current period, leading to classification of this water body as Intermediate in both assessments. It is noted that phosphorus concentrations, on which the Harbour was in breach in 1995-1999, have been considerably reduced since then, and levels in both winter and summer periods are currently very low. Nitrogen levels in the North Harbour, however, remain elevated due to the inflow from the Slaney Estuary. Despite this, there do not appear to be grounds for extending Sensitive Area status to Wexford North Harbour.

Lee Estuary and Cork Harbour

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

Lough Mahon, by contrast, exhibits a partial degree of recovery in respect of dissolved oxygen levels in both periods, though because of the occurrence of elevated chlorophyll concentrations in combination with breaches of nutrient thresholds this water body was classed as Eutrophic in both. It is of note, however, that, while all four of the individual nutrient criteria were breached in Lough Mahon in the 1995–1999 assessment, only one of these, the winter nitrogen criterion, was in breach in the current period. This may to some extent reflect the developments being undertaken under the Cork Main Drainage Project, which was largely completed in 2004 and has achieved the cessation of the discharges of untreated sewage into the Lee Estuary and Lough Mahon. Biological treatment processes are currently in operation at the recently commissioned WWTP at Carrigrennan, Little Island. It is too early to predict whether the addition of nitrogen removal will be required to reverse the eutrophic status of Lough Mahon, recently designated, along with the Lee Estuary, as a Sensitive Area.

The Owenacurra Estuary was confirmed as being in a Eutrophic condition in this assessment, due in large measure to the high levels of nitrogen in the Owenacurra River. The trophic status of the North Channel appears to have improved since the last assessment, though there remains a lack of comprehensive nutrient data in respect of this water body, particularly from the winter months. These water bodies have been jointly designated as a Sensitive Area.

Cashen Feale and Shannon Estuaries

The Cashen Feale Estuary appears to have improved since 1995-1999, though excessive chlorophyll concentrations were observed in the Cashen. The estuaries of the Maigue and Deel Rivers exhibited high nutrient concentrations, though only the Deel Estuary had high dissolved oxygen levels; neither were in breach of the chlorophyll criterion, so were again found to be of Intermediate condition. The Tidal Shannon River and the Fergus Estuary remained in Intermediate condition also, though in both cases this was due to slightly elevated summer phosphate levels only, with no accompanying chlorophyll or oxygen disturbance.

Killybegs Harbour

Killybegs Harbour, which has been designated as a Sensitive Area, improved to an Intermediate condition in the current period; marked deoxygenation is typical in this water body, particularly in the bottom waters. This was also observed outside the Harbour in McSwynes' Bay on a number of surveys in 2002 and 2003, where bottom dissolved oxygen levels in waters over 30 m deep were found to be consistently as low as 50 per cent of normal levels. Since similar data are not available for the previous period, this observation cannot readily be ascribed to any pollution source or event, so further surveillance of this phenomenon is required in future surveys in Killybegs Harbour and its adjacent coastal waters.

Swilly Estuary

Marked deoxygenation was also observed in the Upper Swilly Estuary, Letterkenny. Very little information was previously available for this water body, but pronounced chlorophyll concentrations and deoxygenation levels were noted in the current period. Since background nutrient levels in the inflow of the Swilly River are typically extremely low, these effects are probably attributable to excessive enrichment from Letterkenny WWTP. The volumes of receiving water in the vicinity of the outfall from this WWTP are very limited, so either considerable improvements in effluent quality or relocation of the outfall point are urgently required to address this problem.

Winter Nutrient Monitoring in the Irish Sea and Eastern Celtic Sea

Since 1990, the Marine Institute has been carrying out intensive monitoring of nutrient levels in the Irish Sea and, latterly, the eastern Celtic Sea at the time of minimal biological activity (January-February). While no data on summertime chlorophyll and dissolved oxygen levels are available for these waters, nutrient data collected over the period 1999 to 2003 by the Marine Institute indicate no instances of excessive nutrient enrichment.* This result is consistent with the main finding of the Marine Institute's review of their data for the period 1990 to 2000, which found little evidence of elevated nutrient levels in the coastal and offshore waters of the western Irish Sea and eastern Celtic Sea (McGovern et. al, 2002). Over the review period there were indications of a decrease in both oxidised nitrogen and orthophosphate in all regions with the exception of TON in the southwest Irish Sea where a 5 per cent increase was indicated.

Average winter offshore concentrations of oxidised nitrogen and ortho-phosphate in the Western Irish Sea in the period were found to be 8 µmol/l N and 0.5 µmol/l P, broadly consistent with concentrations reported by other studies in the Irish Sea. Celtic Sea concentrations were very similar, averaging 8.2 µmol/l N and 0.44 µmol/l P, though these statistics are based on only two sets of winter data. Higher concentrations were found in less saline coastal waters as a result of the nutrient loads carried in riverine inflows. Trend analysis indicated that concentrations of orthophosphate have undergone a decrease of almost 25 per cent in the period between 1990-91 and 1999-2000, though no trend in orthophosphate loads discharged annually by Irish rivers over the same period was evident. An increase of almost 20 per cent was suggested in riverine oxidised nitrogen loads, but no clear trend was found in oxidised nitrogen concentrations in the Irish Sea.

These observations might suggest that inputs from Irish rivers do not constitute a major influence on levels of nutrients in the greater Irish Sea relative to levels in the inflow from the Celtic Sea, though land-derived inputs are of significance in the vicinity of the respective river mouths. However, the Marine Institute review (McGovern et al., 2002) acknowledges that the data to hand are not yet sufficiently detailed to allow trends to be definitively identified, particularly in relation to winter

* This is equally true of the remainder of Ireland's coastal and offshore waters on the south, west and north coasts, which are certainly in very high quality.

background nutrient levels in Atlantic and Celtic Sea waters, and that other processes, notably interactions with the seabed and suspended sediment, need to be accounted for in the programme.

One of the main recommendations of the report is to initiate a programme of biological monitoring during the seasonal growth period to investigate links between nutrient concentrations and potential eutrophic effects. An initial project to address this subject, based in the Irish Sea, commenced in 2004. Expansion of these activities into the remaining coastal areas will be necessary in the next few years to fill this major gap in our information on the quality of Ireland's coastal and offshore waters.

MONITORING OF TOXIC CONTAMINANT LEVELS IN ESTUARINE AND COASTAL WATERS

Background

The Marine Institute monitors the levels of priority hazardous substances in a range of commercial fish species landed at Irish ports and also in shellfish from selected sites around the Irish coast. These are substances, such as mercury, that have been identified as being of particular concern for the marine environment and/or to consumers of sea foods. Levels of such substances in fish and shellfish are a good indicator of the contamination in the marine environment as a whole. Inter alia, the monitoring is part of Ireland's contribution to the Joint Assessment and Monitoring Programme of the OSPAR convention on the protection of the waters of the North East Atlantic.

Metals and Chlorinated Hydrocarbons in Fish Landed At Irish Ports

In accordance with the requirements of various EU legislation, the Marine Institute samples a range of fish species landed at five major Irish ports (Castetownbere, Rossaveal, Killybegs, Dunmore East and Howth) on an annual basis and tests these for mercury as well as some other trace metals, such as cadmium and lead, and chlorinated hydrocarbons. EC Regulations (EC, 2001, 2002) set maximum levels for mercury, cadmium and lead in fish.

In 2001 a total of 44 samples from 20 different species of fish landed at six major Irish fishing ports (Dingle in addition to the above five named) were analysed for total mercury and other trace metals and for chlorinated hydrocarbons. The concentration of mercury in the edible tissue ranged from less than the detection level of 0.03 mg/kg to 0.42 mg/kg (i.e. less than the limit of 0.5 mg/kg wet weight for mercury in fishery products set by the EC – a less stringent limit of 1 mg/kg applies to certain species). The levels of lead and cadmium were low and well within the respective limit values of 0.20 and 0.05 mg/kg wet weight set for these trace metals (Tyrrell et al., 2003). There are no internationally agreed standards or guidelines available for other trace metals or for chlorinated hydrocarbons in fishery products but the levels of these contaminants were well below the strictest standard or guidance value for fish tissue applied by individual contracting parties to the OSPAR Convention.

In 2002 all of the results for samples tested were below the maximum limits set (Tyrell *et al.*, 2004) as were the majority of the results for the samples tested in 2003. However, one value, in a sample from dogfish landed at Howth in August 2003, exceeded the EU limit for mercury (Marine Institute, 2004).

Toxaphene and Brominated Flame Retardants in Fish

In addition to the foregoing, special surveys of the occurrence of the pesticide toxaphene and of brominated flame retardants in fish tissues have been undertaken by the Marine Institute in recent years. First produced in 1945 and used as an insecticide, toxaphene is a complex mixture of chlorinated bornanes (CHBs). Although it does not appear to have ever been used in Ireland this pesticide is nonetheless widespread in the marine environment. Because toxaphene is bioaccumulative it does not easily break down in the environment and becomes more concentrated as it moves up the food chain. Levels may be high in some predatory fish and mammals because it accumulates in the bodies of those exposed to it. It is a suspected carcinogen and thus information on the exposure of toxaphene to the consumer of fish is important.

The Marine Institute has participated in the EU project “Investigation into the monitoring, analysis and toxicity of toxaphene” (MATT), which began in 1997, along with participants from the Netherlands, Norway and Germany. Data on the occurrence of this pesticide, which is listed as a persistent organic pollutant (POP), in 55 samples from 18 different fish species taken in Irish waters, have been documented in the study (McHugh et al., 2003). Overall no samples of fish from Irish waters were found to exceed recommended limits, e.g. German and Austrian maximum residue limit (MRL). Toxaphene levels in fish from the north-east Atlantic have already been shown to exceed MRLs in some instances. In the Irish context concentrations were highest in farmed fish and deep-sea species reflecting the bioaccumulation potential due to the high lipid content of former and the diets and longevity of the latter. In an assessment of the risk to the consumer of toxaphene from Irish fishery products, based on MRL and tolerable daily intake (TDI) legislation, it was concluded that while toxaphene has been detected in fish sampled from Irish waters, indicating the ubiquitous occurrence of the compound, no adverse effects are expected in the average consumer of Irish fishery products due to residues in fish.

Brominated flame retardants (BFRs) are a diverse group of high production volume chemicals characterised by their bromine content and use to retard the combustibility of commercial goods (OSPAR Commission, 2001). Hexabromocyclododecane (HBCD) and Tetrabromobisphenol A (TBBPA) are two BFRs currently in use. HBCD’s main application is to flame retard polystyrene that is used as thermal insulation in buildings; a minor use is in upholstery textiles. TBBPA is the primary flame retardant used in electronic circuit boards. Other BFRs include polybrominated diphenyl esters

(PBDEs). BFRs are included as priority hazardous substances in the list of such chemicals under the Water Framework Directive (see Chapter Six).

There is little information on the occurrence of BFRs in the Irish marine environment although the results of analysis of sediment samples taken in Dublin Bay and of hake caught off the south coast were included in a recent study for comparison with North Sea levels. The results for two BFRs, total HBCD (∑HBCD) and TBBPA, in hake liver from a single sample of fish from the Atlantic off the southern coast were respectively <0.6 and < 0.2 µg/kg dry weight. This compares with ranges of <0.7-50 and <0.3-1.8 µg/kg dry weight respectively for ∑HBCD and TBBPA in cod liver samples (n=2) from the North Sea. The results for ∑HBCD in Dublin Bay sediments (n=8) ranged from <1.7 to 12 with a mean concentration of 3.3 µg/kg dry weight. These levels are similar to those measured in estuarine sediment samples (n=9) from the Netherlands: range <0.8-9.9; mean 3.2. To put these levels in some context a range and mean concentration of <2.4-1680 and 199 µg (∑HBCD)/kg were recorded in sediment samples (n=22) from English estuaries (Morris et al., 2004).

The Marine Institute (MI) has carried out a preliminary study of levels of BFRs in Irish farmed salmon from seven aquaculture sites. Analysis of fish fillet samples for PBDEs and HBCD showed the presence of both in all samples at levels similar to those reported in the scientific literature for salmon and other fish species (Marine Institute, 2004b). The Food Safety Authority of Ireland (FSAI), Marine Institute (MI) and Bord Iascaigh Mhara (BIM) completed a more comprehensive survey on the levels of certain POPs, including BFRs, in various fish species, including farmed and wild salmon in 2004.

QUALITY OF SHELLFISH AND SHELLFISH WATERS

Monitoring of Shellfish Waters and Production Conditions for Shellfish

The requirements of the EC Directive 'laying down the health conditions for the production and the placing on the market of live bivalve molluscs' (CEC, 1991c) had to be complied with before 1 January 1993. The Department of Communications, Marine & Natural Resources (DCMNR) is the competent authority in Ireland for classifying shellfish production areas and in 1996 Regulations implementing the directive were made by the then Minister (Minister for the Marine, 1996). However, a shellfish sanitation monitoring programme for classifying shellfish-growing waters, based on a number of parameters including microbiological criteria, had been in operation in Ireland since 1985. The scheme of classification has three categories, corresponding with the criteria and conditions as laid down in the directive, which can be summarised as in Table 4.4.

Although the classification is mainly based on the bacteriological quality of the shellfish, other criteria are also taken into account for the assessment including the following:

TABLE 4.4

Summary of scheme of classification of shellfish production areas operated by the Department of Communications, Marine & Natural Resources under Directive 91/492/EEC. Based on CEC (1991c) and Minister for Communications, Marine & Natural Resources (2003a; 2003b).

Classification	Faecal coliforms/*E.coli* per 100g of shellfish flesh[1]	Requirements
A	Less than 300 faecal coliforms or 230 *E.coli*	None - sale for direct human consumption permitted
B	Less than 6000 faecal coliforms or 4600 *E.coli* in 90% of samples	Purification in an approved plant for 48 hours prior to sale for human consumption
C	Less than 60000 faecal coliforms	Relaying for a period of at least two months in clean seawater prior to sale for human consumption

[1]five-tube, three-dilution MPN test

TABLE 4.5

Total numbers of shellfish sites sampled in five periods between 1991 and 2003 and proportions (%) in Shellsan classes. (Note that percentages do not add to 100 as sites with more than one class are omitted)

	2003	**2000**	**1998-99**	**1995-97**	**1991-94**
Total Number	58*	61**	58***	NA	58****
Class A	21	34	24	NA	55
Class B	62	54	60	NA	29
Class C	2	2	2	NA	3

NA = Not Available

* 8 areas were classed as partly A and B; 1 as B and C

** 4 areas were classed as partly A and B; 1 as partly A, B and C; 1 as B and C

*** 6 areas were classed as partly A and B; 1 as A, B and C; 1 as B and C

**** 5 areas were classed as partly A and B; 1 as A and C; one as B and C

(a) they must not contain toxic/objectionable compounds in such quantities that the calculated dietary intake exceeds the permissible daily intake (PDI) or that taste is impaired.

(b) the upper limits as regards the radionuclide contents must not exceed those laid down for foodstuffs.

(c) the total Paralytic Shellfish Poison (PSP) content in the edible parts must not exceed 80 microgrammes per 100 grams of shellfish flesh in accordance with the biological testing method.

(d) the customary biological testing methods must not give a positive result to the presence of Diarrhetic Shellfish Poisoning (DSP) in the edible parts of the shellfish.

Table 4.5 shows the number of shellfish production areas, as a percentage of total, in each of three categories under the Shellsan scheme of classification, in periods coinciding with the current and earlier national reports on water quality. For the current reporting period the latest classification of November 2003 is given. This can be compared with the classification (A: 24%; B: 66% and C: 2%) for the same production areas in the previous year (December 2002), also within the current reporting period, which shows a very similar situation.

The proportions of areas assigned to Class A has fallen significantly over the 12 year period, the figure for 2001-2003 being the lowest since 1991-1994 (although only 12 per cent of sites were placed in this category in the 1987-1990 period). In contrast, the proportions of Class C sites have remained at a low level over the period (again, a significantly worse situation was recorded in 1987-1990 when 12 per cent of the sites monitored were assigned to Class C). A full list of the sites with their classification in 2003 (Minister for Communications, Marine and Natural Resources, 2003a; 2003b) is given in Appendix V.

Another directive, 'Shellfish' Directive (CEC, 1979), requires that Member States monitor designated shellfish waters to ensure that the quality of the edible species is maintained or enhanced. Regulations giving legal effect to national standards under the directive were transposed into Irish law in 1994 (Minister for the Environment, 1994). Under the directive the sites designated are: Clarinbridge, Kilkieran Bay, Killary Harbour, Mulroy Bay, Bantry Bay, Glengarriff Harbour, Roaring Water Bay, Bay at Aughinish in Clare, Cromane, Maharees, Kilmakilloge, Carlingford Lough, Clew Bay and Bannow Bay.

In accordance with the monitoring requirements of this and the 1991 directive, the Marine Institute collected water and shellfish samples from 20 sites in 2001, 24 in 2002 and 29 (three of which were in Carlingford Lough) in 2003. As well as some of the major growing areas, which included the above 14 designated sites, other production areas such as Wexford Harbour, Arthurstown (Waterford), Dungarvan, Cork Harbour, Kenmare Bay, Cromane (Castlemaine), Tralee Bay, Aughinish (Limerick), Ballysadare and Lough Foyle have been sampled. In 2003, Cheekpoint (Waterford) and Rogerstown (Dublin) were added to the monitoring programme, the latter intended to provide better coverage of the east coast, which is not currently licensed for shellfish production.

All of the sites were analysed for standard physico-chemical parameters, trace metal levels and chlorinated hydrocarbon concentrations. As in previous years the water quality was good and complied with the requirements of the directive. Petroleum hydrocarbons were not observed in any of the shellfish waters nor as deposits on shellfish. The levels of cadmium, lead and mercury in shellfish tissues were generally well within EU limits; one cadmium value (0.97 mg/kg), for an oyster (*Ostrea edulis*) sample from Castlegregory, was close to the limit of 1.0 mg/kg for that metal. Further sampling is being carried out to investigate whether this was an anomalous result (Marine Institute, 2004c)[*]. For the other trace metals and chlorinated hydrocarbons measured, all concentrations were well below the strictest values listed thus confirming the unpolluted nature of Irish shellfish and shellfish-producing waters (Glynn et al., 2003).

Occurrence of Shellfish Biotoxins

The Marine Institute is the National Reference Laboratory for biotoxins (See Box: Marine Biotoxin Sampling Programme) and has operated a National Phytoplankton and Biotoxin Monitoring Programme for the detection of these naturally occurring marine organisms since 1984. The primary aim of the Shellfish Biotoxin Monitoring Programme is the protection of human health with the view to maintaining an excellent reputation for the shellfish industry.

The Department of Communications, Marine and Natural Resources (DCMNR) is contracted by the Food Safety Authority of Ireland (FSAI) to implement the marine biotoxin monitoring programme as part of the latter's statutory function of coordinating the enforcement of all food legislation. The Department's Marine Institute carries out a range of toxin analysis at its own laboratories and also contracts regionally located laboratories to carry out analysis.

The shellfish production areas around the coast of Ireland are monitored on a weekly or monthly basis for the presence of phytoplankton and marine biotoxins (See Box: Toxic Phytoplankton Species). Where biotoxins are detected, the production area is closed and harvesting prohibited until the danger of toxicity has passed (See Box: Marine Biotoxin Sampling Programme). Such closures are essential to protect consumer health and to protect the reputation of the Irish shellfish industry. Exports from the shellfish industry were valued at €52.5 million in 2002 while the national monitoring programme now costs over €1.5 million to implement and administer. Closures of shellfish-growing areas as a result of biotoxin contamination are common in the summer and autumn when toxic algae are present.

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[*] Slightly elevated cadmium in oyster tissue has been recorded previously, e.g. from Clew Bay, Inner Tralee Bay, Aughinish (Co. Limerick) and Kilkieran in 1999 (McGovern *et al.*, 2001), as well as in a number of areas in 1994 and 1995 (Nixon *et al.*, 1995; Smyth *et al.*, 1997). The reason for the seemingly higher levels of cadmium in oysters than in mussels has been attributed to the former species accumulating metals more readily and it has been concluded that the cadmium in these instances is not anthropogenic in origin (Nixon *et al.*, 1995)

Traditionally, molluscan shellfish were only taken for consumption between the months of September and April but nowadays are produced and consumed throughout the year. Consumption of shellfish in Ireland has risen substantially in the past decade, e.g. between 1996 and 1999 there was a 21 per cent increase in consumption of Irish-grown mussels.

Toxic Phytoplankton Species

Although most species of phytoplankton are harmless to humans some contain toxins that can cause illness and even death in extreme cases through the consumption of contaminated shellfish. In Ireland shellfish contamination is presently a year round occurrence with most of the resultant closures of production areas being attributed to *Dinophysis* species. However other toxic species are problematic to the Irish aquaculture industry including *Pseudo-nitzschia* , *Alexandrium* and *Protoperidinium* species.

Dinophysis species are associated with Diarrhetic Shellfish Poisoning (DSP). This can cause diarrhoea, nausea, vomiting, abdominal pain and chills to humans after the consumption of contaminated shellfish. *Dinophysis* spp. are found along the Irish coast and have caused most closures of bays in the shellfish industry since the monitoring programme came into existence. These phytoplankton can be observed throughout the year although they are most prevalent during the summer months.

Alexandrium species are the cause of Paralytic Shellfish Poisoning (PSP). In Ireland the only known positive results for this toxin have occurred in Cork Harbour. *Alexandrium tamarense* is thought to be the causative phytoplankton in this case. PSP toxin has not been observed in any other Irish waters although *Alexandrium* spp. have been recorded along the west and south coasts. The presence of these dinoflagellates triggers the testing of shellfish samples for PSP toxins.

Protoperidinium species are thought to cause Azaspiracid Poisoning (AZP) toxin in shellfish. This toxin came to prominence in 1995 when at least eight people in the Netherlands became ill after eating mussels from Killary Harbour. Symptoms included nausea, vomiting, diarrhoea and stomach cramps. *Protoperidinium* is found widely around the Irish coast and is easily identifiable to the trained eye. It has still to be confirmed that this species is the definite cause of AZP.

Pseudo-nitzschia species are the causative agents of Amnesic Shellfish Poisoning (ASP) toxin (domoic acid) in scallops. They are found in all areas of the Irish coast but have to occur in numbers as high as 50,000+ cells per litre to give rise to significant levels of the toxin in the shellfish.

Source: Marine Institute

The results of bioassay testing for algal toxins in mussel (*Mytilus edulis*) and in oysters (*Ostrea edulis* and *Crassostrea gigas*) in the current and previous reporting periods show that there was generally a much higher level of positive results for the mussel than there was for the two oyster species; this difference is likely to be accounted for both by the greater volumes of water filtered by mussels per unit body weight as well fact that they are cultured in the upper part of the water column where exposure to phytoplankton is likely to be greater than it is for the bottom growing oysters. The data also show that the proportion of samples of all species giving positive results was much greater in the years 1999 to 2001 than it was in the earlier and later years of the period covered. In the case of the oysters, all samples gave negative results in 2002 and 2003.

In July 2001 Irish shellfish were responsible for an outbreak of DSP in Belgium. This followed earlier outbreaks in France associated with Irish mussels. An extensive monitoring effort resulted in the detection of DSP, AZP and ASP toxins in shellfish and necessitated the closure of shellfish production areas for periods of, in some cases, up to 10 months (J. Silke, pers. comm.). While significantly fewer toxic events occurred in Irish waters in 2002 than in 2001, four different groups of shellfish toxins necessitated either bay closure or restricted harvesting (J. Silke, pers. comm.). As is normal in Ireland the main problem was due to toxins of the DSP group particularly in mussels. However, PSP toxicity

Marine Biotoxin Sampling Programme

Ireland has developed a national marine biotoxin monitoring programme for shellfish harvesting areas in accordance with the EU directive on the conditions for the production of bivalve molluscs (CEC, 1991c). The programme covers the following toxins, Diarrhetic Shellfish Poisoning (DSP), Azaspiracid poisoning (AZP), Paralytic Shellfish Poisoning (PSP) and Amnesic Shellfish Poisoning (ASP). Other toxins are also tested for on an ongoing basis.

As specified under the directive live bivalve molluscs, echinoderms, tunicates and marine gastropods (e.g. whelks and periwinkles) must be tested for biotoxins. This includes both commercially farmed and wild species. In Ireland the main bivalve species are mussels, native and pacific oysters, razorfish, scallops, clams and cockles. Before harvesting from any production area two samples, taken a minimum of 48 hours apart, must have biotoxins below the regulatory limit. With the first of these two clear samples the area is assigned a ‘closed pending’ status and with the second the area is assigned an ‘open’ status. If a result is positive for biotoxins then the area is assigned a ‘closed’ status and the area will need two clear results a minimum of 48 hours apart to return to an ‘open’ status again. The frequency of testing is laid down for each toxin-carrying species and this may have seasonal variation. If the frequency is not adhered to then the area loses its ‘open’ status. There are no antidotes available for any of the toxins involved nor can they be destroyed by cooking or processing methods and the only recourse is to preventative measures such as prohibition of sale and to allow the shellfish to detoxify naturally. While other coasts in Ireland can be occasionally affected, the south-west is most liable to be affected by this phenomenon. There is no evidence that such blooms of harmful phytoplankton in the south-west are in the first instance influenced by nutrient enrichment and pollution. In 2000 the detection of phytoplankton was improved with new sampling methodologies introduced including the analysis of toxins by chemical methods to complement the existing bioassay methods.

The National Biotoxin Monitoring Programme was formalised in 2000. Due to the unprecedented number of closures of shellfish production areas during 1999 and 2000 a review of the adequacy of existing controls in place was carried out by the Molluscan Shellfish Safety Committee (MSSC) under the chairmanship of the Food Safety Authority of Ireland (FSAI). The MSSC comprises representatives of FSAI, DMNR, Marine Institute, approved laboratories, BIM, health boards and also the shellfish industry producers and processors. Weekly reports are now issued on a range of bioassay, chemical and phytoplankton tests to over 150 recipients. For example, a total of 3242 bioassays, 3031 chemical analyses and 2900 phytoplankton analyses were carried out in 2001.

Sources: Marine Institute and Food Safety Authority of Ireland

above regulatory threshold levels was measured in both mussels and oysters from Cork Harbour during a three-week period in July resulting in a closure. Production area closures were also relatively few in 2003 and again most resulted from elevated levels of DSP toxin. In mid-September 2003 shellfish sites in the Cork Harbour area were closed as a result of a small bloom of Alexandrium spp following positive bioassays and confirmatory chemical tests (Cusack et al., 2004). Two other areas were closed from January to October due to the presence of AZP.

Up until the early 1980s shellfish contamination with the DSP toxin was so rare in Ireland that it failed to elicit any action by the health and fisheries authorities. However, in 1984, in response to a rapidly developing shellfish industry coupled with detection of Dinophysis species at the Sherkin Island Marine Station, the Irish Biotoxin and Phytoplankton Monitoring Programme commenced (Silke, 2003). Since the early 1990s the most significant events resulting in closures of shellfisheries have been due to the presence of DSP toxins although from 1995 onwards some were also caused by AZP toxins. The overall picture since sampling began shows very limited occurrence of DSP toxin some years, as low as 1.5 per cent for all species, but much higher levels in other years, especially in the summer months (Silke, 2003).

QUALITY OF BATHING WATERS

Background

In Ireland, monitoring of the water quality at designated bathing areas is undertaken in accordance with the provisions of the EU directive concerning the quality of bathing waters (CEC, 1976b). The purpose of the directive is to ensure that the quality of bathing water is maintained and, where necessary, improved so that it complies with specified standards designed to protect public health and the environment. This directive has been given effect in Ireland through the Quality of Bathing Water Regulations 1992 (Minister for the Environment,1992) which have subsequently been amended by Regulations made in 1994, 1996, 1998, 2000 and 2001.

Local authorities are responsible for bathing water quality in their area as well as for monitoring bathing water quality and making information available to the public on water quality during the summer season. The role of the EPA is to collate the results of monitoring which are forwarded to the European Commission for inclusion in the European-wide compendium report published annually by the EU. The EPA also publishes an annual national bathing water report which is released prior to the start of the following bathing season.

An additional role extended to the EPA in 2001 is the authorisation of departures from bathing water quality standards under specific circumstances. National Regulations allow the EPA to grant a departure to a local authority where:

- deviations from the standards have arisen because the water concerned has undergone natural enrichment from the soil without human intervention or

- in the case of the parameters pH, colour and transparency, where exceptional weather or geographical conditions have arisen.

The departure is only granted on condition that it does not constitute a public health hazard. The granting of the departure may also be subject to conditions specified by the Agency and may be restricted to a specified time period.

The number of designated bathing areas has increased over the years to reach a total of 131 sites by 2003. This figure includes both sea water (122) and freshwater (9) areas. (See Chapter Three for information on the freshwater sites). For the purposes of the directive, sampling of bathing areas begins in mid May each year, two weeks in advance of the formal bathing season, traditionally regarded as commencing on the June bank holiday weekend. Sampling must be undertaken at least every two weeks at each designated point and should continue until the end of August. The minimum number of samples to be taken during the season is therefore seven, although this may be reduced to four if the water quality at the site for the previous two years has been of sufficiently high quality. More frequent sampling should be carried out where:

- the results indicate, or an investigation finds, that a deterioration in the water quality has taken place or
- there appears to be a discharge of substances likely to lower the quality of the bathing waters.

Compliance Assessment

While the sampling and analysis criteria for bathing waters is largely similar for both national and EU legislation there are differences in the way in which compliance with the results of these parameters is assessed.

The National Regulations stipulate that each sample obtained must be analysed for the following 8 microbiological and physicochemical parameters:

- Total coliforms
- Faecal coliforms
- Colour
- Mineral oils
- Surface active substances
- Phenols
- Transparency
- Tarry residues, floating materials

Under certain circumstances, in particular where there has been a deterioration of water quality, both the frequency of monitoring and range of analytes must be increased. Similarly, where bathing water quality is found to be consistently of a very good quality, the monitoring frequency may be reduced to a minimum of four times during the bathing season.

In addition to the eight parameters listed under national compliance, further parameters may also be assessed if there are grounds for believing or an investigation shows that the water quality has deteriorated in respect of the particular parameter(s). These additional parameters include faecal streptococci, Salmonella and Enteroviruses. However, it should be noted that bathing areas sampled in Ireland are monitored for faecal streptococci on a regular basis as this parameter is required for assessment under the Blue Flag Scheme. Local Authorities must report the results of sampling to the EPA at the end of each bathing season. The Agency interprets compliance with the Regulations based on all of the parameters which are required to be sampled and analysed.

The parameters which are required to be sampled and analysed under the directive are the same as those prescribed under the National Regulations. However, unlike national compliance which includes all parameters, EU bathing water compliance is based on a sub-set of these parameters
The five parameters considered for EU compliance purposes are:

- Total coliforms
- Faecal coliforms
- Mineral oils
- Surface-active substances
- Phenol

During the bathing season, the water quality at each designated point must be assessed in accordance with specified standards. Three types of standards have been established under European and national legislation:

Mandatory Values are values which must be observed if the bathing area is to be deemed compliant with the directive.

Guide Values are more stringent than the mandatory values and can be regarded as quality objectives which all bathing sites should endeavour to achieve.

National Limit Values are additional standards set by Ireland for a number of parameters (dissolved oxygen, total coliforms, faecal coliforms, faecal streptococci).

The list of water quality parameters along with the guide, mandatory and national limit values is given in Appendix VI.

Seawater Bathing Water Compliance Results 2001-2003

In general, the water quality at marine bathing areas in Ireland has remained at a high standard. During each year of the review period, over 97 per cent of the sites monitored complied with the minimum mandatory standards laid down by EU legislation. The proportion of sites complying with the more stringent guideline standards fell during the review period from a high of 91.7 percent in 2000 to 83.6 per cent in both 2002 and 2003. Despite this it is clear that the long-term trends in compliance with both mandatory and guideline standards are towards better water quality at marine bathing areas over the past decade (Fig. 4.1). Overall, Ireland's bathing water compares very favourably with that in other EU Member States.

In the previous review period (1998-2000), the number of areas failing to comply with the directive's mandatory standards for the five key parameters were two in 1998 (the main strand at Dunmore East, Co. Waterford and Lady's Bay, Co. Donegal – the latter failing due to insufficient monitoring of the physico-chemical parameters), two in 1999 (the main strand at Dunmore East and Ardmore, Co. Waterford) and two in 2000 (Ardmore and Clifden, Co. Galway). In this review period (2001-2003) the numbers failing the minimum mandatory standards were three in 2001 (Clifden and Merrion Strand and Sandymount, Co. Dublin) three in 2002 (Ardmore and Brittas Bay North and Brittas Bay South, Co. Wicklow) and four in 2003 (Balbriggan, Co. Dublin, Bray, Co. Wicklow, Keem, Co. Mayo and Spiddal, Main Beach, Co. Galway). The location and compliance status of all 131 designated bathing areas sampled during 2003 are shown in Fig. 4.2 (this figure includes the freshwater bathing areas).

Bathing Water Compliance in the Greater Dublin Area

A significant number of bathing water areas in the greater Dublin area experienced an improvement in bathing water quality between 2002 and 2003. A major factor in this trend is likely to have been the commissioning of the new wastewater treatment facility located at Ringsend in Dublin, which has significantly reduced the quantity of untreated sewage entering greater Dublin Bay area. A comparison of compliance status between 2002 and 2003 is illustrated in Fig. 4.3.

Proposed Revision of the Directive concerning the Quality of Bathing Water

The current Bathing Water directive is nearly 30 years old and has, since its adoption, contributed greatly to improvement in water quality in the coastal and inland bathing areas in Europe. However, it is recognised that the directive has a number of limitations and weaknesses that need to be addressed, particularly in relation to the specified water quality parameters for monitoring and their associated limit values.

In 2002 the European Commission presented a revised proposal for a new directive on bathing water quality. This proposal is intended to deliver general benefits in relation to improved health protection for bathers and a more proactive approach to beach management, including public involvement. In

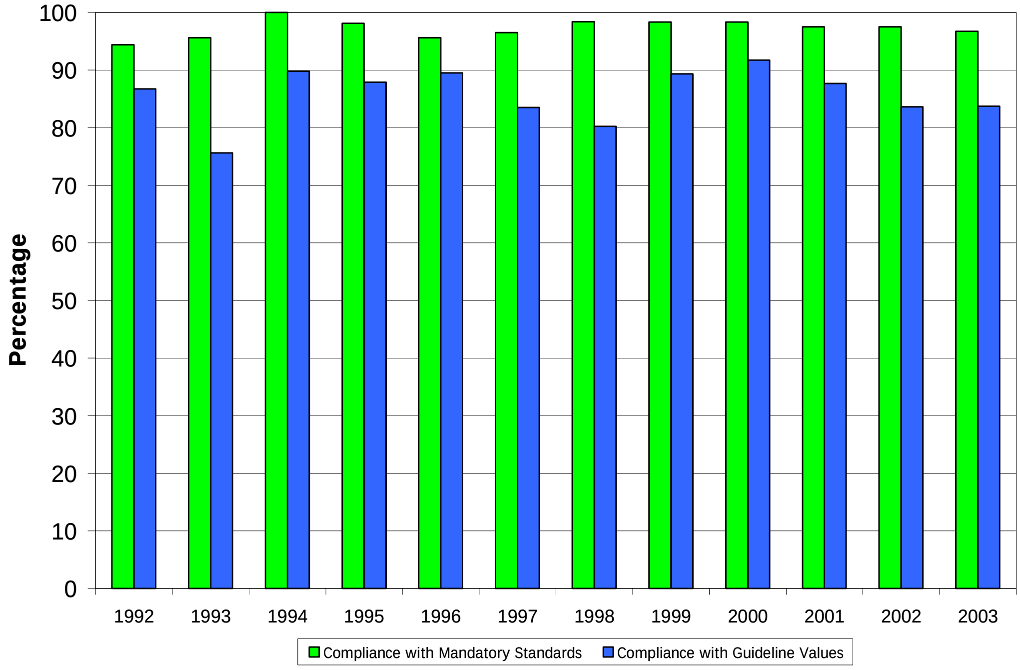

Fig. 4.1 Compliance of sea-water bathing beaches with mandatory and guideline standards (CEC, 1976b) in the period 1992-2003

Fig. 4.2 Designated Bathing Areas and Compliance in 2003

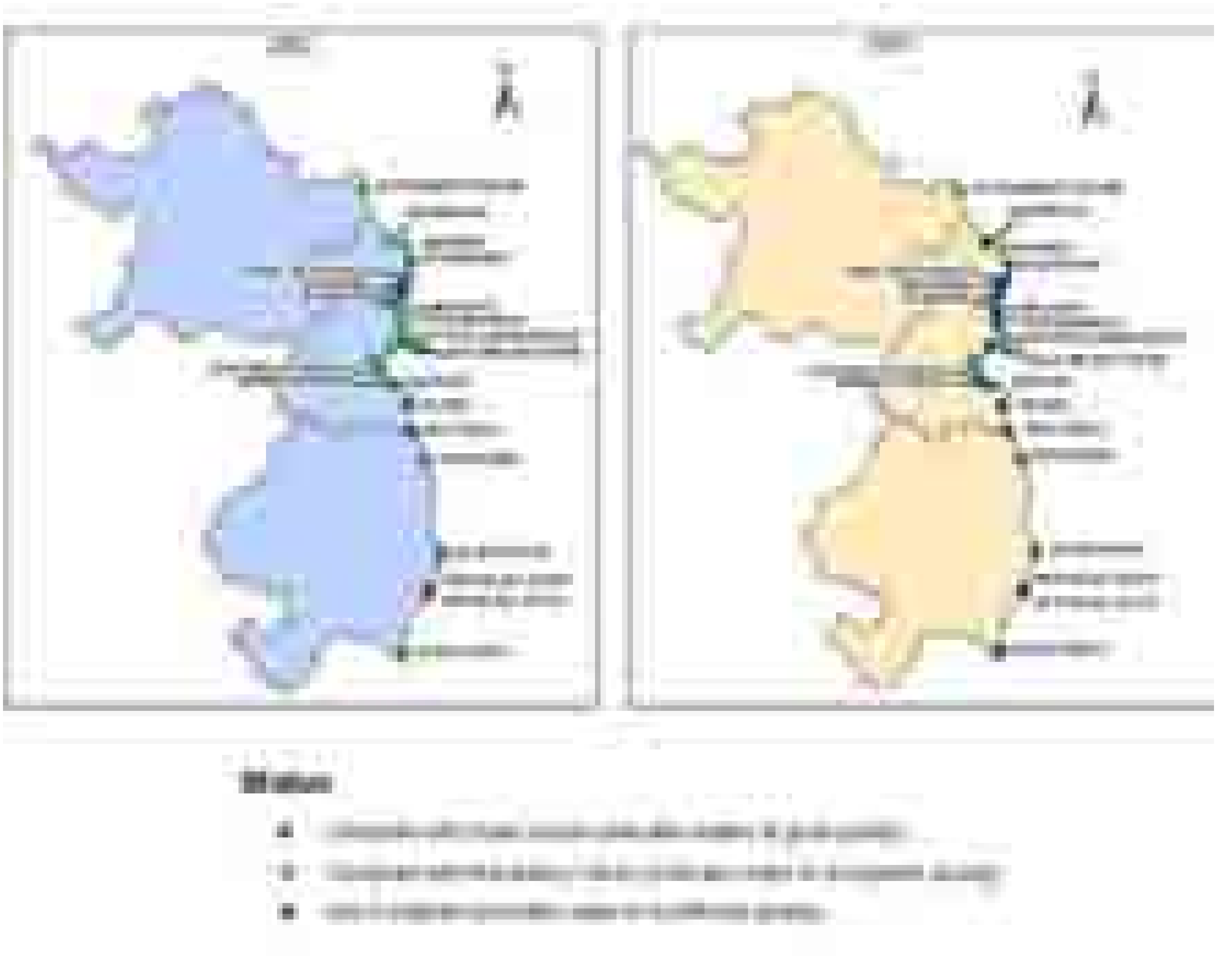

Fig. 4.3 Bathing Water Quality in the Greater Dublin Region 2002 and 2003

terms of monitoring, the new directive proposes to eliminate the tests for 19 different pollutant parameters and replace them with measurements of two bacterial indicators – intestinal Enterococci and *Escherichia coli* – which focus specifically on protection of human health. Compared with current standards, the proposed standards are intended to provide a significantly higher protection against the risk of contracting gastroenteritis and respiratory ailments as a result of bathing.

The proposed directive also aims to make more use of modern communication methods, such as the Internet, to inform the public about the quality of bathing waters and thereby allow a more informed choice on where to bathe. The bathing water quality standards specified in the proposed directive are more stringent than those set by the present directive. As a consequence, some decrease in Ireland's current high level of compliance with bathing water standards might be expected. The Council of the EU adopted a formal Common Position on the bathing water directive at the Environment Council meeting on 20th December 2004. The Common Position was expected to be transmitted to the European Parliament for its second reading in the first half of 2005.

The Blue Flag Scheme

The Blue Flag Scheme is a voluntary scheme to identify high quality bathing water areas, administered in Ireland by An Taisce and at European level by the Foundation for Environmental Education in Europe (FEEE). To receive a blue flag, a bathing site, in addition to maintaining a high standard of water quality, must meet specified objectives with regard to the provision of safety services and facilities, environmental management of the beach area and environmental education. The EPA has co-operated with An Taisce to check that all water quality results obtained by both organisations each bathing season are comparable. The analysis of bathing water in respect of the Directive is separate from, although complementary to, the European Blue Flag Scheme. The EPA also participates in the National Blue Flag Jury, which assists in the initial assessment of the Irish applicants for the Blue Flag Award. The award is based on the performance and standards achieved during the previous bathing season. In 2001, 2002 and 2003, respectively, 75, 75 and 73 blue flags were awarded to Irish beaches (Fig. 4.4). There has been little variation in the proportion of the waters assessed attaining this distinction in recent years.

RADIOACTIVITY MONITORING OF MARINE WATERS

Radioactivity monitoring of the Irish marine environment is carried out by the Radiological Protection Institute of Ireland (RPII). The RPII is the national organisation with regulatory, monitoring and advisory responsibilities in matters pertaining to ionising radiation in Ireland and in 2002 was came under the aegis of the Department of the Environment and Local Government. The most recent report on marine monitoring covers the years 2000 and 2001 (Ryan, et al., 2003). Some 300 samples of fish, shellfish, seaweed, seawater and sediment were collected in 2000 and again in 2001. The results show that the artificial radionuclide of greatest domestic significance continues to be caesium-137. The activity concentration of caesium-137 in the Irish marine environment has remained relatively

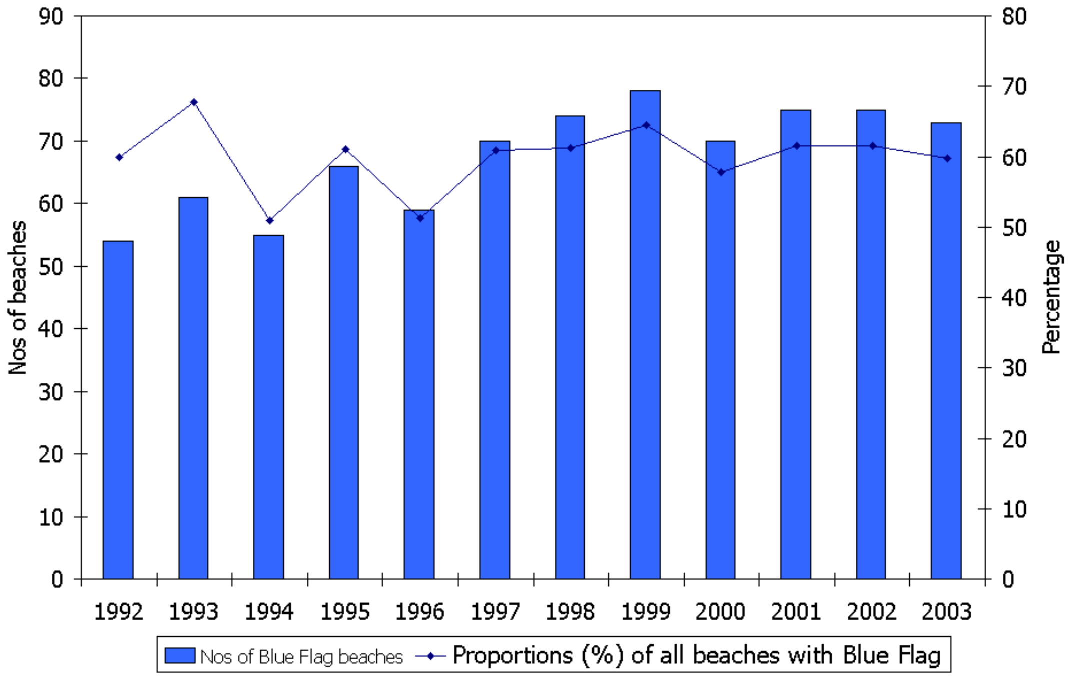

Fig. 4.4 Numbers of bathing beaches awarded Blue Flag status in each year from 1992 to 2003 and the proportions these represent of all beaches monitored. (Source: An Taisce)

stable since the mid-1990s but at a lower level than that recorded during the previous two decades. The highest levels measured were along the north-east coastline.

The consumption of fish and shellfish, from the Irish Sea is the dominant pathway by which radioactive contamination of the marine environment results in radiation exposure of the Irish population. The dose to consumers who eat substantial quantities of seafood (20 g of shellfish and 200 g of fish per day) was estimated to be less than 2 microsieverts (mSv) for 2003 which is similar to that in both 2001 and 2002 (RPII, 2004). In 2000 and 2001 the committed radiation doses to a heavy consumer of seafood from the Irish Sea were 1.18 mSv and 1.20 mSv respectively due to the ingestion of caesium-137, technetium-99, plutonium-238, -239, -240 and americium-241. These compare with doses of 1.42 mSv and 1.33 mSv in 1998 and 1999. Caesium-137 remains the dominant radionuclide, accounting for approximately 60-70 per cent of these doses attributable to sea food. However, it should be noted that these doses represent less than 0.05 per cent of the average annual radiation dose of 3620 mSv to a person in Ireland from all sources of radioactivity.

The increased discharges of technetium-99 from Sellafield have resulted in corresponding increases in the contribution of this radionuclide to the doses of seafood consumers. However, because of the relatively low radiotoxicity of technetium-99 it currently contributes less than 30 per cent of the dose arising from ingestion of fish and shellfish. In 2003, a UK study commissioned by Greenpeace and carried out by Southampton University found traces of technetium-99 discharged from Sellafield in fresh and smoked salmon farmed in Scotland. In the light of public concern in Ireland over these findings, samples of Irish and Scottish smoked salmon, smoked mackerel and fresh salmon were sourced from Irish supermarkets and analysed for their technetium-99 content. Technetium-99 was detected in one of the samples analysed (smoked Scottish mackerel) and the level measured was comparable to those measured in seafood samples analysed routinely as part of the marine monitoring programme. Since, as already indicated, the dose per unit activity is significantly lower for technetium-99 than for caesium-137, the former accounts for less than 30 per cent of the artificial radionuclide dose to an Irish seafood consumer, while approximately 60-70 per cent of this dose is due to Sellafield-sourced caesium-137 (RPII, 2004).

Radiation doses to the Irish population resulting from discharges at Sellafield, on the north-west English coast, are now very low and, on the basis of current scientific knowledge, do not pose a significant health risk. Further reductions in these doses are being pursued through the implementation of the OSPAR Strategy with regard to Radioactive Substances. All signatories to the Strategy are committed to progressive and substantial reductions in radioactive discharges from their facilities. Compliance with the objectives of the OSPAR Strategy should ensure that the radiation doses attributable to the operations at Sellafield and other nuclear facilities are even further reduced in future year (Ryan et al., 2003).

OIL POLLUTION INCIDENTS

Responsibility for the investigation of oil pollution incidents rests with the Irish Coast Guard (IRCG), a division within the Department of Communications, Marine and Natural Resources (DCMNR), as part of its role in developing and co-coordinating an effective regime for marine pollution response. Its functions in this respect are mandated through Government policy and various pieces of national legislation, EU Directives and International Conventions including the following:

- The Sea Pollution Act 1991 which gives effect to the MARPOL Convention and the Intervention Convention.

- The Sea Pollution (Amendment) Act 1999 which gives effect to the International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990.

- The Salvage and Wreck Act which inter alia requires the IRCG, on being made aware of a vessel in difficulty, to take such steps as it thinks fit to minimise the threat of pollution.

The Director and Chief of Operations in the IRCG are authorised officers under the Sea Pollution Act 1991 and Oil Pollution of the Sea (Civil Liability and Compensation) Act 1988 with authority to act in such circumstances and to give directions, for the purpose of preventing, mitigating or eliminating danger from pollution or threat of pollution by oil.

In May 1988 the Government assigned the responsibility to the IRCG for the removal of oil from the coastline and, in the event of major pollution incident, the direction and coordination of the onshore response. Oil pollution of seawater arises mainly from ballast water (mainly from oil tankers); cargo tank washings (resulting from tank cleaning directly into the sea); fuel oil sludge; engine room effluent discharges and in bilge-water (E. Clonan, pers. comm.).

Ireland's Pollution Responsibility Zone (IPRZ) covers an area stretching to 200 miles off the west coast and to the median line between Ireland and the UK in the Irish and Celtic Seas. The area is comparable to Ireland's Exclusive Economic Zone and covers approx 200,000 km2. The IPRZ is an ecologically sensitive area with a wide variety of fauna and flora and supports an active leisure industry, with a large number of blue flag beaches, as well as commerce, including fisheries marine transport and natural resources.

The major maritime incidents causing or with a potential to cause oil pollution that occurred in 2000-2003 are summarised in Table 4.6 In most of these cases anti-pollution measures were successfully deployed and prevented significant loss to water of any fuel or other oils held in the stricken vessels. One exception to this outcome occurred in Dingle Harbour in February 2002 when 40 tonnes of diesel

TABLE 4.6

Summary reports of larger maritime incidents involving the Irish Coast Guard (IRCG) during 2001-2003 in chronological order (Source: E. Clonan, IRCG).

Location	Date	Vessel	Incident	Outcome
Castletown Bere	15 Sept 2001	Elsinor	French registered fishing vessel ran aground on the Foilnaboe Rocks in Castletown Bere. This stern trawler was carrying 40 tonnes of diesel oil and 1 tonne of lubrication oil on board (Fig. 4.5)	The crew abandoned ship on grounding. The Irish Coast Guard (IRCG) deployed an incident manager on scene to oversee the salvage operation to ensure that the threat to the environment was minimised.
Killary Harbour	30 Oct 2001	Lazy Lady	This fish-feeding barge sank in Killary Harbour with 10 tonnes of diesel and 218 tonnes of fishmeal on board.	IRCG deployed an incident manager on site to oversee the salvage operation. Booms were deployed and the vessel was raised. The operation to raise the vessel, remove the oil and fishmeal took 25 days to complete
Dingle Harbour	2 Feb 2002	Celestial Dawn	Irish registered fishing vessel ran aground in the early hours. Soon after impact 40 tonnes of diesel leaked into the sea. The vessel was wedged at the base of cliffs and in danger of breaking up due to strong winds. Crew rescued by SAR helicopter.	Incident occurred in the Dingle Harbour Master's area of responsibility. IRCG acted in monitoring and advisory role. Mainport engaged to secure vessel and remove all remaining pollutants. Scaldais (NL) engaged to lift vessel and remove. Operation lasted one month.
Inishnabro Island (Blasket Islands)	10 May 2002	Fidelma	Wooden-hulled fishing vessel, with 16tonnes of diesel and 30 gallons of lubricating oil on board, struck Inishnabro Is., and sank. Crew rescued by SAR helicopter.	Mainport engaged by owner to remove marine pollutants and subsequently, on issue of wreck removal order by County Council, the same salvors removed wreck.
Foynes Harbour	3 July 2002	Clipper Cheyenne	Roll-on/rool-off dock ship capsized while carrying out ballast operations to take on board barge for transport out of the country. Occurred while	Harbour authorities deployed boom immediately. IRCG deployed stockpile to scene. Incident occurred in Shannon Foynes Port

			alongside the berth at Foynes with 250 tonnes of heavy fuel oil on board. All 15 crew were safe.	area of responsibility. IRCG monitored closely and advised Harbour Master. Owners employed Titan Salvors to refloat the vessel. IRCG staff on scene throughout re-floating operation.
Rosslare Port	27 Jan 2003	Sea Hamex	Roll-on/roll-off vessel (1,823 tonnes) carrying a cargo of 407 cars, with 201 tonnes of heavy fuel (IFO 120) on board, grounded in very squally conditions in Rosslare Port. No evidence of pollution.	Vessel refloated with assistance from tug which was brought from Cork Harbour. No marine pollution.
Donegal Bay	29 Jan 2003	Princess Eva	A 70,000 tonne Panamanian-registered tanker, fully laden with 59,000 m^3 of vacuum gas oil, encountered a violent storm (force 11 and 9 m seas) off the NW coast of Ireland. Two crewmembers were killed and another was airlifted to Hospital. IRCG permitted the vessel to enter the shelter of Donegal Bay. The tanker reported cracks in her deck on anchoring. The Irish Maritime Safety Directorate (MSD) carried out a "Port State Control" Inspection and the vessel was detained until the fractures had been repaired. To facilitate the repairs it was necessary to deploy oil spill response equipment from national stockpiles, carryout a ship to ship (STS) transfer, tank cleaning, gas freeing and repairs under IRCG control.	A safe, successful and pollution-free incident by ensuring that the STS (ship to ship) operation (transfer of 59,000 m^3 of heavy vacuum gas oil) tank cleaning, gas freeing and repairs were carried out in a text book operation. The whole operation took approximately 40 days to complete.
Clogherhead	5 June 2003	Fragrant Cloud	Wooden-hulled fishing vessel struck Clogherhead and sank; all crew members scrambled ashore. Five-foot square hole on port side forward below waterline. Five gallons of lubrication oil in containers, loose in engine room, and one tonne of diesel oil on board.	Wreck removal order issued. Salvors engaged by owner to remove any marine pollutants and remove wreck.

Fig. 4.5 The French fishing vessel *Elsinor* which ran aground on the Foilnaboe Rocks in Castletown Bere on 15 September 2001 (Photograph courtesy of E. Clonan, IRCG).

leaked from the grounded fishing vessel, Celestial Dawn, before measures to contain and remove polluting materials could be put in place.

IRCG received 55 pollution reports during 2001, 41 in 2002 and 52 in 2003, all of which were investigated. An analysis of the incidents for the latter two years of the period showed that 16 of these in 2002 and 14 in 2003 were likely to have been caused by discharges from vessels in the IPRZ; in the majority of cases the identity of the vessels could not be established. The low level of prosecutions compared to the number of reported discharges at sea illustrates the difficulty in identifying a polluter. Aerial surveillance should increase the number of identified polluters (E. Clonan, pers. comm.).

Mineral oils accounted for 70 and 90 per cent respectively of the polluting material observed in 2002 and 2003 and of these bunker, diesel and gas oils were the most frequently identified. The overall geographical pattern for oil discharges indicated that the majority of discharges occurred in the main fishery harbours and surrounding areas. Clusters of slicks were identified in bays and near shore waters with less than 10 to 20 per cent of pollution reported in open sea in these two years.

Chapter Five

THE WATER QUALITY OF GROUNDWATER

INTRODUCTION

In Ireland, groundwater quality is of concern in relation mainly to its suitability for use as a source for drinking water supply, for use in food processing and related industrial operations and in the bottled water industry. It is an important water resource in the State as it accounts for up to 16 per cent of total water supplied by local authorities (Page, et al., 2003). Nationally, one quarter of the water abstracted for public and private drinking water supply is from groundwater while the proportion rises to 86 per cent in some rural areas. A very large number of groundwater supply sources exist, e.g. Wright (1999) estimates that there are at least 200,000 wells in the country. However, only a small proportion of the available groundwater resource is currently being used as a potable water source.

The majority of private groundwater supplies in Ireland are untreated. This heightens the need for both aquifer and source protection as well as the treatment of groundwater to ensure that the quality of drinking water produced conforms to the requirements of the Drinking Water directive and national Regulations. Additionally, as groundwater ultimately discharges from aquifers as base flow or spring flow to receptors such as rivers, wetlands, estuaries or springs, the latter may be affected adversely if such discharge is polluted. Further concerns in respect of groundwaters are that, unlike surface water, the effect and extent of a pollutant or the effect of remedial measures may not be visible and that the rate of recovery from pollution may be much slower than is the case in rivers and lakes.

The Geological Survey of Ireland (GSI) has completed groundwater protection schemes, in association with local authorities, for 55 per cent of the country and is planning to have developed such schemes for the rest of the country by 2010 (Daly, 1999). A groundwater protection scheme concept takes account of the nature of the hazard to groundwater (the potentially polluting activity), the pathway for contaminant migration to the aquifer (the groundwater vulnerability) and the value of the target (aquifer, spring or well at risk). The GSI, in combination with the DELG and the EPA, has published 'Groundwater Protection Schemes' in 1999, a methodology for the development of groundwater protection schemes for Ireland that incorporates these elements of risk assessment (DELG et al., 1999). In addition three groundwater protection responses have been published (for landfills, on-site systems and landspreading of organic wastes) and the EPA are currently developing three further responses jointly with the GSI.

The EU adopted a new Drinking Water Directive in November 1998 (CEC, 1998) replacing the original directive of 1980 (CEC, 1980) and this was transposed into Irish law on the 18th December, 2000 by the European Communities (Drinking Water) Regulations, 2000 (Minister for the Environment and Local Government, 2000). This set of drinking water regulations is radically different from its predecessor and will entail very significant changes in virtually all aspects of implementation, including sample number, parameters, parameter classes, and extent of coverage, and so on. However, it is important to note that the commencement date for the new Regulations is 1st January 2004 so that the Regulations (Minister for the Environment, 1988b) giving effect to the 1980 directive were in force during the period covered by this report.

In December 2000 the Water Framework Directive (WFD) (EP and CEU, 2000) came into force; it establishes a strategic framework for managing the water environment and sets out a common approach to protecting and setting environmental objectives for all groundwaters and surface waters within the European Community. Specifically for groundwater, the Directive aims to protect, enhance and restore all bodies of groundwater, which *inter alia* includes the maintenance and/or attainment of 'good chemical status'. However, the exact requirements of the WFD in relation to groundwater are not yet fully determined at this stage and, in particular, the European Parliament and the Council have yet to adopt specific measures to prevent and control groundwater pollution (Article 17) which, *inter alia*, shall include:

- criteria for assessing good groundwater chemical status, in accordance with Annex II 2.2 and Annex V 2.3.2 and 2.4.5;

- criteria for the identification of significant and sustained upward trends and for the definition of starting points for trend reversals to be used in accordance with Annex V 2.4.4.

In the absence of criteria adopted at Community level, Member States are required to establish appropriate criteria at the latest five years after the date of entry into force of the Directive. The EPA is currently in the process of developing guideline values for the assessment of groundwater quality in Ireland (Keegan, 2003). The draft document sets out the Agency's proposed approach and application of guideline values for the protection of groundwater in Ireland. It has been proposed, therefore, that, on an interim basis, and pending further elaboration of groundwater protection measures at national and Community level, these draft parameters and guideline values be used for the monitoring and characterisation of groundwater bodies for the purpose of river basin projects. Monitoring data collected during the course of these projects will further assist in the elaboration of national groundwater standards.

A detailed commentary on the implementation of the WFD is given in the following Chapter Six.

GROUNDWATER QUALITY IN IRELAND

Background

Groundwater quality is a function of natural processes as well as anthropogenic activities. Natural groundwater quality is generally good, although harmful concentrations of certain ions, e.g. iron, manganese, sulphate, hydrogen sulphide and, near coasts, sodium and chloride, can occur naturally and lead to problems. In Ireland, limestone bedrock and limestone dominated subsoils are common and consequently groundwater is often hard, containing high concentrations of calcium, magnesium and bicarbonate. However, in areas where volcanic rock or sandstones are present, softer water is normal (Daly, 2000). It is important, therefore, that natural hydrochemical variations should be taken into account in establishing any baseline quality criteria, and in interpreting the results of groundwater monitoring programmes.

The concentrations of any contaminants detected in a groundwater monitoring programme will be influenced by source characteristics and proximity, the nature of the contaminant and the geological and hydrogeological influences, including, for example:

- the type of contaminant source (point source or diffuse);
- how far the contaminant source is located from the borehole, well or spring;
- the characteristics of the contaminant (e.g. solubility, and mobility, etc.);
- the characteristics of the aquifer (primary or secondary permeability, presence of karst); and
- the aquifer vulnerability (e.g. the presence or absence of a protective layer of thick, low permeability subsoil above the aquifer).

Vulnerability is the term used to “represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities” (Daly, and Warren, 1998).

The monitoring results will also be influenced by the monitoring regime itself, including:

- the type of groundwater sampling point (borehole, well or spring);
- the construction of the wellhead (whether the surface casing has been properly sealed);
- the abstraction rate and hence zone of contribution (ZOC) to the well;
- the depth of sampling, and the method of sampling (pumped or bailed);

- the time of year; and
- whether analyses are carried out on site or in the laboratory as well as the sample storage procedures and related considerations (see, for example, Hayes (1997)).

Groundwater Monitoring Programme

General Strategy

In the EPA monitoring programme, monitoring has been classified in three categories:

1. Representative or basic monitoring;
2. User-related monitoring; and
3. Pollutant-related monitoring.

The representative or basic monitoring network (see Map 1 in Appendix VII) is operated on a national basis by the EPA and is used to define the state of groundwater quality, to detect trends in groundwater quality and to determine the causes of any changes in quality that are identified. Monitoring stations within this basic network have been selected taking into account hydrogeological conditions and groundwater use. Where drinking water abstractions are used as part of this network, samples are taken at a point antecedent to any treatment process.

User-related monitoring mainly consists of monitoring of those drinking waters originating as groundwater, as required under the current EU directive and corresponding national Regulations. Under these Regulations, all waters used for human consumption as well as water used in the food industry, regardless of origin, is covered. Monitoring of the water quality is required at the point where it is made available to the consumer. Data arising from this monitoring is not presented below as they may reflect changes due to treatment but are included in the EPA's annual reports on drinking water quality.

Pollutant-related monitoring is intended to detect possible pollutant emissions from landfill sites, septic tank clusters, factories and other waste sources and includes the identification and mapping of potential sources of pollution.

In the future, the names of these monitoring programmes will change to reflect the requirements of the WFD which classifies monitoring into two categories: Surveillance Monitoring and Operational Monitoring.

Sampling Frequency and Number of Monitoring Stations in the Period 2001-2003

The information set out below on groundwater quality is based primarily on the analysis of samples taken by the EPA at monitoring stations in the representative network as part of the EPA's National Groundwater

Quality Monitoring Programme. This programme commenced in 1995 and monitoring is carried out twice a year, to coincide with groundwater levels being (1) at or near their lowest levels and (2) at or near their highest levels. Results for the 1995-1997 and 1998-2000 periods have been presented in previous national reports (Lucey, *et al.,* 1999; McGarrigle *et al,* 2002).

The information presented relates to the results of the analyses of groundwater samples taken in the period 2001-2003 for a number of important parameters and indicates whether they meet the standards or Maximum Acceptable Concentration (MAC) set in the Drinking Water Regulations for these parameters. This approach is taken in the absence of the finalisation of the proposed Guideline Values for the Protection of Groundwaters (Keegan, 2003) and is considered appropriate in the light of the fact that many groundwaters are put into supply systems with only minimal treatment, if any.

It was not possible to obtain the full set of six samples at all locations in the period 2001 – 2003; however, for the major parameters, four sampling runs were taken as the minimum for the purposes of obtaining representative water quality data for use in this report. It was considered that a minimum of four samples is required because the average concentration needs to reflect samples taken at different times in the year i.e. at high and low water levels. The numbers of sampling locations excluded on this basis, by county, were as follows: Donegal (1), Galway (1), Kerry (1), Offaly (1), Tipperary North (2), Tipperary South (3), Carlow (3), Meath (3), Waterford (3), Kilkenny (3), Louth (4) and Wicklow (6). The reason for the small number of sampling results at these 31 locations is that (1) they were either found to be unsuitable for monitoring purposes or (2) they were no longer in use as the abstraction of water had ceased. Thus of the 334 sampling locations, 303 only were visited on four or more occasions and the assessments below are based on the data from these latter locations.

An exception to this approach was made in the case of the bacteriological analysis where each individual sample has been considered in the assessment, including those from sampling locations at which less than four samples were taken. This is in acknowledgement of the fact that the bacteriological measurements represent the state of the water regardless of the water level in the well. When considering the assessment in terms of the proportion of monitoring locations showing contamination, all locations, regardless of sample numbers taken, have been considered; however, absence of contamination has only been assumed when at least four samples have given zero counts.

RESULTS OF ANALYSIS OF GROUNDWATER QUALITY SAMPLES TAKEN IN THE PERIOD 2001-2003

Presentation of Data

To ensure uniformity in reporting throughout this report, the comments on water quality below are made in terms of the mean of the sample results at each monitoring station. However, where relevant, individual sample results are also commented upon. The locations of the sampling points and data for selected parameters at each monitoring station are given in Maps 1-10 in Appendix VII. Data are presented as follows: two general characteristics (pH and Conductivity) and then the quality parameters (Ammonia, Nitrate, Chloride, Phosphate, Iron, Manganese, bacteriological assessment and Uranium).

pH

The range of natural pH in fresh waters extends from around 4.5 for acid, peaty upland waters to over 10.0 in waters where there is intense photosynthetic activity by algae. However the most frequently encountered range is 6.5-8.0.

In waters with low dissolved solids, which consequently have a low buffering capacity (i.e. low internal resistance to pH change), changes in pH induced by external causes may be quite dramatic. Extremes of pH can affect the palatability of a water but the corrosive effect on distribution systems is a more urgent problem. In addition, pH governs the behaviour of several other important parameters of water quality. For example, ammonia toxicity, chlorine disinfection efficiency and metal solubility are all influenced by pH.

A total of 1848 individual pH measurements were recorded at 302 monitoring stations. The mean pH results are summarised in Fig. 5.1 and are shown on Map 2 in Appendix VII for the individual locations. Mean pH exceeded pH 8.0 at three monitoring locations, and fell below pH 6.0 at four monitoring locations.

The mean pH was greater than pH 8.0 at sampling locations in counties Roscommon (1), Wexford (1) and Wicklow (1). The mean pH was less than 6.0 at locations in counties Waterford (3) and Wexford (1). There were 10 individual samples with pH greater than pH 8.0 and 51 with pH less than pH 6.0. The highest individual sample pH was 10.2, recorded in County Wexford, whilst the lowest individual sample pH was 4.8 at a location in County Leitrim. The causes of these highly alkaline and acidic samples require further investigation as they appreciably outside the limits for drinking water (6.0 - 9.0).

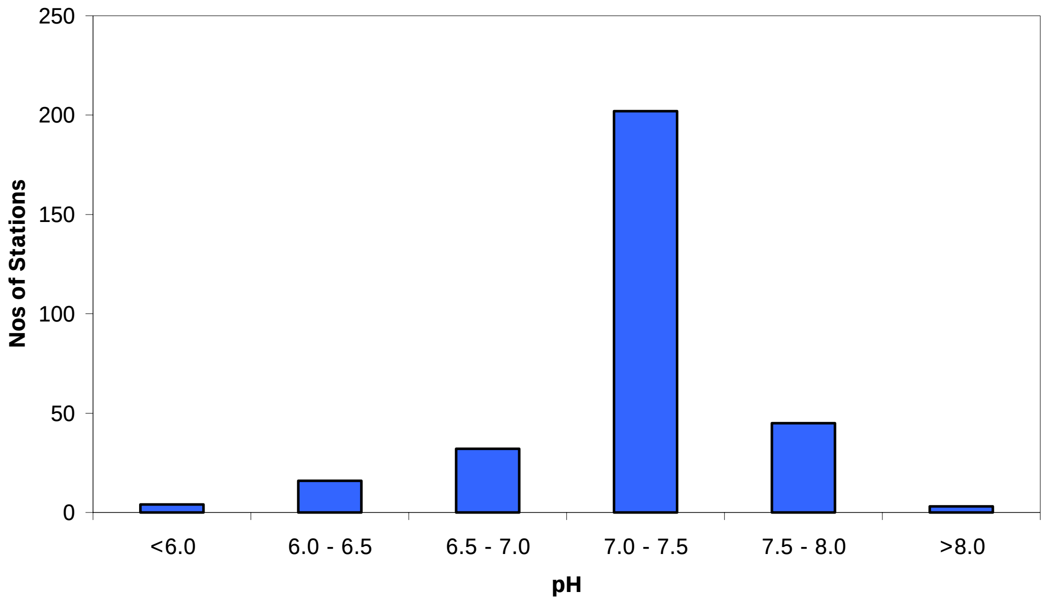

Fig. 5.1 Numbers of sampling stations with mean pH in the ranges indicated

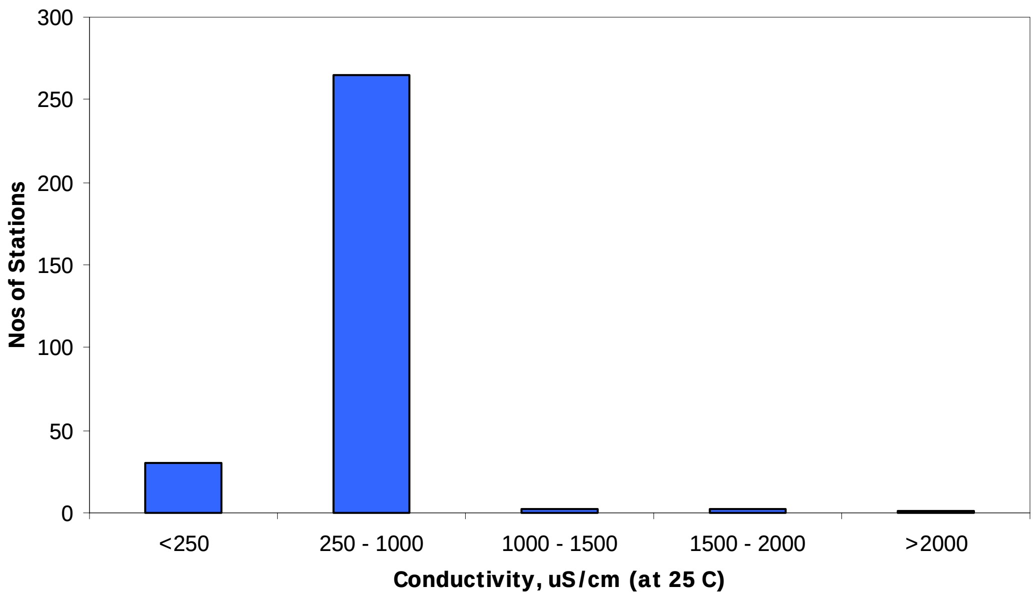

Fig. 5.2 Numbers of sampling stations with mean conductivity in the ranges indicated

Conductivity

The conductivity of a water is an expression of its ability to conduct an electrical current. This property is related to the ionic content of the sample, which is in turn a function of the dissolved (ionisable) solids concentration. Conductivity is thus an invaluable indicator of the range into which hardness and alkalinity values are likely to fall, and also of the order of the dissolved solids content of the water. It is important to note that there is an interrelationship between conductivity and temperature, the former increasing with temperature at a rate of some 2 per cent per degree C.

A total of 1857 individual conductivity measurements were recorded at 301 monitoring stations. The mean conductivity results are summarised in Fig. 5.2 and are shown on Map 3 in Appendix VII for the individual locations. Mean concentrations of conductivity fell between 250 and 1000 µS/cm at the majority (88%) of locations, exceeding 1000 µS/cm at only six (2%). The MAC of 1500 µS/cm (at 25^{o}C) was exceeded by the mean concentrations at three stations, in counties Cavan (1) and Monaghan (2). Concentrations greater than 1000 µS/cm were recorded in 41 individual samples of which 15 exceeded the MAC. The highest individual sample concentration was 2620 µS/cm at a location in County Monaghan.

Ammonia

Ammonia is generally present in natural waters, though in very small amounts, as a result of microbiological reduction of nitrogen-containing compounds (EPA, 2001b). It has a low mobility in soil and subsoil and its presence in groundwater much above 0.1 mg/l N may indicate direct sewage, industrial or agricultural contamination. From the view point of human health, significant concentrations of ammonia can indicate the possibility of sewage pollution and the consequent possible presence of pathogenic micro-organisms (Lucey *et al.*, 1999). Under the Drinking Water Regulations, the maximum allowable concentration (MAC) of ammonia is 0.3 mg/l as $NH4^{+}$ (ammonium) which is equivalent to 0.23 mg/l as N. For clarity, the parameter is referred to below as ammonia and the units used are mg/l N.

A total of 1852 individual samples were analysed for ammonia at 302 monitoring stations. The mean concentration results are summarised in Fig. 5.3 and are shown on Map 4 in Appendix VII for the individual sampling locations. Most (84.8%) of the stations had mean values less than 0.05 mg/l N, values greater than 0.23 mg/l N being recorded at only 20 of the 302 monitoring stations (Fig. 5.3). Mean ammonia concentrations greater than 0.23 mg/l N were found at locations in counties Mayo (1), Donegal (3), Kerry (2), Leitrim (5), Limerick (1), Meath (3), Monaghan (4), and Wexford (1). Of these 20 monitoring stations, 14 also tested positive for total coliforms and six also tested positive for faecal coliforms. Mean ammonia levels above 0.1 mg/l N were recorded at 32 monitoring stations in 15 counties.

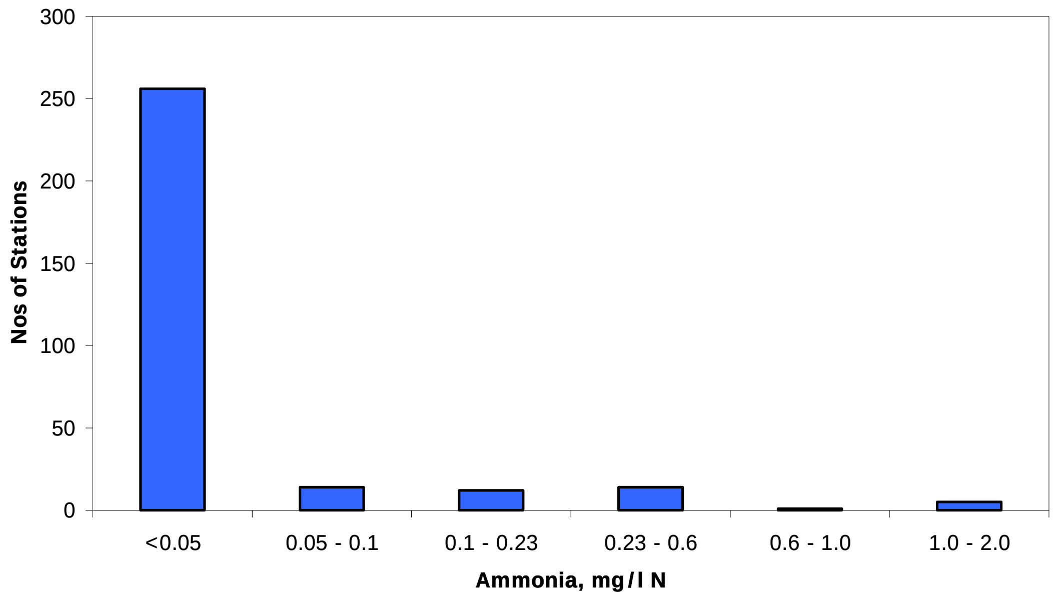

Fig. 5.3 Numbers of sampling stations with mean Ammonia concentrations in the ranges indicated

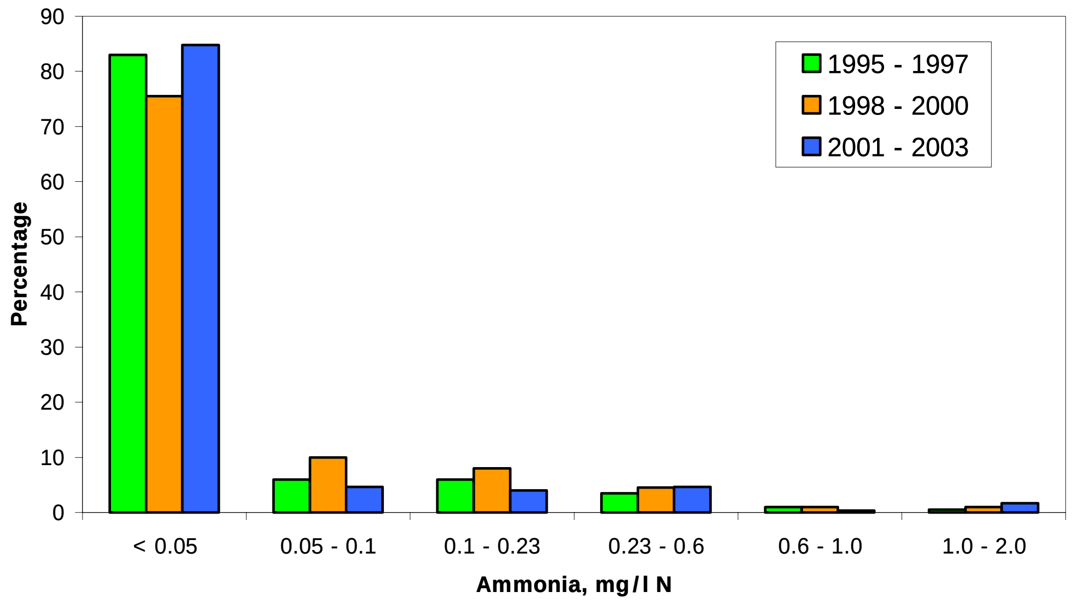

Fig. 5.4 Comparison of the proportions of sampling stations in three reporting periods with mean concentrations of Ammonia in the ranges indicated.

The majority (1744) of individual samples also had ammonia concentrations less than the MAC value of 0.23 mg/l N. Of the 108 samples in which the measured concentrations were greater than or equal to the MAC value, 86 were taken at stations where the mean ammonia concentrations were also greater than 0.23 mg/l N. The highest individual ammonia concentration recorded was 2.7 mg/l N at a location in County Kerry and may have been attributable to the presence of a nearby pig farm.

Ammonia concentrations greater than 0.1 mg/l N may indicate a nearby organic waste source. This demonstrates the need for disinfection of drinking water supplies but also the need for suitable borehole siting, construction and protection. All boreholes should be adequately grouted from the ground surface through the subsoils to prevent the ingress of surface contamination. Boreholes should also be located such that they are not too close to or downgradient of potential contamination sources such as septic tank percolation areas (DELG *et al*, 1999).

The percentages of stations with mean ammonia concentrations in each classification range in 1995-1997, 1998-2000 and 2001-2003 are shown in Fig. 5.4. The proportion of mean concentrations exceeding the 0.23 mg/l N threshold increased slightly from 6.5 per cent in the 1998-2000 sampling period to 6.6 per cent in 2001-2003, compared to 5.0 per cent in 1995-1997. Overall, however, the proportion of concentrations within each of the classification ranges in 2001-2003 is similar to those in the 1995-1997 and 1998-2000 sampling periods.

Nitrate

Nitrate is present naturally in water in low concentrations, typically in the range 5 - 9 mg/l NO_3. However, most nitrate found in waters is of anthropogenic origin, coming from organic and inorganic sources, the former including waste discharges and the latter comprising mainly artificial fertilisers. Excessive nitrate contamination is generally observed in low yielding wells in close proximity to potential point waste sources but may also arise result from diffuse, agricultural sources. It may develop into a more widespread problem unless mitigation measures such as nutrient management planning are put in place.

There are health risks associated with excess nitrate consumption in the human diet. These include methaemoglobinaemia in infants (blue baby syndrome) and possible carcinogenic hazards. The toxicity of nitrate to humans is thought to result solely from its reduction to nitrite. Nitrite is involved in the oxidation of normal haemoglobin to methaemoglobin which is unable to transport oxygen to the body's tissues (WHO, 1996). If water contains more than 450 mg/l NO_3 nitrate, it is unsuitable for livestock (Freeze and Cherry, 1979). Under the Drinking Regulations, the MAC for nitrate is 50 mg/l as NO_3, which is equivalent to 11.3 mg/l as N. In addition, a guide level of 25 mg/l NO_3 (or 5.65 mg/l N) was specified in the 1980 directive and is recommended as an indication of appreciable contamination.

A total of 1831 individual nitrate measurements were recorded at 301 monitoring stations. The mean concentration results are summarised in Fig. 5.5 and are shown on Map 5 in Appendix VII for the individual locations. Those recorded at 231 (76.8%) monitoring stations were less than the guide level 25 mg/l NO_3 while of the 70 monitoring stations exceeding this level five, in counties Louth, Kilkenny, Roscommon, Waterford and Westmeath, exceeded the MAC of 50 mg/l NO_3. At all of these five locations ammonia concentrations were less than 0.05 mg/l N but bacterial contamination was observed at three, with one (in Westmeath) having faecal coliform counts greater than zero.

Concentrations greater than 25 mg/l NO_3 were recorded in 405 individual samples of which 34 exceeded the MAC of 50 mg/l NO_3. Of the latter samples, 20 were taken at stations where the mean nitrate concentration also exceeded the MAC. The highest individual sample concentration was 139 mg/l NO_3 at a location in County Westmeath.

The percentages of stations with mean nitrate concentrations in each classification range in 1995-1997, 1998-2000 and 2001-2003 are shown in Fig. 5.6. The proportions of mean concentrations exceeding the 50 mg/l NO_3 threshold increased slightly from 1.5 per cent in the 1998-2000 sampling period to 1.7 per cent in 2001-2003, compared to 3.0 per cent in 1995-1997. Otherwise, the proportions of concentrations within each of the classification ranges in 2001-2003 is similar to those in the 1995-1997 and 1998-2000 sampling periods.

Chloride

Chloride exists in all natural water, the concentration varying widely and with the value reaching a maximum in sea water (average 20,000 mg/l Cl). Chloride does not pose a health hazard to humans and the principal consideration is in relation to palatability. Where there is a high chloride concentration there also may be an associated high sodium level. In freshwaters, chloride originates from both natural, mainly rainfall, and anthropogenic sources, such as run-off containing de-icing salts, the use of inorganic fertilizers, landfill leachates, septic tank effluents, animal feeds, industrial and domestic effluents. It may also arise from seawater intrusion in coastal areas. Because it is such a rich source of chloride, a high level or a significant increase of the ion may give rise to suspicions of pollution from sewage.

Under the Drinking Water Regulations, the MAC for chloride is 250 mg/l Cl; however, one would expect levels around 30 mg/l in uncontaminated groundwater, except in coastal areas. Concentrations vary and what is important is not the absolute value but rather the relative level from one sampling period to the next.

A total of 1855 individual chloride measurements were recorded at 303 monitoring stations. The mean

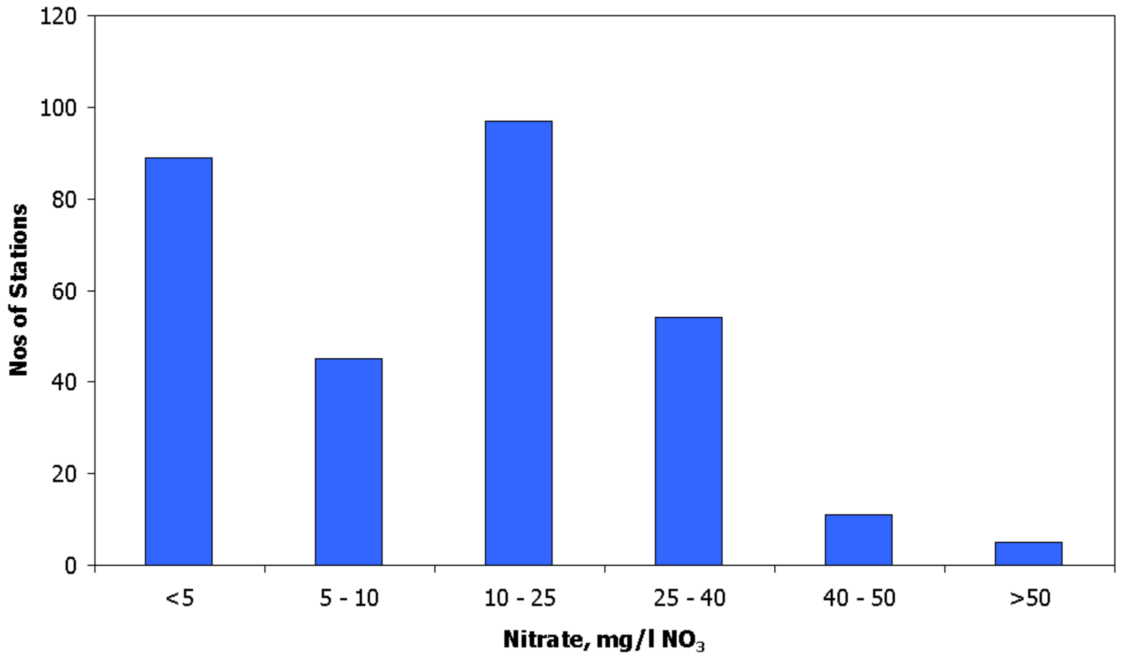

Fig. 5.5 Numbers of sampling stations with mean Nitrate concentrations in the ranges indicated.

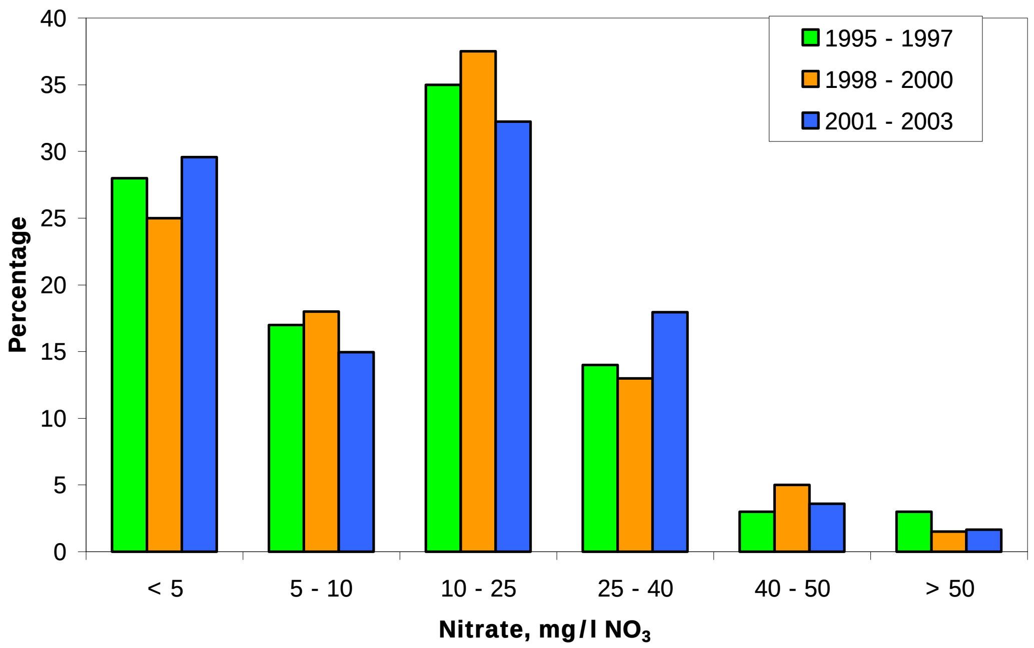

Fig. 5.6 Comparison of the proportions of sampling stations in three reporting periods with mean concentrations of Nitrate in the ranges indicated.

concentration results are summarised in Fig. 5.7 and are shown on Map 6 in Appendix VII for the individual locations. The bulk (84.8%) of the locations sampled had a mean chloride concentration less than 30 mg/l Cl and of the 46 exceeding this level, only eight had mean concentrations over 50 mg/l Cl. The mean chloride concentration did not exceed 100 mg/l and the MAC of 250 mg/l Cl was not exceeded in any individual sample, the highest single concentration recorded being 209 mg/l Cl at a location in County Donegal.

Of the eight monitoring sites with mean chloride concentrations exceeding 50 mg/l Cl, a site in County Donegal had coinciding high ammonia concentrations for each sample. A site in County Kerry had coinciding high bacterial count and nitrate concentrations while a site in County Monaghan had coinciding high bacterial count and high ammonia concentrations. High concentrations of chloride, when coinciding with high concentrations of ammonia, nitrate and bacterial counts may indicate contamination from sewage or industrial effluents.

The percentages of stations with mean chloride concentrations in each classification range in 1995-1997, 1998-2000 and 2001-2003 are shown in Fig. 5.8. The situation was very similar in each of the three periods, the only slight difference being the small number of locations at which the mean concentrations exceeded 100 mg/l in the two earlier periods.

Phosphate

Phosphorus is used as an agricultural fertiliser and in household cleaning detergents as well as in industry. In its mineralised form, phosphate, it is a major source of concern for surface waters because small amounts may lead to eutrophication of lakes and rivers. However, phosphorus is not a problem in groundwater because it is not very mobile in soils or sediments and is therefore considered to be retained in the soil zone; thus it unlikely to penetrate to groundwaters. Where it does so in significant quantities, it may act as a further source of nutrient enrichment pathway for receptors such as lakes, rivers and wetlands.

The MAC[*] for phosphorus in drinking water is 5 mg/l as P_2O_5, equivalent to 2.2 mg/l P. This is well above natural levels and unlikely to occur in source water. The Phosphorus Regulations (Minister for the Environment and Local Government, 1998), sets a limit of 0.03 mg/l P for the annual median phosphate concentration in rivers in order to prevent eutrophication. This may be taken as a guide level for groundwater when providing baseflow to a river.

[*] 1988 Directive and Regulations; a limit for phosphorus is not included in the 1998 directive

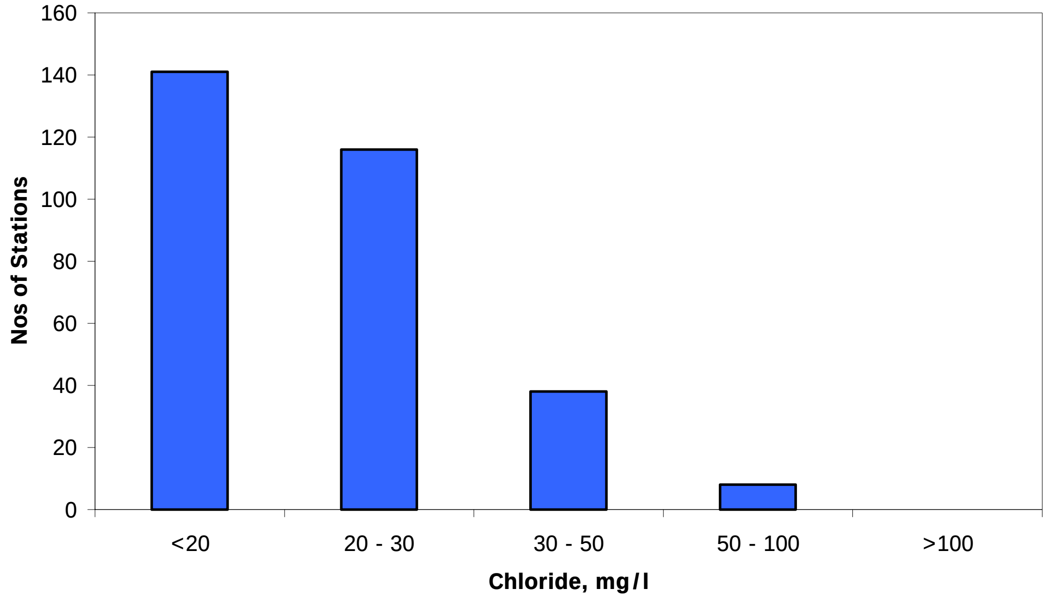

Fig. 5.7 Numbers of sampling stations with mean Chloride concentrations in the ranges indicated.

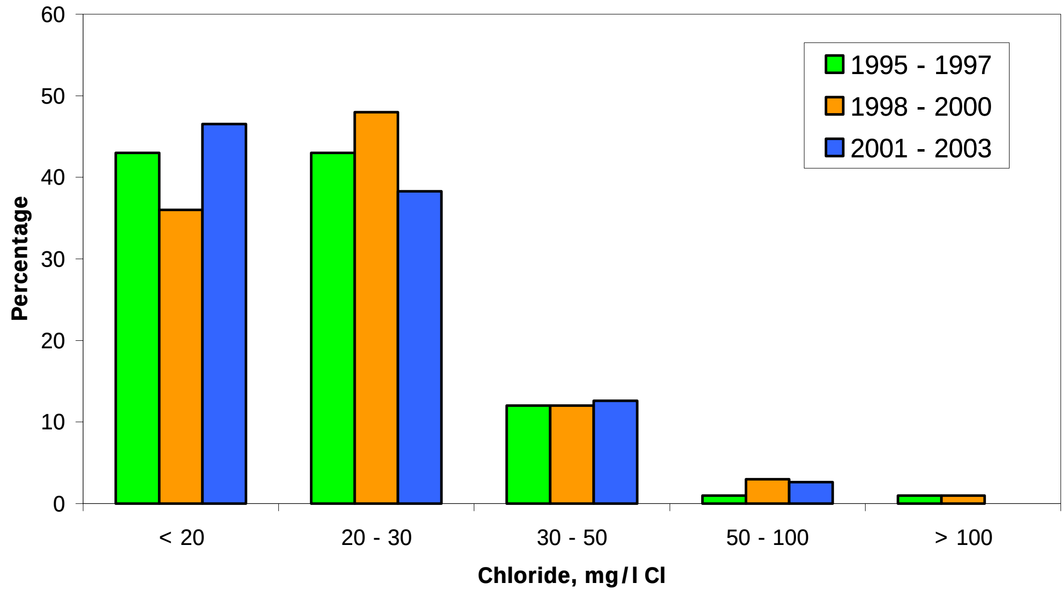

Fig. 5.8 Comparison of the proportions of sampling stations in three reporting periods with mean concentrations of Chloride in the ranges indicated.

A total of 1827 individual phosphate measurements were recorded at 303 monitoring stations. The mean concentration results are summarised in Fig. 5.9 and are shown on Map 7 in Appendix VII for the individual locations. Mean concentrations of phosphate exceeded 0.03 mg/l P at 94 monitoring stations and exceeded 0.05 mg/l P at 54 monitoring stations. The mean phosphate concentration did not exceed the drinking water MAC of 2.2 mg/l P at any station.

Concentrations greater than 0.03 mg/l P were recorded in 493 samples of which one exceeded 2.2 mg/l P. This sample had a concentration of 10.4 mg/l P and was taken at a location in County Monaghan.

The percentages of stations with mean phosphate concentrations in each classification range for 1995-1997, 1998-2000 and 2001-2003 are shown in Fig. 5.10. The proportion of stations with mean concentrations exceeding 0.05 mg/l P increased from 7.4 per cent in the 1998-2000 sampling period (8.0% in 1995-1997) to 17.8 per cent in 2001-2003. The proportion with concentrations greater than 0.03 mg/l P was higher in 2001-2003 (31.0%) than in the 1995-1997 (23.0%) and 1998-2000 (22.7%) sampling periods which may have resulted in a greater risk of eutrophication in associated surface waters.

In general phosphate levels in groundwater are not a cause of concern in relation to its use as a drinking water supply. However, there are areas of the country where the levels of phosphate in groundwater may contribute to eutrophication of rivers and lakes particularly if they provide significant amounts of baseflow during the summer months. This potential interaction between groundwater and surface water is emphasised in the WFD and will be considered further in future monitoring programmes.

Iron and Manganese

Iron is present in significant amounts in soils and rocks, principally in insoluble form. However, many complex reactions, which occur naturally in ground formations, can give rise to more soluble forms of iron, which will therefore be present in water passing through such formations. Background levels vary considerably depending on the rock structure. Excessive concentrations of iron do not cause health problems but are of concern for aesthetic and taste reasons. Taste is not usually noticeable at iron concentrations below 0.3 Fe mg/l. Laundry and sanitary ware will stain at concentrations above 0.3 Fe mg/l.

As a precaution against storage of excessive iron in the body the Joint FAO/WHO Expert Committee on Food additives, established a provisional maximum tolerable daily intake (PMTDI) of iron of 0.8 mg/kg body weight from all sources in 1983 (WHO, 1996). Allocation of 10 per cent of the PMTDI to drinking water suggests that a concentration of 2 mg/l Fe in water supplies does not present a hazard to health. However, no health-based guideline value for iron has been proposed by the WHO (WHO 1996).

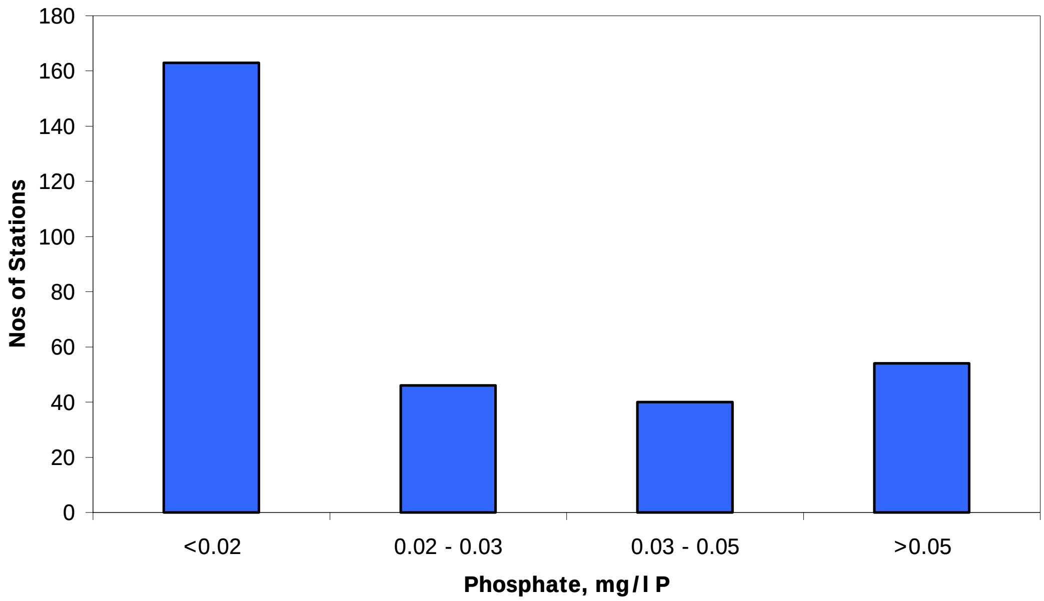

Fig. 5.9 Numbers of sampling stations with mean Phosphate concentrations in the ranges indicated.

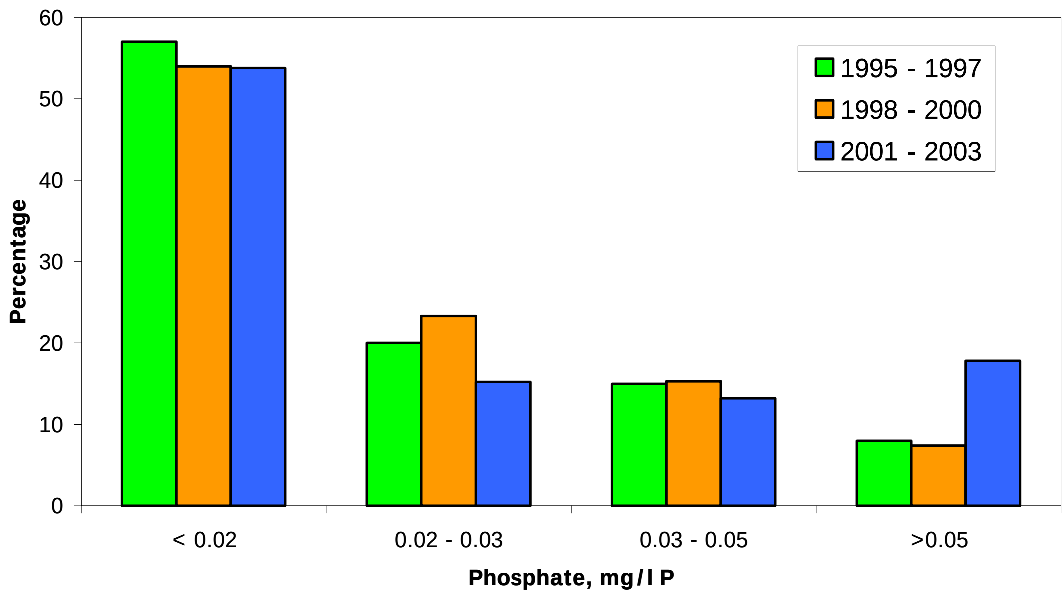

Fig. 5.10 Comparison of the proportions of sampling stations in three reporting periods with mean concentrations of Phosphate in the ranges indicated.

Manganese is also found widely in soils. Like iron, it may be present in solution in groundwaters due to reducing conditions and the excess metal will be deposited as the water is brought to the surface and re-aerated. The principal objection to the presence of relatively large concentrations of manganese in drinking waters is, again, aesthetic due to turbidity and taste, and it has little significance for health. At concentrations exceeding 0.1 mg/l Mn, the manganese ion imparts an undesirable taste to beverages and stains plumbing fixtures and laundry (Griffin, 1960). The WHO has set a provisional health based guideline value of 0.05 mg/l Mn for drinking waters, which should be adequate to protect public health (WHO, 1996).

Since organic pollution can lead to serious de-oxygenation of groundwater and provide reducing conditions to bring the two metals into solution, marked increase in levels of iron and manganese above background levels can be considered as potentially indicating such pollution.

Under the 1988 Drinking Water Regulations, MACs of 0.2 mg/l Fe and 0.05 mg/l Mn have been set for iron and manganese. Identical limits have been incorporated in the 2000 Regulations.

Iron A total of 1790 individual iron measurements were recorded at 299 monitoring stations. The mean concentration results are summarised in Fig. 5.11 and are shown on Map 8 in Appendix VII for the individual locations. Mean concentrations of iron less than 0.1 mg/l Fe were recorded at 187 (62.5%) monitoring stations and exceeded the MAC of 0.2 mg/l Fe at 49 stations in counties Dublin (1), Kerry (1), Kildare (1), Kilkenny (1), Limerick (1), Roscommon (1), West Meath (1), Cavan (2), Laois (2), Mayo (2), Galway (3), Waterford (3), Wexford (3), Tipperary South (3), Donegal (4), Meath (6), Monaghan (6) and Leitrim (8). The highest individual sample concentration was 7.92 mg/l Fe at a location in County Leitrim.

The percentages of stations with mean iron concentrations in each classification range for 1995-1997, 1998-2000 and 2001-2003 are shown in Fig. 5.12. There has been an overall decline in the proportion of stations exceeding the MAC since 1995, the proportion of mean concentrations exceeding 0.2 mg/l Fe decreasing from 22 per cent in 1995-1997, to 18 per cent in the 1998-2000 and to 16.4 per cent in 2001-2003.

Manganese A total of 1799 individual manganese measurements were recorded at 298 monitoring stations. The mean concentration results are summarised in Fig. 5.13 and are shown on Map 9 in Appendix VII for the individual locations. Mean concentrations of manganese exceeded 0.02 mg/l Mn at 81 monitoring stations but were less than the MAC of 0.05 mg/l Mn at 246 (82.6%) stations. The 52 stations with mean concentrations exceeding 0.05 mg/l Mn are located in counties Dublin (1), Limerick

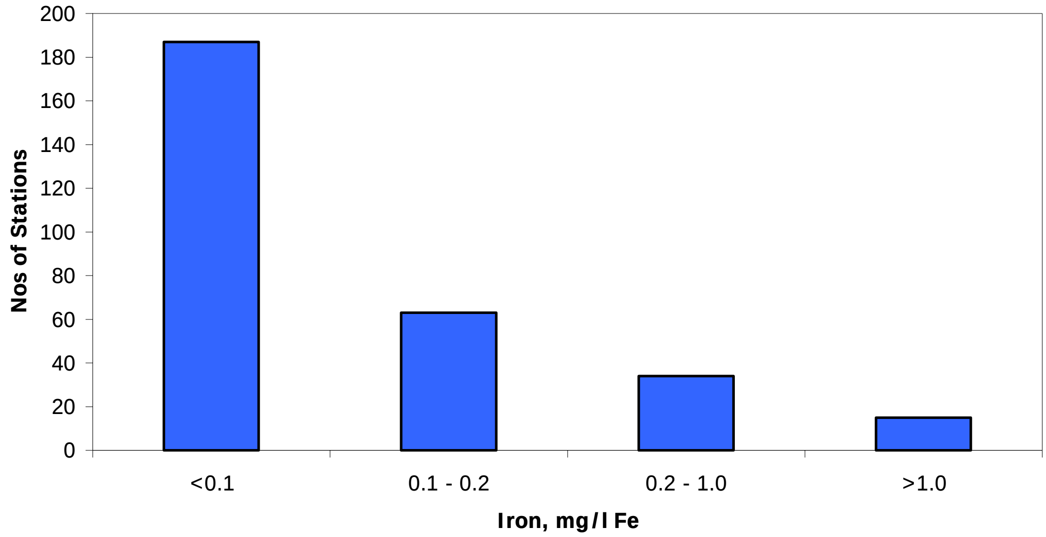

Fig. 5.11 Numbers of sampling stations with mean Iron concentrations in the ranges indicated.

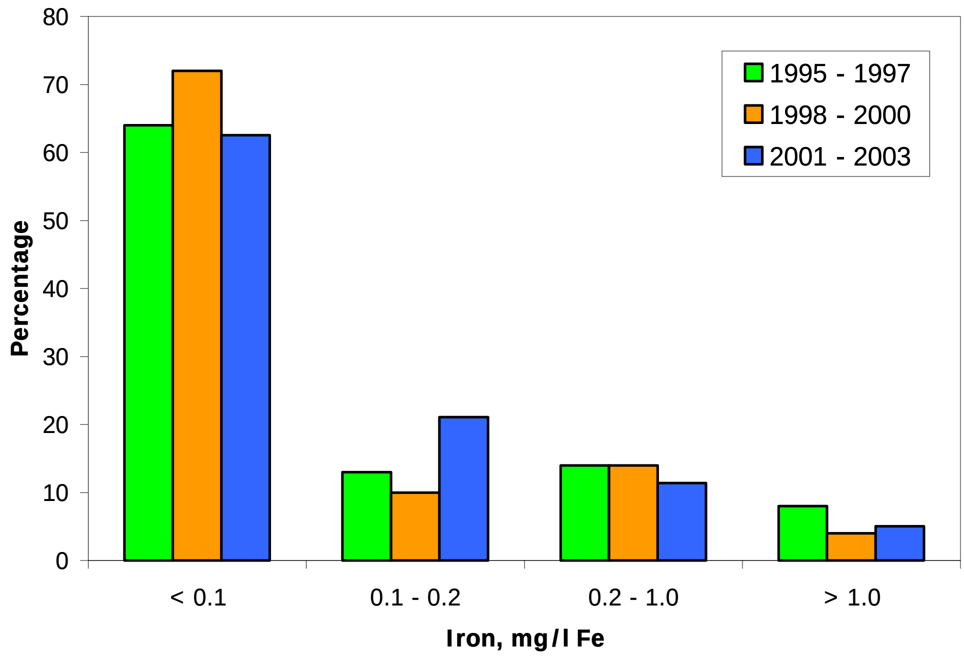

Fig. 5.12 Comparison of the proportions of sampling stations in three reporting periods with mean concentrations of Iron in the ranges indicated.

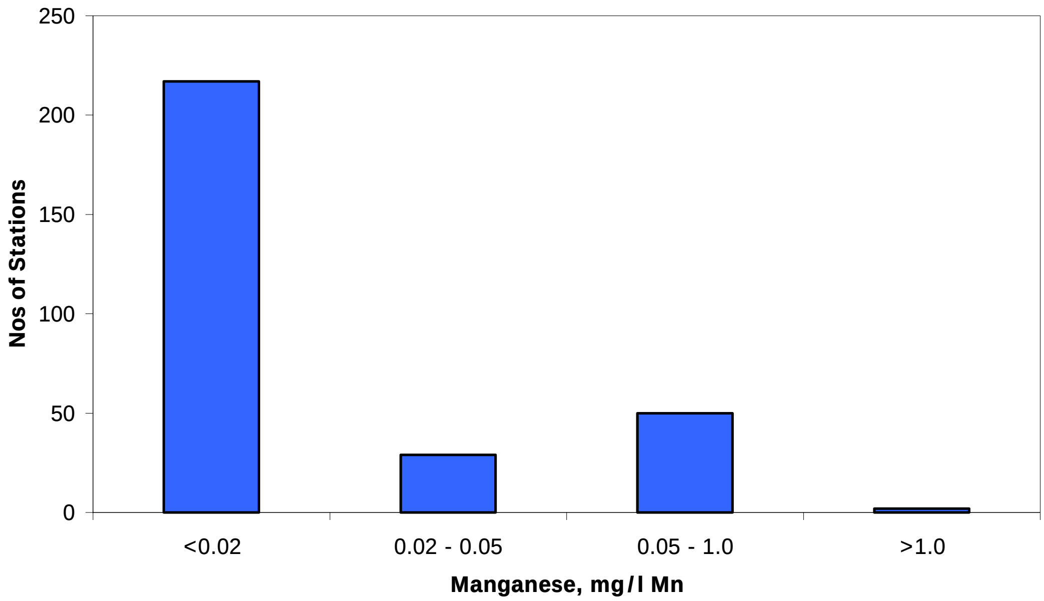

Fig. 5.13 Numbers of sampling stations with mean Manganese concentrations in the ranges indicated.

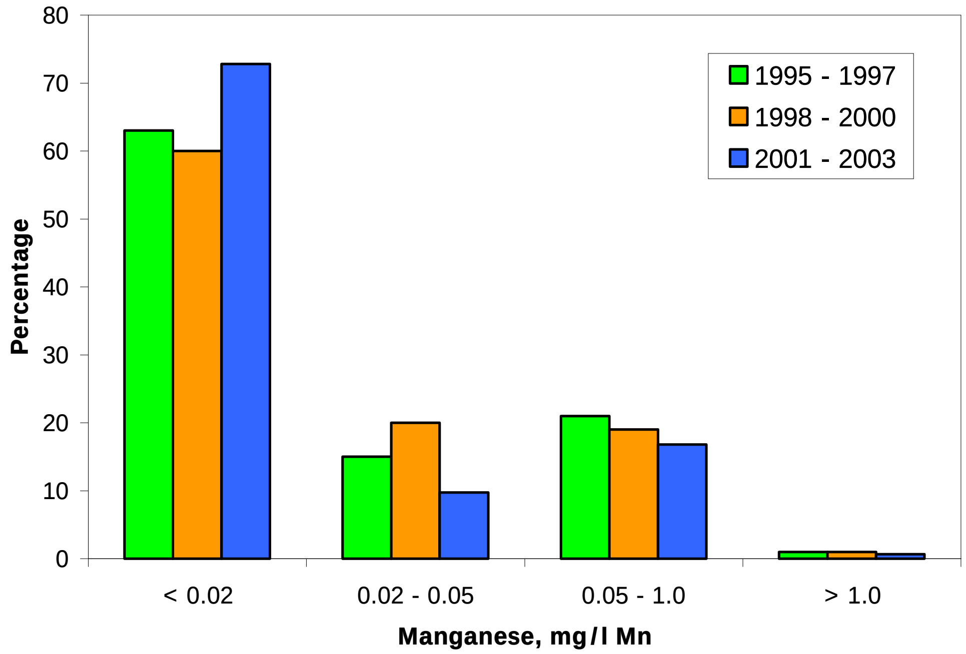

Fig. 5.14 Comparison of the proportions of sampling stations in three reporting periods with mean concentrations of Manganese in the ranges indicated.

(1), Offaly (1), Tipperary North (1), Waterford (1), Galway (2), Kilkenny (2), Laois (2), Cavan (3), Kerry (3), Kildare (3), Tipperary South (3), Monaghan (4), Donegal (5), Wexford (6), Leitrim (7) and Meath (7). Concentrations greater than 0.05 mg/l Mn were recorded in 289 individual samples, of which 22 exceeded 1.0 mg/l Mn. The highest individual sample concentration was 4.63 mg/l Mn at a location in County Kerry.

The percentage of stations with mean manganese concentrations in each classification range for 1995-1997, 1998-2000 and 2001-2003 are shown in Fig. 5.14. A similar trend to iron is clear, the proportions of mean manganese concentrations exceeding the MAC decreasing slightly from 22 per cent in 1995-1997 to 20 per cent in 1998-2000 and to 17.5 per cent in 2001-2003.

Bacteriological Examination

The results of the 1995-1997 and 1998-2000 EPA groundwater surveys (Lucey, *et al*., 1999; McGarrigle *et al*., 2002) and earlier studies (e.g. Daly, 1994; Daly and Woods, 1995) indicate that the main groundwater quality problems are associated with local microbiological rather than chemical contamination. Microbiological contamination is most likely to arise from the entry of faecal matter to waters. In practice, the presence of faecal coliform bacteria (e.g. *Escherichia coli*) in water samples is taken as an indicator of faecal contamination and thus of the potential presence of associated pathogenic micro-organisms, i.e. those organisms capable of causing disease (e.g. viruses and the protozoan *Cryptosporidium*). Disinfection techniques, e.g. chlorination, are used to counteract this potential problem in public water treatment. However, the majority of private groundwater supplies do not undergo any treatment prior to use.

Sources of *E. coli* and other faecal coliforms likely to contaminate groundwaters include septic tank effluent, agricultural organic wastes and landfill sites. The natural environment, particularly soils and subsoils, can be effective in removing bacteria and viruses due to ingestion by worms and other soil organisms, and by filtration and absorption. However not all areas are naturally well protected. High risk situations include karst areas, sands and gravels with a low clay content and a high watertable and extremely vulnerable fractured aquifers which allow the rapid movement of contaminants into groundwater with minimal attenuation. While the presence of clayey subsoils, tills and peat will, in many instances, retard the vertical migration of microbes, preferential secondary flow paths such as cracks in clay materials can allow the filtering effect of the subsoils to be bypassed.

From the perspective of human use and consumption of groundwaters, the most important consideration is the absence of pathogens. These organisms are not native to aquatic systems and usually require an animal host for growth and reproduction. However, they can survive and can be transported in natural water systems. The delineation of source protection areas referred to in the Groundwater Protection

Schemes (DELG at al., 1999) is based on the premise that in some circumstances, bacteria and viruses can live longer than 50 days in groundwater.

The bacteriological measurements made in the period were of total coliforms and faecal coliforms numbers in 100 ml of sample. Under the 2000 Regulations it will be necessary to undertake counts specifically of *E. coli* and also of Enterococcal bacteria.

A total of 1803 samples were examined for faecal coliforms at 301 monitoring stations in the reporting period. Positive counts were obtained in 399 (22.1%) samples, 214 (11.8%) of which exceeded 10/100 ml (Fig. 5.15). The positive counts were obtained in samples from 146 locations, although at eight of these the numbers of samples taken was less than four; thus faecal coliforms were present in samples from almost half (49%) of the monitoring locations on one or more occasions. This is similar to the outcome of the monitoring in the 1998-2000 period (51% of locations with one or more positive samples).

A count of 10/100 ml is regarded as a threshold value indicating gross contamination. Faecal coliform counts in excess of 10/100 ml were recorded at 93 monitoring stations, including 10 separate locations in counties Galway and Tipperary South. The highest faecal coliform counts in an individual sample (>2419 /100 ml) were recorded at locations in counties Galway (1), Kerry (1), Tipperary South (1), Kilkenny (3).

Some coliforms that grow naturally in the soil are not of faecal origin. A total of 1807 samples at 303 monitoring locations were examined for total coliforms, of which 958 showed positive counts. This indicated that not all of the coliform contamination is faecal in nature.

The percentages of samples with faecal coliform counts in each classification range for 1995-1997, 1998-2000 and 2001-2003 are shown in Fig. 5.16. The proportion of individual samples with positive counts decreased from 38 per cent in the 1998-2000 sampling period (34% in 1995-1997) to 22 per cent in 2001-2003, whilst the proportions of individual samples exceeding 10/100 ml counts decreased from 20 per cent in the 1998-2000 sampling period (18% in 1995-1997) to 11.8 per cent in 2001-2003. The data show, therefore, that there has been a substantial decline in the number of samples with faecal contamination compared with the previous reporting period.

Any indication of faecal contamination must be regarded as a matter of serious concern and the circumstances promptly investigated. This matter has been addressed in detail in the annual reports on drinking water quality published by the Agency (e.g., Page et al., 2004).

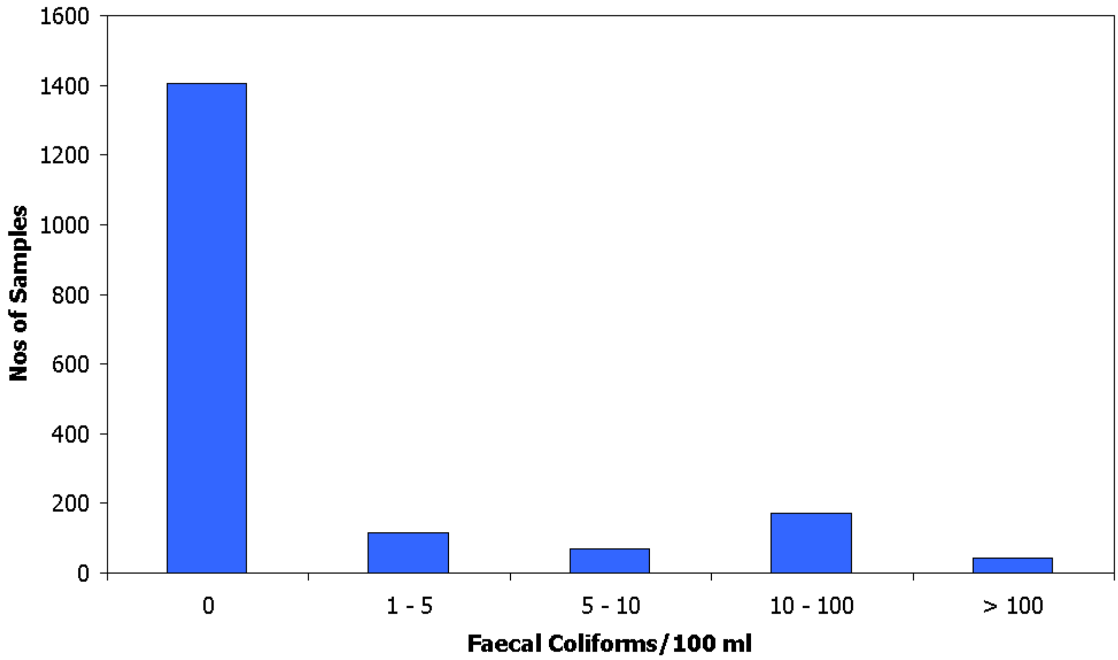

Fig. 5.15 Numbers of samples with Faecal Coliform counts in the ranges indicated.

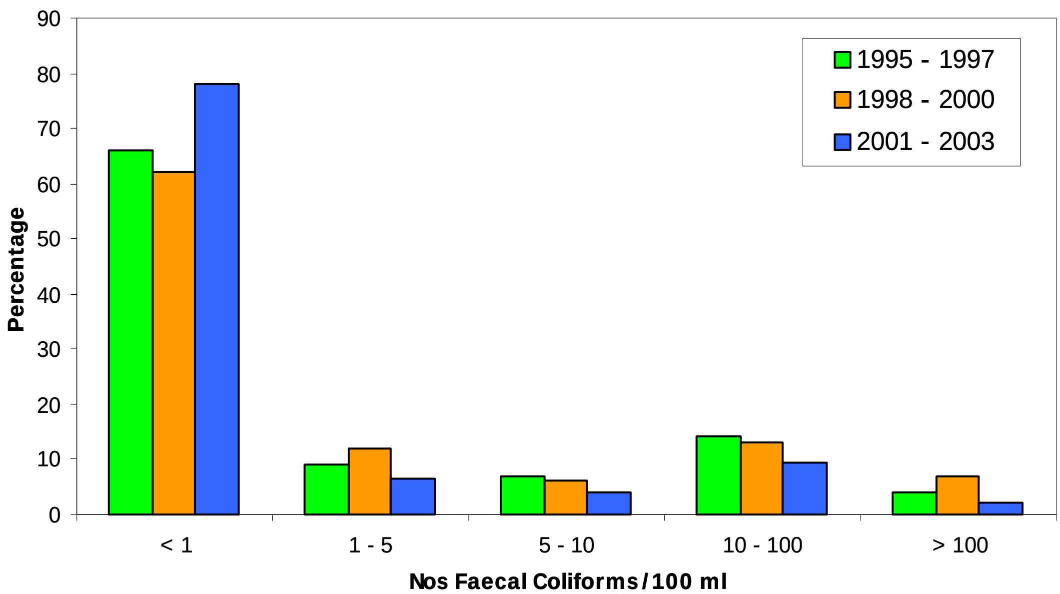

Fig. 5.16 Comparison of the proportions of samples taken in three reporting periods with Faecal Coliform counts in the ranges indicated.

Uranium

Uranium is a naturally occurring heavy metal that is present in small amounts in rock, soil, air, water, plants and animals. It is present in greater than average amounts in some rocks such as granite, phosphate deposits and various other mineral deposits. Given that uranium is found throughout nature, some exposure to the metal is a common occurrence. WHO in 1998 set a provisional guideline limit of 2 μg/l for uranium in drinking water but conceded that this level was probably exceeded in many supplies. A draft provisional guideline of 9 μg/l was issued in 2003 and a more recent review of the position is likely to lead to a revised guideline in the range 10-15 μg/l (WHO, 2004). It is noted that the US EPA has set a maximum contaminant level of 30 μg/l for uranium in drinking waters while an interim limit of 20 μg/l has been adopted in Canada (DELG, 2002).

Relatively high levels of uranium were detected in some groundwater samples taken by the EPA in the Baltinglass area of Co. Wicklow in 2001. it was decided to conduct a more systematic survey of its occurrence in these waters in the current reporting period. The data collected on uranium levels in groundwaters in 2001-2003 will form a benchmark against which the results of future surveys will be judged.

Screening of Water Supplies for Uranium

Following notification to Wicklow County Council of the high concentrations of uranium in groundwater samples from Baltinglass in 2001 and consultation with the RPII, the EPA recommended that the Council arrange for a survey of public and private water supplies in the county to determine the levels of uranium in the water supplies. In addition, local authorities were advised generally by the Department of the Environment and Local Government to undertake a screening of their water supply sources for uranium levels, particularly in areas where high radon levels had been recorded or where granite rock predominated. The EPA subsequently analysed 516 samples from supplies located in 16 different sanitary authority areas, the majority of the samples being from groundwaters. The survey included public water supplies, group water schemes and private wells and was mostly undertaken between October 2002 and February 2003. The results generally indicated that uranium was present in a small number of supplies at relatively elevated levels.

The majority of the supplies recording elevated levels of uranium were located in Carlow and Kildare. In the public water supplies monitored, the highest concentration of uranium detected was in the Ballinkillen supply in Carlow (53 µg/l). Lower levels slightly in excess of the 9 µg/l WHO draft provisional guideline were exceeded in a further four public water supplies. Elevated levels of uranium were detected in four group water schemes. Levels of concern were found in two of these supplies, the Killerig/Straboe scheme (55–60 µg/l) and the Ballyloo scheme (45 µg/l). The latter is in Carlow; the former is on the Carlow/Kildare boundary and supplies areas of both counties. Two other schemes in Carlow and Kilkenny also exhibited levels slightly in excess of 9 µg/l. There were eight private wells with elevated levels of uranium, all of which were in either Carlow or Kildare. One such well had levels of up to 290 µg/l.

The Killerig/Straboe scheme is reported to be in the process of being incorporated into the North Carlow Regional Scheme, while the Ballinkillen public water scheme and Ballyloo group water scheme are to have alternative sources of water provided for distribution under the 2003 Rural Water Programme for Carlow. The private wells that had elevated levels of uranium (all of which were from the same area) have since been connected to the Carlow North Regional Scheme.

A total of 1228 individual uranium measurements were recorded at 247 monitoring stations in 2001-2003. The mean uranium concentration results are summarised in Fig. 5.17 and are shown on Map 10 in Appendix VII for the individual locations. Mean concentrations of uranium were less than the detection limit (1.0 μg/l U) at 188 (76.1%) monitoring stations while they exceeded the WHO 1998 provisional

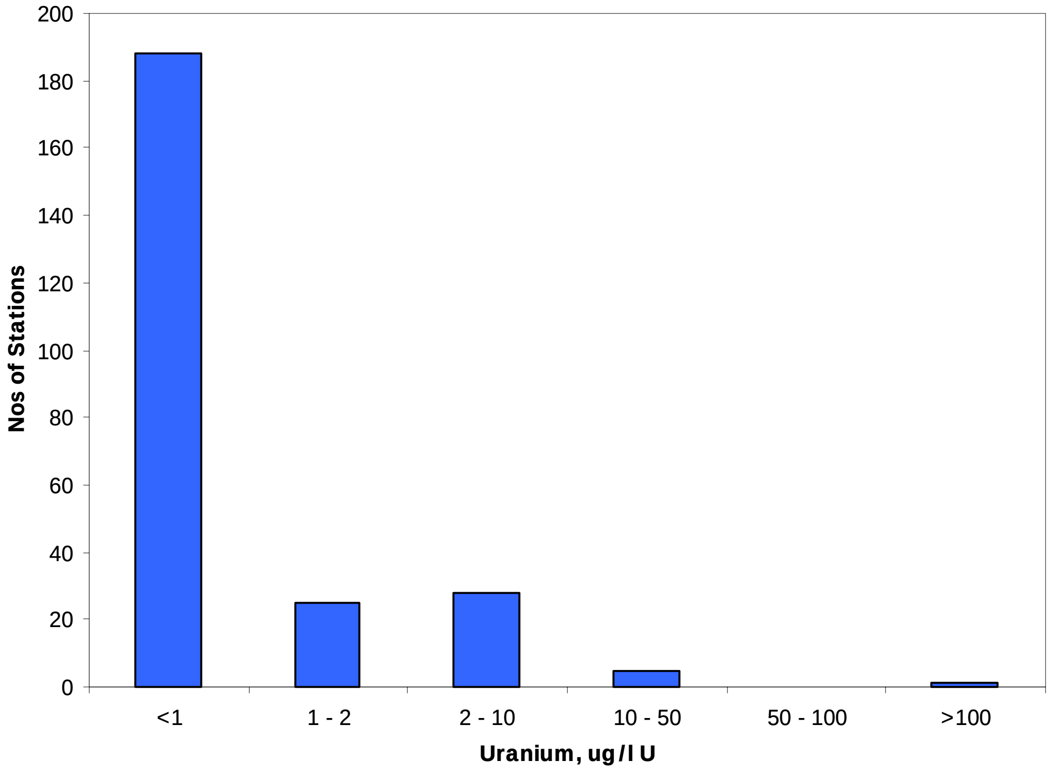

Fig. 5.17 Numbers of sampling stations with mean Uranium concentrations in the ranges indicated.

guideline limit of 2.0 μg/l U at 34 monitoring locations; mean concentrations over 10 μg/l U were recorded at only six locations. Mean concentrations exceeded 100 μg/l U at one monitoring station in Co. Wicklow. Concentrations greater than 1.0 μg/l U were recorded in 243 individual samples of which 173 exceeded 2.0 μg/l U and 24 exceeded 10.0 μg/l U.

The highest individual sample concentration was 132 μg/l U at a location in County Wicklow. In February 2005, the Health Services Executive (HSE) circulated a report (HSE, 2005) on the findings of an investigation of this source. This noted that uranium was a naturally occurring element (a metal) that is found throughout nature, especially in granite rock. Naturally occurring uranium is very slightly radioactive but international research shows no evidence that its ingestion at levels that occur naturally in the environment leads to adverse health effects relating to this aspect. In studying the health affects of uranium, the HSE's focus was on possible toxic effects on the kidney. The HSE found that the consumption of drinking water containing uranium at the levels measured in this case had no discernible effect on kidney function despite using a range of sensitive and specific tests and referral to a consultant nephrologist for opinion where indicated.

Chapter Six

IMPLEMENTATION OF THE WATER FRAMEWORK DIRECTIVE

INTRODUCTION

The directive establishing a framework for Community action in the field of water policy, commonly known as the Water Framework Directive (WFD), was formally adopted by the EU Parliament and Council in October 2000 (EP and CEU, 2000). It represents the outcome of a general review of water policy in the EU initiated by the Commission in the early 1990s at the request of the Council and requires a major change in the approach to water resources management in the Member States. An opportunity is taken in this chapter to summarise the work which has been undertaken to date by the EPA, the local authorities and other public bodies on the implementation of the directive since the making of the Regulations giving effect to the directive in the State in December 2003.

In contrast to the aims of many of the existing water directives, which seek to protect specific uses of water, the new directive is concerned, *inter alia*, with the protection of the aquatic ecosystem *per se* or, where necessary, its restoration, to achieve conditions (*good status*) in all waters which are only slightly degraded from those of the natural or *reference* state. The definition of good status in the case of surface waters is based on both *ecological status*, viz the composition of the faunal and floral communities and the natural chemical and physical characteristics, and on *chemical status* which, in the context of the directive, refers to a number of specified toxic and/or bioaccumulative substances. In the case of groundwaters good status relates to the natural chemical composition of the water and to these same chemical substances as well as to *quantitative status* (i.e. the extent to which reserves are depleted by abstractions).

These targets, which must be achieved by 2015, are likely to be very demanding in many cases, especially in those waters where there has been a long history of pollution or, as with many surface waters, physical disturbance. It is not surprising, therefore, that the directive makes provision for less demanding or delayed targets in some cases, including situations where the reversal of physical alterations is not practicable. In addition to the quality target, the directive also promotes the sustainable use of water resources, the elimination of the discharge of specified hazardous substances and the mitigation of the effects of floods and droughts.

Management of waters must be undertaken on the basis of hydrological units, termed river basin districts (RBDs); these may comprise individual river catchments or groups of contiguous catchments.

Entities or “competent authorities” must be designated to undertake the management and other tasks in each RBD. Where river basins are shared by two or more Member States, these States must act together through international RBDs (IRBDs).

The directive specified as an initial task that the nature of the waters in each RBD be characterised and the human impact on these resources assessed before the end of 2004. This was also to include an economic analysis of water use. The characterisation process is required to be reviewed not later than the end of 2013 and again at six year intervals after that date. Each RBD must prepare, by 2009, programmes of measures considered necessary to achieve the quality and other goals of the directive and ensure that these are operational by 2012. In addition, the RBD must prepare, again by 2009, a management plan for its waters which includes, *inter alia*, the basic information arising from the characterisation process as well as a summary of the measures specified. Both the programmes of measures and the management plans must be reviewed by 2015 and subsequently at six year intervals.

A further task required by the directive is the preparation of monitoring programmes which, in addition to providing an overview of water status in each RBD, are intended to assess the efficacy of any measures instituted and to assist in determining the causes of any failure of particular waters to meet the quality objective. An annex to the directive gives very detailed specifications as to how these programmes should be implemented and the nature of the classification systems which must be used to document the results. The monitoring programmes are required to be operational by the end of 2006.

There is a very specific requirement that the public be consulted in the implementation of the directive, in particular the preparation of the management plans. To this end, the RBD must make relevant information available to the public in a timely manner, thereby facilitating commentary and consultation. The Commission must also be kept informed of the implementation of the directive and must, in particular, receive copies of the management plans and monitoring programmes as well as summaries of the reports on characterisation.

At EU level, the Commission has convened a Strategic Co-ordination Group (SCG) to oversee and advise on a common implementation strategy (CIS) for the directive in the Union. The Group is comprised of senior scientific and administrative officials from each Member State together with Commission personnel. A number of working groups report to the SCG on specific matters and their advice has been issued to the Member States in a set of guidance documents for the promotion of the CIS.

GENERAL ARRANGEMENTS FOR NATIONAL IMPLEMENTATION

Regulations

Member States were required to incorporate the WFD into national law by the end of 2003 and this was done in Ireland under Regulations made in December of that year (Minister for the Environment, Heritage and Local Government, 2003). These regulations place the main responsibility for implementation of the directive on the EPA and the local authorities as the competent authorities proper but identify a number of other public bodies on whom a general requirement is placed to support the aims of the directive. The local authorities are responsible for the programme of measures and the making of management plans while the EPA is assigned a number of specific technical tasks, including the preparation of monitoring programmes, reporting and overseeing roles.

River Basin Districts (RBDs)

The Regulations define seven RBDs for the purpose of the directive, four of which are wholly within the State and three of which are international RBDs (IRBD), shared with Northern Ireland (Fig. 6.1). The Shannon catchment is defined as an IRBD in recognition of the fact that groundwater draining from a small area within N. Ireland contributes to the headwaters of the river. However for implementation purposes, this status is waived and it is dealt with in toto by the State. The Regulations also specify one local authority to act as co-ordinator in each RBD, viz. Dublin City Council (Eastern RBD), Carlow County Council (South Eastern RBD), Cork County Council (South Western RBD), Galway County Council (Western RBD), Limerick County Council (Shannon RBD), Donegal County Council (North Western RBD) and Monaghan County Council (Neagh Bann RBD). A number of county councils will be involved in more than one RBD as administrative boundaries do not coincide with those of the river basins.

Financial support of the order of €50 million has been provided by central government to the local authorities to assist with the initial implementation of the directive. These monies have been used in each RBD to commission appropriate projects from consultants to provide the necessary information, data and advice needed by the authorities to allow them to meet their statutory obligations under the Regulations. The projects have been commissioned on a staged basis; thus, work commenced in 2002 in the case of the South Eastern RBD, in 2003 on the Shannon and Eastern RBDs and in 2004 on the South Western and Western RBDs.

The Regulations make specific provision for consultation, co-operation and liaison at Ministerial and public authority levels with the corresponding authorities in N. Ireland in relation to the implementation of the directive in the cross-border IRBDs. To this end, a joint consultation paper (DOE and DEHLG, 2003) was issued in the two jurisdictions in 2003 to set out the background to the WFD and the proposed administrative arrangements to be put in place for the implementation process and to invite comment on these proposals.

Fig. 6.1 River Basin Districts and International River Basin Districts also showing outer limits of coastal waters included in each District.

At a more specific level, water management in the North West and Neagh-Bann IRBDs is being progressed by the North-South Shared Aquatic Resource (NS-SHARE) Project. The NS-SHARE Project commenced in August 2004 and forms an important element for implementation of the Water Framework Directive and for North-South co-ordination in the IRBDs designated under the Directive. The project is led by Donegal County Council on behalf of the relevant authorities North and South. In this case, 75 per cent of the cost is being met by funds provided under the EU INTERREG IIIA programme, the remainder being provided by the implementing bodies North and South. The project, over the course of three years, is developing and implementing working tools for water management in relation to these shared waters and in relation also to the North Eastern RBD which lies wholly within N. Ireland.

National Co-ordination

A National Co-ordination Group, consisting mainly of representatives of Government departments and agencies involved directly or indirectly in the water area, was convened by the Department of the Environment, Heritage and Local Government (DEHLG) in 2000 to consider the broad issues concerned in the then proposed directive and subsequently to advise on the implementation of the adopted instrument in the State.

Following the making of the Regulations in December 2003, the EPA convened a Technical Co-ordination Group in early 2004 to guide the implementation process at a more detailed level, with regard especially to the technical aspects. This group is again composed of relevant departmental and agency representatives but also includes local authority and consultant personnel involved in the RBD projects. Working Groups have also been convened to consider and advise on specific matters on behalf of the Technical Co-ordination Group. These include a groundwater WG convened by the Geological Survey of Ireland (GSI) and a risk assessment WG convened by the EPA.

In carrying out the implementation work to date, close liaison has been maintained with the responsible agencies in N. Ireland and in the UK generally, in view primarily of the need for co-operation in the cross border IRBDs but also in recognition of the fact that the aquatic ecology of the two islands is quite similar and that benefits could arise, therefore, from co-operation on some of the technical aspects of the directive. To this end representatives of the EPA and other state agencies involved in the implementation of the WFD participate in specially convened working groups with personnel from the NI agencies and also attend similar groups at UK level. In turn, personnel from the NI agencies participate in the Technical Co-ordination Group and its various working groups.

Local Co-ordination

The implementation of the individual RBD projects is overseen by a Steering Committee consisting primarily of representatives of the lead local authority, DEHLG and the EPA. This group is assisted by a management committee which, in addition to the foregoing, has representatives from all of the local authorities involved as well as other state agencies and representative bodies. This allows for a wide range of opinions to be canvassed on various aspects of the implementation process. In addition, each of the RBDs organises public briefing sessions.

Research

Implementation of the directive requires a large amount of information on the aquatic environment, in relation particularly to biological aspects, as well as the consideration of new approaches to assessment. In order to meet some of these needs, the EPA commissioned a number of research projects under the Environmental Research, Technological Development and Innovation (ERTDI) Programme 2000-2006, funded under the National Development Plan 2000-2006 and managed by the Agency. Most of these were the subject of a special call for tenders in 2002 (EPA, 2002) but a number of research fellowships were awarded in 2000 in anticipation of the needs of the directive. Areas covered by the research projects and fellowships include lake and river ecology, groundwater vulnerability and recharge characteristics and the identification of water-dependent conservation areas. The total funding awarded was of the order of €2.0 million.

INITIAL TASKS

Article 3(8) Report

This was the first significant matter to be dealt with under the directive and Regulations. The latter required the EPA to submit to the EU Commission by June 2004 the information on the competent authorities and on the RBDs specified in Article 3(8) of the directive. A further requirement was a description of the institutional arrangements put in place to implement the directive in the international RBDs. A related task was the preparation in Geographical Information System (GIS) format of descriptions of the boundaries of the RBDs together with a listing of their main rivers. These tasks were completed by the Agency within the period specified; the details of the competent authorities submitted are available on the EPA's web site.*

Characterisation Report

The most important initial task specified by the directive is the preparation of reports on the characteristics of the RBDs and two annexes give detailed specifications of the information to be included in these reports. Under the Regulations, summaries of the Characterisation Reports were required to be submitted by the RBDs to the EPA by December 2004. The EPA, in turn, was required to submit a summary of these reports to the Minister and to the EU Commission by the end of March 2005. However, it was agreed later by the EPA and the local authorities that, as a *modus operandi*,

* www.epa.ie/PublicAuthorityServices/WaterFrameworkDirective/

the required information for all of the RBDs would be combined in one database on a working web site available to all parties; from this, the EPA would draw material for the summary report to be sent to the Minister and the Commission and the local authorities material for individual RBD reports.

The gathering and assessment of information for the characterisation report were carried out by the RBD project teams and the EPA through 2004 and built on work which had commenced in earlier years in anticipation of the tasks to be assigned by the Regulations. Brief descriptions of the main areas covered are given below. The full characterisation report and the summary submitted to the EU Commission by the EPA on 22nd March 2005 are given on the public web site for the WFD (www.wfdireland.ie)

Identification and Mapping of Water Bodies

This task was assigned to the EPA and required the mapping of river, lake, transitional (estuarine), coastal and groundwater bodies. In the case of surface waters, the depictions of these on the 1:50000 Ordnance Survey Maps were taken as a reference base for this purpose. The water bodies identified are intended to be the units on which management measures, if necessary, will be focused in the future and their identification will therefore highlight the targets of such measures for the public.

In the case of rivers, the water body definition has been based mainly on stream order and a total of 4,467 stretches has been have been delineated, generally representing second order or larger stream and river channel. The directive indicates that only stream channels with catchment areas greater than 10 km^2 are to be considered for this purpose, thus excluding nearly all of the first order streams.

A total of 210 lake water bodies have been identified with areas equal to or greater than 50 ha, the limit set in the directive for reporting purposes; these are nearly all complete lakes, the need for sub-division being considered in only a few cases. A further 535 smaller lakes, used as sources of water or located in areas subject to special protection measures, have been taken into account in the risk assessment procedure (see below).

The total number of tidal water bodies identified is 309, of which 196 are in transitional and 113 in coastal waters. Salinity characteristics and other physical features were the main factors used to delineate individual water bodies in the transitional waters while in the case of the coastal waters the main distinction was between bays and open sea areas. Some additional sub-divisions were made in both cases, in the context of the risk assessment procedure (see below), to distinguish, e.g. localised waters enclosed by ports and other built structure or those subject to dredging.

The task of distinguishing groundwater bodies was led by the GSI and necessitated a considerable amount of new data collection and assessment on bedrock geology, soils and sub-soils as well as subsequent mapping of this information. This permitted the identification of four groundwater body types, based on the flow regime in the aquifer, viz karstic, productive fissured bedrock, gravels and poorly productive bedrock. Using CIS recommendations on defining boundaries between aquifers, nearly 400 groundwater bodies of these four types were initially identified. The total number was subsequently increased to 757 as a result of a sub-division of some of the original units delineated; this sub-division was needed to give separate recognition to local areas where potential impact from various pressures was assessed as significant. An additional task undertaken in this area was the identification of those groundwater bodies which act as the water supply for surface aquatic or semi-aquatic systems, such as turloughs or fens, with special conservation status.

Typology and Reference Conditions for Surface Waters

A further task assigned to the EPA was the determination of the physical types of surface waters which support different biological characteristics. The purpose of these distinctions, termed typology, is to ensure that in future monitoring of the biological characteristics of rivers, lakes and tidal waters, appropriate baseline or reference conditions are available for comparison. Since the faunal and floral communities vary depending on the physical nature of the habitat (e.g. hard or soft water or fast or slow flowing river currents) it is important that “like be compared with like” when assessing the degree to which the present conditions differ from the unaltered state. In addition, it is necessary to determine the nature of the faunal and floral communities which constitute this unaltered state or reference condition for each type recognised. These tasks, in the cases of rivers and lakes, have been supported by research projects carried out under the above-mentioned ERTDI Programme. For transitional and coastal waters, the typology and reference conditions developed for the UK, including N. Ireland, will be applied in the State in view of the similarity of conditions in the tidal waters around the two islands.

In the case of rivers, geological features, i.e. the extent of calcareous rock in the catchment, determining the hardness level of the water, and slope as the determinant of current speed, were the features having the greatest influence on the fauna and flora at sites studied. Thus, the typology developed for rivers is based primarily on these features and recognises 12 types, based on three geological categories and four slope categories. A similar number of basic types has been recognised for lakes, using in this case water alkalinity (three categories) as a surrogate for geological nature of the catchment, mean depth (two categories) and size (two categories) as the determining features. The UK typology scheme for tidal waters recognises six transitional and 12 coastal water types, based on discriminatory features including salinity levels and degree of wave exposure. Of these 12, two transitional and five coastal water types have been recognised in the State’s tidal waters.

Reference or virtually undisturbed conditions for the river and lake types identified were also investigated in the course of the ERTDI projects mentioned above and where possible have been documented for the biological elements which must be addressed in monitoring programmes. Fish populations were not included in the WFD research projects and the definition of reference conditions for these will rely mainly on existing records held by the fishery agencies; in the case of rivers, further guidance will be provided by the results of an ERTDI project comparing the composition of fish populations and water quality conditions as rated by the biological assessment scheme used by the EPA. For some of the river and lake types recognised, it has not been possible to locate sites exhibiting undisturbed conditions; in these cases, it may be necessary to use expert judgement to define the reference state.

A further qualification in this area is the need to assess hydromorphological conditions at the putative reference sites. This is a new concept in the assessment of aquatic resources and recognises the fact that physical alterations, e.g. weirs and dams or other flow controls, as well as abstractions, may have a significant effect on the biology or chemistry of the waters involved. A further project under the ERTDI programme was commissioned to devise a method for assessing this aspect of waters but has not yet been finalised. It is possible that some of the reference sites selected will be shown to have significant hydromorphological alterations and this could preclude their use as baseline situations for the assessment of biological changes.

Designation of Artificial (AWBs) and Heavily Modified (HMWBs) Water Bodies

It was mentioned at the start of the chapter that the directive allows for some modification of the objective of good quality in the case of water bodies which have been subject to major physical alterations. Where such a designation is justified, the objective to be achieved is good ecological potential, this being a minimal departure from maximum ecological potential. The directive suggests that the latter should be based on the type of natural water body which the modified water most closely resembles. A typical case would be a river impoundment which is likely to resemble a lake; in such a case, therefore, the maximum ecological potential would be defined by the reference condition in a natural lake which has similar characteristics to the impoundment. The directive also requires the identification of artificial (i.e. constructed) water bodies, canals being a typical example, and the same approach is specified for the setting of the ecological objectives. In both cases, however, the specific chemical quality objective applies without modification.

The provisional identification of HMWBs and AWBs was assigned to the EPA under the Regulations. It was agreed with the RBD project teams, however, that the latter would undertake the basic work on this aspect and would put the resulting proposals to the EPA for approval. In general, HMWB designation has been proposed for a relatively small number (37) of water bodies. These include the obvious cases of river impoundments, such as those on the Liffey and Lee, as well as areas around ports in tidal waters. In the case of rivers, it was decided that drainage works would not be regarded as a basis for provisional designation of HMWBs as it was considered that ameliorating measures could be employed to minimise the scale and duration of any effects of the works on the flora and fauna. Final decisions on the HMWBs will not be needed until the management plans are drafted in 2008 and in the meantime further assessment will be made to determine if the designations are fully justified on economic and social grounds. A total of 37 AWBs has also been proposed, the majority of these being canals.

Impact of Human Activity on the Status of Surface Waters and Groundwaters

This is an important aspect of the characterisation process and involves the application of risk analysis to determine the likelihood that the objectives of the directive will not be met in individual water bodies due to artificial agencies. While, in theory, the risk of non-achievement relates to 2015, for practicable purposes the analysis has been carried out for the *status quo* as there would be difficulty in predicting the nature of or the outcome of any increased pressures or ameliorating measures likely to arise in the intervening years up to that date. The prime purpose of this exercise is to identify those water bodies where restorative or protective measures are or might be needed, thus assisting the preparation of the formal programme of measures due by 2009; before that date, the process will be further refined by the results of the monitoring programmes due to commence in 2006.

The analyses undertaken have involved gathering information on all of the environmental pressures likely to affect the waters concerned, not only pollutant discharges but also physical pressures such as abstractions or channel alteration and other factors such as the presence of alien species which may have impacts on the native flora and fauna. In addition, the available information on the current condition of water bodies (impact data), mainly arising from the water quality survey work of the local authorities, the EPA and the fishery agencies, was compiled. In conjunction with this information gathering exercise, criteria and thresholds were developed for each type of pressure and impact in relation to the level of risk which these represented. This work benefited from the guidance issued at EU level and from the work of UK expert groups.

While the directive requires only a differentiation between waters at and not at risk, it was decided to adopt a modification of this approach to allow for the lack of adequate data in many cases leading to uncertainty in the assignment of risk. Thus a four-category scheme was used, as follows:

1a Waters – those deemed to be at risk with a high degree of confidence

1b Waters – those probably at risk but where the data available are limited

2a Waters – those unlikely to be at risk but where the data are limited

2b Waters – those deemed not to be at risk with a high degree of confidence.

In the case of 1a waters, there is a strong case for identifying and implementing the necessary measures immediately while for 2b waters the need is to prevent any deterioration. For the waters in the intermediate categories, further investigation of pressures and impact will be needed to allow final decisions on risk status and the need for restorative measures to be reached.

A precautionary approach is specified for the risk analysis, i.e. the overall risk for a water body is to be determined by the most pessimistic of the outcomes for all of the pressure factors and impact data considered. Thus, in many of the water bodies assessed, the risk status has been determined by a pressure factor even though the water quality information suggests that current conditions are good.

One exception to this approach is made in the case of river water bodies for which there is a recent assessment of conditions based on the EPA's biological quality index; in view of the fact that the index incorporates most of the biological elements required to be examined by the directive in assessing quality status, it overrides the pressure analyses related to pollution (but not those related to hydromorphological impacts) in cases where it indicates that in-stream conditions are good. For the considerable proportion of the river waters assessed that are not covered by current monitoring programmes, the procedure has been assisted by the outcome of a further ERTDI project which established statistically significant relationships between the biological quality index and various land uses in the relevant catchment. This allowed the prediction of the probability of achieving or not achieving a good quality rating in a particular water body and this prediction was considered in conjunction with information on pressures in assigning risk. However, the predicted quality was the deciding factor in assigning risk only in cases where it indicated a more pessimistic situation than the pressure analysis.

Determination of the risk to groundwaters involved the development of a simple pressure-pathway-receptor model which incorporated information on vulnerability of aquifers to pollution and the behaviour of different pollutants in the soil. Vulnerability is measure of how easily pollutants can gain access to and migrate through the aquifer and depends on the nature and depth of the soil overburden and on the type of rock beneath. For instance, shallow and gravel overburdens and a fissured rock base lead to high vulnerability while clays and non-fissured rock base are associated with a low vulnerability. In regard to pollutants, the model takes into account their mobility in soils; some such as nitrate move readily through the soil while others, such as phosphate and some organic compounds, bind to the soil particles so that break-through to the aquifer may be retarded.

It is important to note that the outcome of the risk analysis process, based as it is on a precautionary approach, cannot be compared with the results of water quality surveys which refer solely to actual conditions. In addition, the process takes into account factors, especially the potential impact of physical alterations to the water body, which have not to date been included in the routine survey of aquatic resources. It thus presents a "worst case" scenario which requires to be substantiated by further investigation.

Table 6.1 gives the overall result of the analysis for the four categories of water and shows that nearly two thirds each of river water bodies, larger lake water bodies and groundwater bodies are deemed to be at or probably at risk (i.e. risk ratings of 1a or 1b). However, when the larger and smaller lakes are considered together, the proportion at risk reduces to 38 per cent. In the case of the tidal waters, while over half of the transitional water bodies are deemed to be at risk, the proportion of coastal water bodies so assessed is the lowest for all categories of waters. In the majority of cases, the "at risk" status is due either to morphological factors or to diffuse sources of pollutants. The former include intensive land use in the catchment, flood protection measures and, particularly in rivers, drainage activities.

The proportions of the water bodies in each RBD assessed as at or probably at risk generally reflect the regional differences seen in water quality statistics. Thus, significantly more surface water bodies are deemed to be at risk in the Eastern and South Eastern RBDs and the Neagh-Bann IRBD compared to the South Western and Western RBDs and the North Western IRBD. These differences generally reflect population densities and the nature and intensity of land use.

Economic Analysis of Water Use

The characterisation of each RBD also required that an economic analysis of water use be carried out in terms of the costs of providing the public supplies and waste treatment and in relation to the principle of cost recovery prompted by the directive. This work was undertaken as a national study and commissioned directly by DEHLG from consultants.

A key point arising from the study is the relatively low rate of cost recovery for water supply (71%) and sewerage schemes (28%) due mainly to the current policy of zero charging for water services in the domestic sector. It is also of note that, while the increase in water demand by 2015 is estimated to be 77 million litres, the projected savings from the elimination of leaks and other conservation measures over the period, are as much as 65 million litres (although this excludes Dublin). The full report is available on the public web site for the WFD.

Register of Protected Areas

Article 6 of the directive requires the Member States to compile a register of all the areas in each RBD that have special protection under EU or national legislation, including that related to the protection of habitats and species. Also covered by this requirement are the waters used for the abstraction of significant public supply. This task was assigned to the EPA under the Regulations and was completed on schedule in December 2004.

TABLE 6.1

Numbers and proportions of water bodies of each category assessed as at risk (1a and 1b water bodies) of failing to meet the objectives of the WFD

Water Body Category	Total Nos of Water Bodies	Nos. at Risk	Per Cent at Risk
Rivers	4467	2854	64
Lakes (All)	745	280	38
Lakes (=/> 50 ha)	210	134	64
Groundwaters	757	471	62
Transitional Waters	196	104	53
Coastal Waters	113	30	27

Intercalibration

The directive places a strong emphasis on the composition of the fauna and flora of surface waters in the assessment of quality status. In terms of these biological features, the objective of good status implies only a minor deviation from the reference or high quality conditions defined for each type of river, lake and tidal water. Of particular importance is the degree of deterioration which would be considered to reduce conditions below good status to a moderate or lower status as defined in the directive. Such a deterioration would indicate a need for restoration and thus have implications for investment in waste water treatment or other measures.

Since these financial implications are likely to be matters of political sensitivity, it is important that the nature of the boundary between good and moderate status is comparable across all of the Member States while remaining consistent with the definitions in the directive. Agreeing such a boundary would be relatively straightforward if confined to physico-chemical parameters of water status but the need to give biological deterioration prime consideration makes the process much more complex. This is due to the natural differences of the aquatic flora and fauna which arise from variations in climate, altitude and other physical factors as well as barriers to the spread of some species. A number of *ecoregions*, or areas with similar flora and fauna, of which the island of Ireland constitutes one such biogeographic entity, is recognised across Europe, based on these differences. For example, the diversity of organisms at a reference site on an Irish river (Ecoregion 17) would be considerably lower than that in a river of similar physical type in western France (Ecoregion 13). This difference has to be taken into account when defining the biological parameters of good status in the two Member States.

In order to deal with these potential problems, the directive provides for the undertaking of intercalibration exercises to compare, in terms of the biological parameters in particular, how the Member States provisionally define the good – moderate and the high – good boundaries in their waters. To this end, each Member State was required to submit to the Commission in 2003 a list of sites proposed to be included in the intercalibration procedure. The sites were to be representative of the two boundary conditions and also to take account of specific pressures, e.g. sites deemed to be representative of the good – moderate boundary where the potential impact is excess of nutrient input. Typology was also to be taken into account in the selection; however, due to technical difficulties, it was necessary to use a modified typology for the purpose of the exercises, this being broader than the national typologies and in effect amalgamating those for adjacent ecoregions. The EPA undertook the selection of suitable sites for Ireland and these were submitted to the Commission in the latter half of 2003; further information on the sites was submitted on request in 2004.

The Commission was required to compile a register of all of the intercalibration sites submitted by the Member States and publish it by December 2004. This has been delayed by legal considerations and is not now likely to be published until mid 2005. The intercalibration exercise itself is required to be completed by June 2006 and will involve consideration of the biological and supporting information for the sites. This will be undertaken by the working groups mentioned above, one of which will deal with sites in each of the specific geographical areas defined for the exercises. The recommendations of the working groups will be considered by the Commission with the assistance of a regulatory committee established under the directive.

The final outcome of the intercalibration exercise is due to be published by the Commission in December 2006 and will indicate the values, in terms of numerical ratios (ecological quality ratios - EQRs) comparing the observed situation with the reference state, by which the key boundary conditions will be defined. These values will be incorporated into the classification schemes to be used by the Member States in reporting on the results of monitoring.

FUTURE TASKS

Considerable progress has been made to date on the implementation of the directive but the more important tasks remain to be addressed. The immediate requirement is the preparation of monitoring programmes and the establishment of classification systems. These tasks are primarily assigned to the EPA under the Regulations and must be completed by June 2006. In the case of the classification systems, this area is being assisted by work undertaken in the context of the NS SHARE project for the cross border RBDs, mentioned above, which will propose schemes for the biological elements, suitable for expression as EQRs. Additional progress is being achieved in this area by participation in UK working groups addressing the same issues. Proposals for classification systems arising from the foregoing, and the details of the monitoring to be undertaken, will be further developed by a special working group convened by the EPA and reporting to the Technical Co-ordination Group. The monitoring programmes are required to be in operation by December 2006 but survey work will be undertaken by the RBD projects before then to clarify some of the less well substantiated outcomes of the risk analysis.

The RBDs have also agreed to carry out in 2005 a preliminary screening of surface and groundwaters for those specific chemical substances, the discharges of which to the aquatic environment are to be eliminated or minimised under the WFD. In particular, the survey will measure concentrations of the 33 priority substances identified for inclusion in Annex 10 of the directive. Measurements will be made on levels of the substances in sediments and animal tissue as well as in the waters. The results of this screening exercise will be of assistance in determining the scope of the continuing measurements of such substances which should be incorporated in the formal monitoring programmes.

The major tasks to be undertaken subsequently are the preparation of the programmes of measures and the management plans for each RBD. These tasks, which are the responsibility of the local authorities in the first instance, are not due to be completed before June 2009 according to the

Regulations but it is likely that preliminary work will commence in 2005 with the consideration of the general principles to be adopted. This is the case in particular for the programmes of measures which must be available in draft form for comment by the middle of 2008. The programmes must also identify the environmental quality objectives for the RBDs, in line with the specifications in Article 4 of the directive. These include the general objective of good status for all waters, the prevention of deterioration of any waters and the elimination of or reduction of the discharges of the specific chemical substances.

Apart from the investment in any measures required to achieve its basic objectives, full implementation of the directive is likely to require additional resources in a number of areas. In particular, the monitoring requirements are very demanding and considerably extend the range of biological observations which have been incorporated to date in water quality survey work in the State. Thus, a greater range of expertise as well as additional personnel is likely to be needed by the EPA and the other public bodies to whom monitoring tasks are assigned.

Chapter Seven

DISCUSSION AND CONCLUSIONS

The data and other information presented in the foregoing chapters are considered to give a relatively comprehensive picture of the quality of the State's significant surface water and groundwater systems in the 2001-2003 period. While the coverage of the current monitoring programmes, as pointed out in Chapter One, appears limited in proportion to the total number of water bodies in the State, most of the larger systems have been examined in the period and the situation in many can be taken as representative of adjacent unsampled systems. The surveyed waters also include those most at risk of pollution from direct discharges of waste as well as those in areas where non-point waste inputs, e.g. from intensive farming activities, present a similar threat.

Surface and groundwater systems constitute a valuable national resource for both social and economic purposes and the extent to which they are polluted has major implications for the costs involved in their use. The greatly enhanced economic development of the country which commenced in the 1960s and which accelerated following entry to the European Community, not only increased the dependence on water resources but also created much more intensive pressures on them, in particular on the maintenance of their quality. The previous reports in this series have documented the deterioration of a considerable part of the river channel over the last 30 years and this may be taken as a general index of the impact on water resources which the economic development of the State has had in that period. While it has been pointed out previously that the extent of this deterioration is relatively minor in many cases, it has merited highlighting in view, firstly, of the fact that Irish waters were and are not subject to the intensity of pressure experienced in many other EU Member States and, secondly, of the high quality status which existed generally up to the early 1970s, epitomised, in particular, by the ubiquitous occurrence of the pollution-sensitive salmon and trout.

The location of the main cities and towns in the coastal areas and the relatively small size of inland urban areas are factors which lessen the potential for pollution of the freshwater systems in Ireland. However, the intensification of farming over the last thirty years has counteracted these favourable circumstances to a significant extent. The impact of the much larger volumes of waste discharged directly to estuaries and coastal waters is mitigated by the generally greater volumes of water available for their dilution in these tidal systems; although there has been considerable localised pollution of such waters in the vicinity of most of the larger towns and cities, with impacts on the sanitary quality of bathing and shellfish areas in particular, it is notable that the passage of salmon to and from freshwater has not been prevented by the condition of estuarine waters.

Improvements in the treatment of domestic and industrial wastes over the last 20 years has led to a greatly decreased level of organic pollution; thus, severe deoxygenation, high concentrations of biochemical oxygen demand and the growth of bacterial and fungal slimes below waste outfalls are now relatively rare. Such impacts were common, if mostly localised, in rivers up to the mid 1980s but the upgrading of treatment to the secondary level in many inland towns from the 1970s onwards and more recently in the coastal areas has led to a major reduction of this most objectionable form of pollution. The now small length of river channel classified as seriously polluted attests to this change. It is arguable, however, that the incidents of this type of pollution due to the entry of farm wastes to waters was more damaging than that caused by point source discharges; while these events are usually of short-term duration, the highly concentrated nature of the wastes often causes complete deoxygenation and other water quality impacts leading to fish kills. Again, there has been a reduction in the occurrences of this type.

The main remaining threat to the quality of surface waters is eutrophication leading to increased plant productivity, either in the water column or on the substratum. While this may seem a more benign effect than that of organic pollution, in its more intense form it may lead to similar impacts due to the decay of large amounts of plant biomass. The main causative agents involved, phosphate and nitrate, are only partly removed from point source wastes in the course of standard secondary treatment; while the removal of phosphate is being incorporated in a growing number of treatment plants in inland areas, the removal of nitrogen has yet to be undertaken on a similarly wide basis. However, the designation of a number of tidal waters as sensitive under the Urban Waste Water Treatment directive requires consideration, at least, of such a measure by the relevant local authorities.

Observations based on research and on monitoring suggest that the contribution of farming activities to nutrient enrichment of waters is greater than that of point sources, at least in the inland areas. The marked increase, direct or indirect, of the productivity of farm land over the last thirty years, which could only have been attained by the application of greater amounts of artificial fertilisers, particularly nitrogen and phosphorus, carries an inevitable potential to fertilise the waters draining such land. In addition, the change in livestock rearing practices, which is the basis of the increased productivity, has led to the generation of large quantities of manure slurries which are subsequently spread on land. In addition to the threat which this represents to surface waters, contamination of groundwaters may also result, especially in karstic areas where the possibility for attenuation of waste by absorption in the soil above the aquifer may be bypassed. Rapid passage of the wastes to the aquifer may result in bacterial contamination as well as increased nitrate levels.

It is clear from the preceding chapters that a considerable part of the State's surface waters continue to show the presence of eutrophication to a lesser or greater degree. In the case of the rivers, the proportion affected remains at almost 30 per cent of the 13,000 km of surveyed channel, despite the slight improvement noted in the previous reporting period. The expectation is that the position is more favourable in the much larger length of unsurveyed channel; however, since most of this is composed of small (first order) streams, with limited dilution, confirmation of its status by representative survey work is needed.

The incidence of eutrophication in the lake waters surveyed is less than it is for rivers, with over 80 per cent of the individual lakes and over 90 per cent of the total area of standing water surveyed in a satisfactory condition. However, this assessment is complicated in the case of the Shannon lakes by the filtering effect of the zebra mussel colonies on the phytoplankton and in the case of some of the large western lakes by the signs of enhanced growth of sessile algae on some shores. Again, there are a large number of unsurveyed lakes, mostly small water bodies located in the western counties; previous observations using a remote sensing technique (McGarrigle, *et al.*, 2002) suggest, however, that the likelihood of eutrophication in these waters is generally low.

Application of the recently developed screening procedure for the determination of the trophic status of tidal waters, described in Chapter Four, indicates that a considerable proportion of the surveyed estuaries and coastal waters are subject to eutrophicaton. Since they are in receipt of the waste discharges from the larger cities and towns and lie at the ends of the freshwater reaches of the rivers, this is not an unexpected position although the implications of the enrichment are not fully clear. If it were to cause serious deoxygenation this would be potentially detrimental to the passage of migratory fish such as the salmon. However, the degree of deoxygenation recorded in the surveys has been relatively moderate and where present may be due as much to the presence of organic waste as to algal development. Excessive growth and subsequent decay of sessile algae in response to eutrophication may be of greater impact, especially in amenity areas, as has occurred on the northern shores of Dublin Bay.

In relation to groundwaters, the finding of most concern is the detection of faecal coliforms on one or more occasions at almost half of the sampling points. This indicates that protection of groundwater is still less than ideal and creates a risk to consumers of groundwaters, especially in cases where no disinfection is employed prior to use. However, it is noted that the compliance of Group Water Schemes, which mostly use groundwaters as a source, with the bacteriological standards of the Drinking Water Regulations, improved over the 2001-2003 period (Page *et al.*, 2004) presumably reflecting better pre-treatment. Taking into account the location of the sampling points there seems little doubt that farming activities are responsible for much of the bacterial and nitrate contamination recorded in the period. However, it is likely that waste from septic tank systems are also contributing to the contamination observed; the risk presented by a proliferation of these facilities in line with the increase of house building outside the serviced urban areas will need to be kept under surveillance by the local authorities if increased groundwater contamination is to be avoided.

Nitrate contamination of waters is currently of concern in view of the case taken against the State in the European Court of Justice by the Commission for failure to implement aspects of the Nitrates directive. The information presented herein suggests that many surface and groundwaters, particularly in the eastern half of the country, have nitrate concentrations significantly above the natural levels. This is particularly marked in groundwaters where the mean concentrations recorded in the 2001-2003 period exceeded the drinking water guideline of 25 mg/l NO_3 at nearly 25 per cent of the sampling points while individual samples with concentrations above the mandatory limit of 50 mg/l NO_3 were taken at 14 of these locations. While the levels in the surface waters are generally lower, it is likely that they are still sufficiently enhanced in many cases to add to the impact of eutrophication initially promoted by phosphorus enrichment in rivers and lakes and to act as the main stimulant of this effect in some tidal waters. The draft Action Plan prepared in accordance with the decision to apply the controls on nitrate loss from farming required by the directive on a national basis, rather than resorting to the designation of particular areas (vulnerable zones) for the application of the controls, should lead to improved management of manure slurries throughout the State. This should reduce not only the loss of nitrate but also of phosphate from farm land, thereby reducing in turn the potential for eutrophication in adjacent waters.

The available data suggest that there is currently little contamination of waters with toxic and bioaccumulative substances. This is evidenced in particular by the monitoring of shellfish tissue in tidal waters by the Marine Institute which continues to show that levels in Irish waters are generally amongst the lowest in Europe. There is a requirement under the Water Framework directive to undertake more systematic monitoring of certain toxic substances, especially those regarded as a priority for elimination from waste discharges or for stricter controls. As mentioned in Chapter Six, a preliminary survey of the levels of these priority substances is being undertaken by the River Basin District implementation projects and this will provide a basis for the definition of a more long-term monitoring strategy. Detection of some of the substances listed cannot be ruled out as they are constituents of commonly used products, e.g. fire retardants; in view of the likely stringent limits to be set for such substances, controls on their levels may be necessary for some discharges. It is notable in this connection (see Chapter Two) that research has indicated the presence of endocrine disrupting substances below a sewage treatment plant outfall on the R. Liffey.

Adoption of the Water Framework directive has probably set the EU States more taxing objectives for water quality and the integrity of the aquatic ecosystem than that required by earlier directives and by existing national standards. While the intercalibration of the biological approaches to defining good quality, referred to above in Chapter Six, have not yet been completed, it is unlikely that this definition will be less stringent than those used for the assessments in this report. Thus, all of the waters identified as unsatisfactory in the preceding chapters will require improvement to meet the WFD objectives. The further implementation of the directive will, *inter alia*, involve the identification of the measures required for each situation. In so far as they concern water quality issues, it is likely that these will include upgrading of treatment for nutrient removal in a number of cases, both in the municipal and industrial sectors. However, it is inevitable that the main thrust of such restorative programmes will have to be directed at non-point sources of waste, especially those attributable to farming. As stated earlier, control of such wastes to prevent water pollution is an inherently more difficult task than it is for point sources.

In this context it is worth noting the recent completion of the large scale research project supported by the EPA-managed Environmental Research Technological Development and Innovation (ERTDI) programme which dealt with phosphorus loss from agriculture as well as nitrogen loss from a farm in a highly vulnerable groundwater zone (Kiely et al., in press). The main benefit of the project will be in applying its scientific results to the control of P losses from the 'hot-spots' that deliver phosphorus to surface waters, especially:

- the chemical conditions that favour the loss of phosphorus from Irish soils are now well understood as a result of the project.
- the importance of the pathway of water through the soils in transporting phosphorus from soils is also now well understood as a result of the project's work.

Putting these two aspects together will enable River Basin Districts to implement highly specific control measures that can a) pinpoint the riparian hot-spots along streams and rivers from which most phosphorus is lost and b) stem the losses from these regions which usually comprise less than 10 per cent of the total catchment area. Successful control measures may include grant-aiding tree planting in these clearly identified 'hot-spots' in order to prevent future slurry or fertiliser spreading and to reduce soil P concentrations in these loss-prone regions.

Thus, the research findings provide an improved basis for formulating management measures in relation to controlling the polluting potential of farm wastes. Other research funded through the ERTDI programme has, as explained in Chapter Six, provided information on several aspects of the aquatic environment required for the WFD implementation process. The preparation of the Characterisation report for each River Basin District has also involved the documentation for the first time of many other aspects of surface and groundwaters including a detailed examination of the pressures exerted on them by agriculture, industrial and domestic activities and the risk which these constitute to the attainment of the directive's objectives. Overall, therefore, the understanding of the aquatic environment has been greatly improved over the last five years and this provides a firm basis for its management and conservation in the future.

To conclude, the data and other information available for the 2001-2003 period indicate that:

- Eutrophication affects a considerable proportion of the surface waters of the State and is the main threat to these systems. At least in the freshwaters this is attributed primarily to excess phosphorus input.

- Intermittent contamination of groundwaters with faecal coliforms appears to be relatively widespread and constitutes a risk for those using such waters for drinking without sterilisation.

- Nitrate contamination, to a lesser or greater extent, affects both surface and groundwaters. In the former it is generally present at levels less than the guide limit set for drinking water but is likely to be contributing to the impact of eutrophication; in the latter it is often present at levels higher than those in surface waters and in a significant number of the locations sampled exceeds the limits for drinking water.

- The waters identified as unsatisfactory herein are not likely to be of good status in terms of the Water Framework directive and will, therefore, require improvement within the time limits set by that directive.

- The main restorative measure required for surface water is nutrient loss control. In relation to point sources, this will necessitate further upgrading of sewage and industrial waste treatment plants to facilitate the removal of phosphorus and/or nitrogen; for certain sewage treatment plants such upgrading is also a requirement under the Urban Waste Water Treatment directive.

- Control of nutrient loss from farming activities is a more widespread need. The National Action Plan for the implementation of the Nitrates directive should provide a basis for the reduction of nitrate and phosphate losses from farm land, which is the main contributor of these nutrients to waters. It should also benefit groundwaters in reducing the potential for bacterial and nitrate contamination.

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APPENDIX I

Biological and Physico-Chemical Surveillance and Water Quality Assessment of Rivers

INTRODUCTION

The various uses of rivers inevitably involve conflicting interests and often such uses disrupt river ecology. The fact that several of the more important beneficial uses of rivers (e.g. abstraction, amenity, waste disposal) are dependent on biological processes is rarely appreciated: if the self-purification process, for example, is disrupted (e.g. by pollution, drainage or over-abstraction) some or all beneficial uses may be impaired or lost. It is important, therefore, to keep ecological disruption to a minimum and to maintain the aquatic ecosystem in a healthy, functional condition. Progress towards this goal can be monitored by chemical or biological means or, preferably, by a combination of both. In general it could be said that whilst physico-chemical analysis may measure the *causes* of pollution (i.e. the pollutants) biological analysis is the only means whereby the ecological *effects* of pollution can be measured.

The most commonly encountered forms of pollution in this country are eutrophication and organic pollution; less frequently encountered are non-organic types such as toxic pollution (e.g. by sheep dip or industrial chemicals), siltation (e.g. arising from over-grazing, drainage, quarrying or stone-cutting operations) and, in recent years, acidification in sensitive afforested areas. The term eutrophication is used to describe the abnormal production of plants of all kinds (micro- and macroscopic) in surface waters affected by excessive inputs of the plant nutrients nitrogen and phosphorus. Such inputs arise a) by the leaching or overland runoff from agricultural lands of inorganic nitrogen and phosphorus and b) by the breakdown of organic matter such as sewage, food-processing or other industrial wastes or land-spread animal manure slurries. Eutrophication of surface waters may be also encountered in areas where land is disturbed for peat harvesting or forestry purposes. Organic pollution is a term used to describe the oxygen depleting effects caused by the breakdown of organic wastes (e.g. sewage) in receiving waters. This bio-degradation or self-purification process, as it is called, is dependent, initially at least, on aerobic micro-organisms which reduce the organic material to its constituent elements and in the process consume oxygen. In the presence of organic matter, therefore, ambient dissolved oxygen (DO) levels fall whilst the biochemical oxygen demand (BOD) - a measurement of the rate of oxygen usage by aerobic micro-organisms - rises; this process also leads to eutrophication due to the release of compounds of nitrogen and phosphorus.

The measurement of the ambient concentrations of such parameters, therefore, gives a good indication of the condition of the water as regards contamination by organic waste. Traditionally, this type of waste has mostly originated at 'point-source' discharges (sewage, industrial wastes), but in recent years an ever increasing proportion arises from 'diffuse' agricultural sources i.e., run-off from land of wastes from intensive animal-rearing operations, the development of which in the past 15 to 20 years has been accompanied by a very marked increase in the extent of eutrophication.

All types of pollution cause physico-chemical and biological changes in receiving waters and so the assessment of water quality/pollution may be approached from the chemical or the biological aspect. In practice, a combination of both approaches is preferable to either on its own.

Biological Assessment

In the presence of pollution, characteristic and well-documented changes are induced in the flora and fauna of rivers and streams. Particularly well documented are the changes brought about by organic pollution in the macroinvertebrate community i.e., the immature aquatic stages of aerial insects (mayflies, stoneflies etc.) together with Crustacea (e.g. shrimps), Mollusca (e.g. snails and bivalves), Oligochaeta (worms) and Hirudinea (leeches). The changes which occur are due to the varying sensitivities of the different components of the community to the stresses caused by pollution. It is known that similar organisms inhabit similar habitats and that the most sensitive species inhabit the riffle areas. It is also well known that community diversity declines in the presence of pollution and that sensitive species are progressively replaced by more tolerant forms as pollution increases. Ideally, all the components of the aquatic biota (the micro- and macro-fauna and flora) should be utilised but in practice macroinvertebrate community analysis is found to be satisfactory for routine water quality monitoring purposes.

For the purposes of the EPA assessment procedure benthic macroinvertebrates have been divided into five arbitrary 'Indicator Groups' as follows: Group A, the sensitive forms, Group B, the less sensitive forms, Group C, the tolerant forms, Group D, the very tolerant forms and Group E, the most tolerant forms. These groups, and their relationships with the Biotic Index (Q values) are set out below (page I.5).

In contrast to physico-chemical surveys which extend throughout the year, biological surveys are usually undertaken in the summer-autumn period (June-October) when flows are likely to be relatively low and water temperatures highest. Surveys during this period are likely, therefore, to coincide with the worst conditions to be expected in those reaches affected by waste inputs.

Biological material for examination is obtained by sampling in the shallower, faster-flowing areas (riffles) and the assessment of water quality is made on site. Having determined the relative proportions of the various organisms in the sample, water quality is inferred by a comparison of this data with that which might be expected from unpolluted habitats of the type under investigation. Other relevant factors such as the intensity of algal and/or weed development, water turbidity, bottom siltation, substratum type, current speed and water depth, DO saturation and water temperature, are also taken into account in the assessment procedure.

Relationships between water quality and macroinvertebrate community structure are usually described by means of a numerical scale of values. Such a compression of biological information inevitably results in a loss of meaningful information but some such procedure is essential if this information is to be meaningful to non-biologists. The EPA scheme of Biotic Indices or Quality (Q) Values and its relationship to water quality is set out here.

'Q' Value	**Community Diversity**	**Water Quality**	**Condition***
Q5	High	Good	Satisfactory
Q4	Reduced	Fair	Satisfactory
Q3	Low	Doubtful	Unsatisfactory
Q2	Very Low	Poor	Unsatisfactory
Q1	Little/None	Bad	Unsatisfactory

* 'Condition' refers to the likelihood of interference with beneficial or potential beneficial uses.

The intermediate values (Q1-2, 2-3, 3-4 etc.) denote transitional conditions. The scheme mainly reflects the effects of organic pollution (i.e. deoxygenation and eutrophication) but where a toxic effect is apparent or suspected the suffix '0' is added to the biotic index (e.g. Q1/0, 2/0 or 3/0). An asterisk after the Q value indicates something worthy of special attention, typically heavy siltation of the substratum. The scheme may be further simplified as shown by the classification set out below:-

Biotic Index	Quality Status	Quality Class
Q5, Q4-5, Q4	Unpolluted	Class A
Q3-4	Slightly Polluted	Class B
Q3, Q2-3	Moderately Polluted	Class C
Q2, Q1-2, Q1	Seriously Polluted	Class D

Class A waters are those in which problems relating to existing or potential beneficial uses are unlikely to arise and they are, therefore, regarded as being in a 'satisfactory' condition. Classes B, C and D are to a lesser or greater extent 'unsatisfactory' in this regard. For example, the main characteristic of Classes B and C waters is eutrophication which may interfere with the amenity, abstraction or fisheries potential. In Class D waters excessive organic loading lead to deoxygenation and may produce 'sewage fungus' growths, and as a consequence most beneficial uses are severely curtailed or eliminated.

Eutrophication is typically to be found in the recovery zones below seriously or moderately organically polluted reaches or, as stated above it may arise as a consequence of the run-off of nutrients from agricultural or forestry land. Waters assessed as Q3-4 (slightly polluted - Class B) are essentially transitional between the satisfactory Class A and the unsatisfactory Class C but it was considered prudent to classify such waters as unsatisfactory primarily because of the potential adverse effects on game fish (salmon and trout) and game fisheries. Wild game-fish will be severely stressed or killed by nocturnal DO depletion which may occur in such waters, particularly in times of low flow and elevated temperature. Where such stress is a regular feature game fish will disappear and they may be replaced by more tolerant varieties of coarse fish. Even if game fish survive, the angling potential of such waters may be severely impaired by the filamentous algal and/or weed growths which are a common feature of slightly polluted waters.

Table I.1 (below) sets out some of the principal characteristics of the four water quality classes and the relationship between these and the biotic indices (Q1 to Q5).

Physico-Chemical Assessment of Water Quality

For the assessment of organic pollution the more commonly measured parameters include DO, BOD, Ammonia, Oxidised Nitrogen (Nitrites plus Nitrates) and Phosphates. Continuous records of concentration and flow would form the ideal basis for water quality assessment but in practice this is impossible for financial, technical and logistical reasons. Reliance must, therefore, be placed on discrete samples; because such samples constitute only a minute fraction of the whole body of water under investigation and because they are only representative of conditions at the particular time of sampling the interpretation of data arising from such samples requires great care.

Unlike the biological assessment of water quality, where the incidence and intensity of pollution is based on the degree to which the chosen organism association deviates from its expected natural diversity, the physico-chemical assessment is usually based on a comparison of the measurements made with water quality criteria or with standards derived from such criteria. The setting of national standards for water, sewage and other effluents by the Minister for the Environment is provided for under the Local Government (Water Pollution) Act, 1977 and the Environmental Protection Agency Act, 1992. Regulations setting standards for phosphorus (S.I. No. 258 of 1998) have been issued under the Water Pollution Act by the Minister in order to combat eutrophication of surface waters and to give effect to the requirements of Council Directive 76/464/EEC on pollution caused by certain dangerous substances. The recently issued phosphorus regulations are unique in that they not only set standards for the element in question but they also take into account the biological quality of rivers and the trophic status of lakes as assessed by EPA. This is a recognition of the

Biological Assessment of Water Quality in Eroding Reaches (Riffles & Glides) of Rivers and Streams*

Biotic Indices (Q Values) and typical associated macroinvertebrate community structure. See overleaf for details of the Faunal Groups.

Macroinvertebrate Faunal Groups**	Q5	Q4	Q3-4	Q3	Q2	Q1
Group A	At least 3 taxa well represented	At least 1 taxon in reasonable numbers	At least 1 taxon Few - Common	Absent	Absent	Absent
Group B	Few to Numerous	Few to Numerous	Few/Absent to Numerous	Few/Absent	Absent	Absent
Group C	Few	Common to Numerous *Baetis rhodani* often Abundant Others: never Excessive	Common to Excessive (usually Dominant or Excessive)	Dominant to Excessive	Few or Absent	Absent
Group D	Few or Absent	Few or Absent	Few/Absent to Common	Few/Absent to Common	Dominant to Excessive	Few or Absent
Group E	Few or Absent	Few or Absent	Few or Absent	Few or Absent	Few / Absent to Common	Dominant
Additional Qualifying Criteria						
***Cladophora* spp.** Abundance	Trace only or None	Moderate growths (if present)	May be Abundant to Excessive growths	May be Excessive growths	Few or Absent	None
Macrophytes (Typical abundance)	Normal growths or absent	Enhanced growths	May be Luxuriant growths	May be Excessive growths	Absent to Abundant	Present/Absent
Slime Growths (Sewage Fungus)	Never	Never	Trace or None	May be Abundant	May be Abundant	None
Dissolved Oxygen Saturation	Close to 100% at all times	80% - 120%	Fluctuates from < 80% to >120%	Very unstable. Potential fish-kills	Low (but > 20%)	Very low, sometimes zero
Substratum Siltation	None	May be light	May be light	May be considerable	Usually heavy	Usually very heavy and anaerobic

Note occurrence/abundance of groups in above table refers to some but not necessarily all of the constituents of the group. The Additional Qualifying Criteria apply in virtually all circumstances. Single specimens may be ignored. Seasonal and other relevant factors (i.e., drought, floods) must be taken into account.

* Macroinvertebrate criteria do not apply to rivers with mud, bedrock or sand substrata, very sluggish or torrential flow, head-water or high altitude streams and those affected by significant ground water input, excessive calcification, drainage, canalisation, culverting, marked shading etc.

** See Further Observations overleaf.

Macroinvertebrates grouped according to their sensitivity to organic pollution

TAXA	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**
	Sensitive	*Less Sensitive*	*Tolerant*	*Very Tolerant*	*Most Tolerant*
Plecoptera	All except *Leuctra* spp.	*Leuctra* spp.			
Ephemeroptera	Heptageniidae Siphlonuriidae *Ephemera danica*	Baetidae (excl. *Baetis rhodani*) Leptophlebidae	*Baetis rhodani* Caenidae Ephemerellidae		
Trichoptera		Cased spp.	Uncased spp.		
Odonata		All taxa			
Megaloptera				Sialidae	
Hemiptera		*Aphelocheirus aestivalis*	All except *A. aestivalis*		
Coleoptera			Coleoptera		
Diptera			Chironomidae (excl. *Chironomus* spp.) Simuliidae, Tipulidae		*Chironomus* spp. *Eristalis* sp.
Hydracarina			Hydracarina		
Crustacea			*Gammarus* spp. *Austropotamobius pallipes*	*Asellus* spp. *Crangonyx* spp.	
Gastropoda			Gastropoda (excl. *Lymnaea peregra* & *Physa* sp.)	*Lymnaea peregra* *Physa* sp.	
Lamellibranchiata	*Margaritifera margaritifera*		*Anodonta* spp.	Sphaeriidae	
Hirudinea			*Piscicola* sp.	All except *Piscicola* sp.	
Oligochaeta					Tubificidae
Platyhelminthes			All		

Observations on Q Determination Scheme

Q5 assigned if :-

a) Group A at least *common**: Typically with ***either*** one or more Heptageniidae spp or *Ephemera* sp. plus three or more Plecoptera spp ***or else*** four or more Plecoptera species present
b) Group B ranging from scarce/absent to numerous
c) Group C not more than *common** but *B. rhodani* may be dominant*
d) Groups D and E *scarce** or absent.
e) Macrophytes, if present, diverse and not excessive in development.
f) Filamentous algae if present not excessive
g) *Cladophora*, sewage 'fungus' and other slime growths/complexes absent.
h) substrata clean and unsilted.
i) DO close to 100% at all times.

* As defined below.

Q4 assigned if :-

a) At least ***one*** Group A taxon present in, at least, *fair numbers**
b) Group B taxa may be *common**, *scarce** or absent
c) *B. rhodani* usually *dominant** Other Group C taxa never *excessive**
d) Groups D and E may be present in *small numbers** or absent
e) Macrophyte & algal growths not excessive
f) *Cladophora,* if present, not excessive
g) Sewage 'fungus' and other slime growths absent
h) Substrata may be lightly silted
i) DO ranging from 80 to 120%

Q3-4 assigned if :-

a) At least ***one*** Group A taxon present in, at least *small numbers**.
b) Group B *common**, *scarce** or absent
c) Group C *numerous**, *dominant* or excessive**.
d) Group D *common**, *scarce** or absent
e) Group E *scarce** or absent.
f) Macrophytes and algal growths usually luxuriant, often excessive.
g) *Cladophora*, usually excessive.
h) Sewage 'fungus' and other slime growths sometimes present in small amounts.
i) Substrata may be considerably silted.
j) DO ranging from < 80 to >120%.

Q3 assigned if :-

a) Group A absent.
b) Group B *fair numbers**, *scarce** or absent
c) Group C usually *excessive** (*Gammarus, Hydropsyche* etc. may be fungus infested).
a) Groups D (excl. *Asellus) common**, *scarce** or absent
e) Group E *scarce** or absent
f) Macrophytes, if present often silted and/or infested with epiphytic algae.
g) *Cladophora* usually excessive.
h) Sewage 'fungus' and other slime growths/complexes may be considerable.
i) Substrata may be heavily silted.
j) DO ranging from <80 to >120%.

Q2 assigned if :-

a) Groups A and B absent.
b) Group C *scarce** or absent.
c) *Asellus sp.* c*ommon** *to excessive*.* Other Group D taxa may be c*ommon**, *numerous** or *excessive*.*
d) Group E may be *common*.*

e) Macrophytes, if present silted and/or infested with epiphytic algae/sewage fungus.
f) *Cladophora* not usually apparent.
g) Sewage fungus and other slime growths/complexes usually considerable.
h) Substrata usually heavily silted. Often smells of sewage/detergent.
i) DO usually quite low (20 - 50%)

Q1 assigned if :-
a) Groups A, B and C absent.
b) Groups D *scarce** or absent
c) Group E *dominant**.
d) Macrophytes absent.
e) *Cladophora* absent.
f) Sewage 'fungus' and other slime growths/complexes present or absent.
g) Substrata usually heavily silted with anaerobic deposits. Often smells of H_2S.
h) DO usually very low, sometimes zero.

1) The above scheme outlines the typical macroinvertebrate composition of rivers and streams unaffected (Q5) or variously affected (Q4 to Q1) by organic waste inputs.

2) Where possible all available habitats should be sampled by kick sampling, stone washing and weed sweeping.

3) Single specimens may be ignored as they are likely to have drifted from upstream.

4) Q5 only ascribed in absolutely pristine conditions with diverse and balanced faunal community.

5) Providing points f and g (at Q5 and Q4 above) not breached Q5 and Q4 may be also ascribed where faunal criteria are not met due to:-
a) significant ground-water input
b) very hard, calcareous conditions
c) very oligotrophic conditions
d) other relevant factors

6) The terms "Taxon/Taxa" are defined by the level of identification for each Class/Order as follows :-

Platyhelminthes	genus	Trichoptera	genus
Oligochaeta	family	Odonata	genus
Hirudinea	genus	Megaloptera	genus
Mollusca	genus	Hemiptera	genus
Crustacea	family	Coleoptera	family
Plecoptera	genus	Diptera	family
Ephemeroptera	genus	Hydracarina	presence

(Chironomidae :- *thummi-plumosus* or non-*thummi-plumosus*)

Abundance Category	**Approximate Percentage Frequency of Occurrence***
Present	1 or 2 individuals
Scarce/Few	<1%
Small numbers	<5%
Fair numbers	5 -10%
Common	10 - 20%
Numerous	25 - 50%
Dominant	50 - 75%
Excessive	>75%

- Per 2 minute kick sample + stone washing.

Table I.1 General characteristics of the various Biological Quality Classes

Quality Classes	**Class A**		**Class B**	**Class C**	**Class D**	
Quality Ratings (Q)	Q5	Q4	Q3-4	Q3	Q2	Q1
Pollution Status	Pristine, Unpolluted	Unpolluted	Slight Pollution	Moderate Pollution	Heavy Pollution	Gross Pollution
Organic Waste Load	None	None	Light	Considerable	Heavy	Excessive
Maximum B.O.D.	Low (< 3 mg/l)	Low (< 3 mg/l)	Occasionally elevated	High at times	Usually high	Usually very high
Dissolved Oxygen	Close to 100%	80%-120%	Fluctuates from <80% to >120%	Very unstable Potential fish-kills	Low, sometimes zero	Very low, often zero
Annual Median ortho-Phosphate	~0.015 mg P/l	~0.030 mg P/l	~0.045 mg P/l	~0.070 mg P/l	usually > 0.1 mg P/l	usually > 0.1 mg P/l
Siltation	None	May be light	May be light	May be considerable	Usually heavy	Usually very heavy and anaerobic
'Sewage Fungus'	Never	Never	Never	May be some	Usually abundant	May be abundant
Filamentous Algae	Limited development	Considerable growths Diverse communities	*Cladophora* may be abundant	*Cladophora* may be excessive	May be abundant	Usually none
Macrophytes	Diverse communities Limited growths	Diverse communities Considerable growths	Reduced diversity Luxuriant growths	Limited diversity Excessive growths	Tolerant species only. May be abundant.	Usually none or tolerant species only.
Macroinvertebrates (from shallow riffles)	Diverse communities. Normal density. Sensitive forms usually numerous.	High diversity. Increased density. Sensitive forms scarce or common.	Very high diversity. Very high density. Sensitive forms scarce.	Sensitive forms absent. Tolerant forms common. Low diversity.	Tolerant forms only. Very low diversity.	Most tolerant forms. Minimal diversity.
Water Quality	Highest quality	Fair quality	Variable quality	Doubtful quality	Poor quality	Bad quality
Abstraction Potential	Suitable for all	Suitable for all	Potential problems	Advanced treatment	Low grade abstractions	Extremely limited
Fishery Potential	Game fisheries	Good game fisheries	Game fish at risk	Coarse fisheries	Fish usually absent	Fish absent
Amenity value	Very high	High	Considerable	Reduced	Low	Zero
Condition	Satisfactory	Satisfactory	Transitional	Unsatisfactory	Unsatisfactory	Unsatisfactory

eutrophication effects of excess phosphorus and of the biological assessment schemes used by EPA. The Regulations apply to rivers and lakes assessed by EPA in the period 1995 to 1997 and require that ***either*** the chemical ***or*** the biological criteria specified must be met by the 31st of December 2007 unless there are good reasons - which are specified - why these criteria cannot be met. For waters surveyed subsequent to 1997 the standards must be met within ten years of the first survey.

Standards for Phosphorus in Rivers

(µg P/l = micro-grammes per litre).
The annual ***median*** concentration of molybdate reactive phosphate shall not exceed
a) 15 µg P/l in Q5 waters
b) 20 µg P/l in Q4-5 waters
c) 30 µg P/l in Q4 waters
d) 50 µg P/l in Q3-4 waters
e) 70 µg P/l in Q3 waters

or

f) that existing satisfactory biological quality conditions (i.e., Q5, Q4-5 and Q4) be maintained and
g) that less than satisfactory biological conditions (Q3-4 or less) be improved. In general the improvement required is of half a quality rating (e.g., Q3-4 to Q4) but seriously polluted waters (Q2 or less) must be restored to Q3 as a minimum requirement

Standards for Phosphorus in Lakes

The annual **mean** concentration of total phosphorus shall fall within the ranges
a) ≤5 µg P/l in Ultra-Oligotrophic lakes
b) >5 to ≤10 µg P/l in Oligotrophic lakes
c) >10 to ≤20 µg P/l in Mesotrophic lakes
d) >20 to ≤50 µg P/l in Eutrophic lakes.

or

e) that existing satisfactory biological quality conditions (defined as Ultra-Oligotrophic, Oligotrophic and Mesotrophic status) be maintained and
f) that unsatisfactory biological conditions (Eutrophic, Hypertrophic) be improved as follows - Eutrophic waters to achieve Mesotrophic status and Hypertrophic waters to achieve Eutrophic status.

In addition to the phosphorus regulations, legally binding standards for water quality in Ireland arise from various EC Directives. Of particular relevance in the present context are the 'Surface Water' and 'Freshwater Fish' Directives (C.E.C., 1975, 1978). The former deals with the quality requirements of waters used as sources of public supply while the latter sets standards for waters harbouring game or coarse fisheries, although these are legally binding only in the case of 'designated' waters. Both of these Directives are now the subject of National Regulations, (Minister for the Environment, 1988, 1989). A digest of these standards and guidelines for the more important of the physico-chemical parameters of pollution by organic wastes as appropriate to fishery salmonid) waters is set out below:

Freshwater Fish Regulations	**Water Quality Guidelines**
Dissolved Oxygen (DO) :	
50% of samples $\geq$ 9 mg/l O2	50% of samples $\geq$ 9 mg/l O2 95% of samples $\geq$ 6 mg/lO2 No sample < 4 mg/l O2
Biochemical Oxygen Demand (BOD):	
$\leq$ 5 mg/l	$\leq$ 4 mg/l
Ammonia:	
$\leq$ 0.02 mg/l NH3 or $\leq$ 0.016 mg/l N* $\leq$ 0.8 mg/l N**	$\leq$ 0.02 mg/l NH3 $\leq$ 0.016 mg/l N*

* = un-ionised ** = total

These limits are more stringent than those applicable to the same parameters in abstraction waters receiving standard-treatment, as set out in the 'Surface Water' Regulations. The same position holds in the case of most other water quality parameters so that the suitability of waters for fisheries is usually a good assurance of their suitability for abstraction and for many other uses. The major exceptions are nitrate and microbiological quality in which cases even high levels of contamination will not *directly* affect fish life.

Advantages and Shortcomings of the two Quality Assessment Methods

Physico-chemical techniques have the merit of being precise, discriminatory and quantitative and they are, therefore, essential if unpolluted waters are to be chemically typed or if pollutants in water are to be identified and their concentrations quantified. Information of this type is essential to good water management as it provides the basic information required by licensing authorities for the assessment of compliance by licensed discharges with prescribed standards. With regard to general water quality monitoring, however, and particularly where a large number of clean rivers are to be monitored - as in this country - a distinct disadvantage of a purely chemical approach is the cost; whereas just two biological samples per annum (winter and summer) would normally provide a reasonably accurate assessment of average water quality, a considerably greater number of physico-chemical samples would normally be required to achieve such an assessment with the same degree of confidence.

A knowledge of the types of pollutants likely to be present is a prerequisite for effective chemical monitoring. With the increasing complexity of many industrial effluents this may prove to be difficult if not impossible in certain circumstances. Furthermore, if a discharge is irregular or surreptitious there is a good chance that it will not be detected at all by routine chemical monitoring programmes. Since benthic macroinvertebrate communities respond to a wide range of water quality characteristics and pollutants and because they can reflect the effects of mixed pollutants these shortcomings can often be overcome by biological analysis.

A disadvantage of the biological approach is that, although capable of detecting ecological change, indicative of water quality change, it does not identify the specific cause of a change; for this physico-chemical analysis is essential, especially in the case of toxic pollution. It should also be pointed out that whilst water indicated to be of poor quality on biological grounds is suspect for most uses, water indicated to be of good quality on such grounds, although acceptable for most uses including fisheries, may not always be free from pathogens or harmful trace organics and may not therefore be acceptable as drinking water. Assessment of this aspect requires specific microbiological and physico-chemical tests. Finally, in assessing water quality from data involving benthic communities due recognition must be given to the influences of other ecological factors such as depth and flow rate, substratum type, the influence of shading and seasonal changes in life cycle.

From the foregoing it may be appreciated that both physico-chemical and biological water quality assessment techniques have their own particular applications, advantages and disadvantages so that only by a combination of both may the limitations of each be overcome and a thorough understanding of the total situation be gained. The advantages and shortcomings of the two approaches are summarised below.

Comparison of Biological and Chemical Water Quality Assessment Techniques

REALM	**PERFORMANCE**	
	Chemical	**Biological**
Precision (Pollutant concentration assessment)	Good	Poor
Discrimination (Pollutant identification)	Good	Poor
Measure of Effects	No	Yes
Cost	High	Low
Single Sample Value	Poor	Good

CONCLUSION: ***Combination of both techniques preferable to either alone***

REFERENCES

C.E.C. (COUNCIL OF THE EUROPEAN COMMUNITIES), 1975. Council Directive of the 16 June 1975 concerning the quality required of surface water intended for the abstraction of drinking water in the Member States (75/440/EEC). *Official Journal of the European Communities,* No. L 194/26.

C.E.C. (COUNCIL OF THE EUROPEAN COMMUNITIES), 1978. Council directive of 18 July 1978 on the quality of freshwaters needing protection or improvement in order to support fish life (78/659/EEC). *Official Journal of the European Communities,* No. L 222/1.

MINISTER FOR THE ENVIRONMENT, 1988. *European Communities (Quality of Salmonid Waters) Regulations, 1988.* S.I. No. 293 of 1988. Dublin, Stationery Office.

MINISTER FOR THE ENVIRONMENT, 1989. *European Communities (Quality of Surface Water intended for the Abstraction of Drinking Water) Regulations, 1989.* S.I. No. 294 of 1989. Dublin, Stationery Office.

APPENDIX II

River locations at which parameter values exceeded limits set in the Salmonid Waters Regulations in the period 2001-2003. Table shows the total number of samples taken and the number exceeding the prescribed limit(s).

pH:

Criteria: 95% of values to be not less than 6 and not greater than 9.

Code	River	Station	Location	No. of Samples	No. < 6	% <6
12S02	SLANEY	100	Seskin Br	**12**	**1**	*8*
12S02	SLANEY	200	Kelsha Br	**12**	**1**	*8*

Dissolved Oxygen (DO):

Criteria: All values to be greater than 6 mg/l O_2 and 50% of values to be greater than 9 mg/l O_2

Code	River	Station	Location	No. of Samples	No <6	No <9	% < 9
07B04	BOYNE	100	River Br (Clonkeen Br)	**130**	**1**	**55**	*42*
07B04	BOYNE	300	Kinnafad Br	**128**	**26**	**67**	*52*
12S02	SLANEY	500	Leinster Br	**12**	**1**		
15N01	NORE	200	Nore Br, SE of Roscrea	**31**	**2**	**12**	*39*
15N01	NORE	300	Quaker's Br	**31**	**1**	**17**	*55*
22M01	MAINE	50	Br SW of Tobermaing Ho.	**30**	**17**	**30**	*100*

BOD:

Criteria: 95% of values to be not greater than 5 mg/l O_2

Code	River	Station	Location	No. of Samples	No > 5	% > 5
01F01	FINN (DONEGAL)	700	Footbridge, Ballybofey	**9**	**1**	*11*
15N01	NORE	2180	u/s King's R confl	**8**	**1**	*13*
15N01	NORE	2500	Inistioge Br	**36**	**2**	*6*
16A01	AHERLOW	100	Br SW of Ardrahin	**32**	**2**	*6*
16A01	AHERLOW	200	Galbally Br (R25)	**32**	**2**	*6*
16A01	AHERLOW	300	Stagdale Br	**30**	**2**	*7*
16A01	AHERLOW	600	College Br	**31**	**2**	*6*
23F01	FEALE	800	Br at Finuge	**31**	**2**	*6*
23F01	FEALE	860	Railway Br u/s Ferry Br	**28**	**2**	*7*
34C01	CASTLEBAR	200	Br 2.5 km d/s Castlebar	**19**	**2**	*11*
34O03	OWENGARVE (SLIGO)	100	Bridge in Curry	**30**	**2**	*7*
39L02	LURGY	280	d/s Kilmacrennan STW	**20**	**2**	*10*
39M01	MAGGY'S BURN	200	d/s Milford (d/s STW)	**18**	**3**	*17*
39S02	SWILLY	300	Old Town, Letterkenny	**13**	**1**	*8*
39S02	SWILLY	350	u/s Sprack Burn	**12**	**2**	*17*
39S02	SWILLY	370	d/s Sprack Burn	**13**	**4**	*31*

Contd.

APPENDIX II Contd.

TOTAL AMMONIUM:

Criteria: 95% of samples to be less than 1 mg/l NH_4

Code	River	Station	Location	No. of Samples	No > 1	*% > 1*
07B04	BOYNE	300	Kinnafad Br	**129**	**36**	*28*
39L02	LURGY	280	d/s Kilmacrennan STW	**20**	**6**	*30*
39M01	MAGGY'S BURN	200	d/s Milford (d/s STW)	**18**	**4**	*22*

UN-IONISED AMMONIA:

Criteria: 95% of samples to be less than 0.02 mg/l NH_3

Code	River	Station	Location	No. of Samples	No > 0.02	% > 0.02
07B04	BOYNE	300	Kinnafad Br	**129**	**31**	*24*

NITRITES:

Criteria: 95% of samples to be less than 0.05 mg/l NO_2

Code	River	Station	Location	No. of Samples	No > 0.05	% > 0.05
01F01	FINN (DONEGAL)	700	Footbridge, Ballybofey	**9**	**8**	*89*
01F01	FINN (DONEGAL)	800	Bridge S. of Stranorlar	**9**	**9**	*100*
01F01	FINN (DONEGAL)	890	0.5 km u/s Br S of Killygordon	**8**	**4**	*50*
01F01	FINN (DONEGAL)	910	d/s Br S of Killygordon	**8**	**6**	*75*
01F01	FINN (DONEGAL)	1080	u/s Castlefinn STW	**11**	**9**	*82*
01F01	FINN (DONEGAL)	1100	Castlefin Bridge	**11**	**6**	*55*
01F01	FINN (DONEGAL)	1400	u/s Lifford STW	**12**	**12**	*100*
01F01	FINN (DONEGAL)	1500	d/s Lifford STW	**12**	**11**	*92*
07B04	BOYNE	100	River Br (Clonkeen Br)	**130**	**76**	*58*
07B04	BOYNE	300	Kinnafad Br	**129**	**128**	*99*
07B04	BOYNE	600	Ashfield Br	**133**	**120**	*90*
07B04	BOYNE	800	Inchamore Br	**129**	**104**	*81*
07B04	BOYNE	900	Scarriff Br	**130**	**97**	*75*
07B04	BOYNE	1400	u/s Knightsbrook R (RHS)	**126**	**87**	*69*
07B04	BOYNE	1450	600m d/s Boycetown R	**118**	**79**	*67*
07B04	BOYNE	1600	Ballinter Br	**130**	**71**	*55*
07B04	BOYNE	1800	Railway Br Navan	**28**	**11**	*39*
07B04	BOYNE	1900	2km d/s Navan (LHS)	**133**	**100**	*75*
07B04	BOYNE	2100	Slane Br	**139**	**84**	*60*
07B04	BOYNE	2200	Oldbridge (Obelisk Br)	**148**	**73**	*49*
10D01	DARGLE	250	1km u/s Bray Br	**15**	**1**	*7*
10V01	VARTRY	300	Newrath Br	**13**	**1**	*8*
12S02	SLANEY	950	0.2 km u/s Rathvilly Br	**32**	**6**	*19*
12S02	SLANEY	1100	Rathmore Br	**31**	**11**	*35*
12S02	SLANEY	1200	Moatabower Br	**31**	**11**	*35*
12S02	SLANEY	1300	Tullow Br	**31**	**5**	*16*
12S02	SLANEY	1400	Ford 3km d/s Tullow Br	**28**	**8**	*29*
12S02	SLANEY	1500	Aghade Br	**31**	**9**	*29*
12S02	SLANEY	1600	Kilcarry Br	**31**	**5**	*16*
12S02	SLANEY	1700	New Br nr Kildavin	**31**	**3**	*10*

Contd.

APPENDIX II Contd.

12S02	SLANEY	1800	Slaney Br Bunclody	**31**	**4**	*13*
12S02	SLANEY	1900	Clohamon Br	**32**	**4**	*13*
12S02	SLANEY	2000	1.3km d/s Clohamon Br	**29**	**5**	*17*
12S02	SLANEY	2100	Ballycarney Br	**31**	**7**	*23*
12S02	SLANEY	2200	Scarawalsh Br	**31**	**6**	*19*
12S02	SLANEY	2250	N of Greenmount Ho	**10**	**3**	*30*
12S02	SLANEY	2300	Enniscorthy Br	**32**	**8**	*25*
15N01	NORE	100	Curragunneen Br	**31**	**8**	*26*
15N01	NORE	200	Nore Br, SE of Roscrea	**31**	**15**	*48*
15N01	NORE	300	Quaker's Br	**31**	**22**	*71*
15N01	NORE	400	New Br	**31**	**19**	*61*
15N01	NORE	500	Br S of Coolrain, Kildrigh	**30**	**18**	*60*

NITRITES:

Criteria: 95% of samples to be less than 0.05 mg/l NO_2

Code	River	Station	Location	No. of Samples	No > 0.05	% > 0.05
15N01	NORE	600	Castletown, New Road Br	**31**	**3**	*10*
15N01	NORE	700	Kilbrickin Br	**31**	**4**	*13*
15N01	NORE	800	New Br Cloncough	**31**	**2**	*6*
15N01	NORE	900	Poorman's Br	**30**	**6**	*20*
15N01	NORE	1000	Waterloo Br	**31**	**13**	*42*
15N01	NORE	1100	Watercastle Br	**30**	**7**	*23*
15N01	NORE	1200	New Br, u/s Durrow	**31**	**7**	*23*
15N01	NORE	1300	Tallyho Br	**31**	**12**	*39*
15N01	NORE	1400	0.5 km u/s Ballyragget	**31**	**14**	*45*
15N01	NORE	1500	1.5 km d/s Ballyragget	**27**	**11**	*41*
15N01	NORE	1600	Lismaine Br	**30**	**12**	*40*
15N01	NORE	1700	Threecastles Br	**32**	**10**	*31*
15N01	NORE	1750	ENE of Troyswood House	**38**	**12**	*32*
15N01	NORE	1900	St John's Br, Kilkenny	**30**	**8**	*27*
15N01	NORE	1950	Fennessy's Mill (Ossory Br)	**31**	**9**	*29*
15N01	NORE	2000	NE of Warrington	**29**	**11**	*38*
15N01	NORE	2100	Bennettsbridge, 600 m d/s Br	**31**	**19**	*61*
15N01	NORE	2180	u/s King's R confl (u/s abstr)	**9**	**6**	*67*
15N01	NORE	2200	Ballylinch Br	**31**	**21**	*68*
15N01	NORE	2300	Thomastown Br (Mid)	**31**	**24**	*77*
15N01	NORE	2400	Brownsbarn Br	**30**	**22**	*73*
15N01	NORE	2500	Inistioge Br	**32**	**17**	*53*
16A01	AHERLOW	100	Br SW of Ardrahin	**32**	**19**	*59*
16A01	AHERLOW	200	Galbally Br (R25)	**33**	**18**	*55*
16A01	AHERLOW	300	Stagdale Br	**33**	**22**	*67*
16A01	AHERLOW	400	New Br	**33**	**18**	*55*
16A01	AHERLOW	500	Second Ford d/s New Br	**33**	**16**	*48*
16A01	AHERLOW	600	College Br	**33**	**12**	*36*
16A01	AHERLOW	700	Br S of Ashgrove Ho	**33**	**9**	*27*
16A01	AHERLOW	800	Cappa Old Br	**32**	**3**	*9*
16A01	AHERLOW	900	Killardry Br	**32**	**7**	*22*
18B02	BLACKWATER (MUNSTER)	200	Nohaval Br	**35**	**5**	*14*
18B02	BLACKWATER (MUNSTER)	300	Duncannon Br	**34**	**4**	*12*

Contd.

APPENDIX II Contd.

8B02	BLACKWATER (MUNSTER)	700	Charles' Br	**33**	**8**	*24*
18B02	BLACKWATER (MUNSTER)	900	Colthurst Br	**35**	**8**	*23*
18B02	BLACKWATER (MUNSTER)	1000	Ballymaquirk Br	**35**	**4**	*11*
18B02	BLACKWATER (MUNSTER)	1300	Lombardstown Br	**35**	**7**	*20*
18B02	BLACKWATER (MUNSTER)	1510	Rly Br, Mallow (RHS)	**35**	**7**	*20*
18B02	BLACKWATER (MUNSTER)	1690	1.2 km d/s Mallow Br	**35**	**8**	*23*
18B02	BLACKWATER (MUNSTER)	1800	Ballymagooly	**2**	**1**	*50*
18B02	BLACKWATER (MUNSTER)	1900	Killavullen Br	**66**	**19**	*29*
18B02	BLACKWATER (MUNSTER)	2000	Ballyhooley Br	**35**	**8**	*23*
18B02	BLACKWATER (MUNSTER)	2100	Cregg Castle	**34**	**7**	*21*
18B02	BLACKWATER (MUNSTER)	2300	Illeclash 2.1 km d/s Fermoy	**35**	**10**	*29*
18B02	BLACKWATER (MUNSTER)	2450	W of Kilmurry Ho	**32**	**14**	*44*
18B02	BLACKWATER (MUNSTER)	2500	Ballyduff Br	**31**	**11**	*35*
18B02	BLACKWATER (MUNSTER)	2600	Lismore Br	**31**	**12**	*39*
18B02	BLACKWATER (MUNSTER)	2700	2km d/s Lismore Br	**30**	**10**	*33*

NITRITES:

Criteria: 95% of samples to be less than 0.05 mg/l NO_2

Code	**River**	**Station**	**Location**	**No. of Samples**	**No > 0.05**	**% > 0.05**
18B05	BRIDE (BLACKWATER)	50	Bride Br, Chimneyfield	**35**	**3**	*9*
18B05	BRIDE (BLACKWATER)	320	Dr Barry Br	**35**	**4**	*11*
18B05	BRIDE (BLACKWATER)	400	Bride Br	**35**	**7**	*20*
18B05	BRIDE (BLACKWATER)	500	Bealacoon Footbridge	**35**	**6**	*17*
18B05	BRIDE (BLACKWATER)	700	Mogeely Br	**33**	**9**	*27*
18B05	BRIDE	800	Tallowbridge	**31**	**8**	*26*
19L03	LEE (CORK)	360	Bealaghaglashin Br (New Br)	**68**	**14**	*21*
19L03	LEE (CORK)	400	Carrigadrohid Br	**72**	**16**	*22*
19L03	LEE (CORK)	500	Rooves Br S of Coachford	**72**	**24**	*33*
19L03	LEE (CORK)	600	Inishcarra Br	**70**	**26**	*37*
19L03	LEE (CORK)	650	Angler's Rest Ballincollig	**72**	**16**	*22*
19L03	LEE (CORK)	800	Weir u/s Victoria Br (Intake)	**64**	**28**	*44*
20A02	ARGIDEEN	45	Argideen Br	**96**	**12**	*13*
20A02	ARGIDEEN	60	Ballaghcummer Br	**72**	**6**	*8*
20A02	ARGIDEEN	100	Lisselane Br (Jones Br)	**98**	**14**	*14*
20A02	ARGIDEEN	150	Castleview Br	**94**	**14**	*15*

Contd.

APPENDIX II Contd.

20A02	ARGIDEEN	200	Kilmaloda Br	**91**	**12**	*13*
22M01	MAINE	50	Br SW of Tobermaing House	**30**	**2**	*7*
22M01	MAINE	300	Herbert Br	**30**	**3**	*10*
22M01	MAINE	400	Br 2km d/s Castleisland	**30**	**3**	*10*
22M01	MAINE	500	Br NW of Currans	**30**	**4**	*13*
22M01	MAINE	600	Maine Br, Currans	**30**	**2**	*7*
22M01	MAINE	700	Maine Br (Lower)	**30**	**4**	*13*
22M01	MAINE	800	Castlemaine Bridge	**30**	**7**	*23*
23F01	FEALE	750	Weir SW of Greenville	**34**	**2**	*6*
23F01	FEALE	800	Br at Finuge	**31**	**3**	*10*
23F01	FEALE	860	Railway Br u/s Ferry Br	**27**	**2**	*7*
27F01	FERGUS	700	Clonroad Br	**34**	**3**	*9*
27F01	FERGUS	720	Bridge S.W. of Doora	**32**	**5**	*16*
39G01	GLASHAGH (UPPER)	300	Cabra Br	**12**	**12**	*100*
39G02	GLASHAGH (LOWER)	170	Barrack Bridge	**18**	**18**	*100*
39L01	LEANNAN	500	Ballydone Br (u/s L Fern)	**20**	**20**	*100*
39L01	LEANNAN	550	0.8 km d/s L. Fern	**13**	**13**	*100*
39L01	LEANNAN	700	Bridge at Claragh	**17**	**17**	*100*
39L01	LEANNAN	800	Drumonaghan Br	**18**	**15**	*83*
39L02	LURGY	250	Br in Kilmacrennan	**16**	**16**	*100*
39L02	LURGY	280	d/s Kilmacrennan STW	**17**	**17**	*100*
39M01	MAGGY'S BURN	150	d/s Br in Milford (u/s STW)	**17**	**17**	*100*
39M01	MAGGY'S BURN	200	d/s Milford (d/s STW)	**18**	**18**	*100*
39S02	SWILLY	50	Swilly Br (near Breenagh)	**12**	**12**	*100*
39S02	SWILLY	190	75m u/s Br at Newmills	**11**	**11**	*100*
39S02	SWILLY	300	Old Town, Letterkenny	**12**	**12**	*100*
39S02	SWILLY	350	u/s Sprack Burn near Church	**12**	**12**	*100*
39S02	SWILLY	370	d/s Sprack Burn	**13**	**13**	*100*

Dissolved Copper:
Criteria:

95% of samples to be less than 0.005 mg/l Cu where Hardness is 10 mg/l $CaCO_3$.
95% of samples to be less than 0.022 mg/l Cu where Hardness is 50 mg/l $CaCO_3$.
95% of samples to be less than 0.04 mg/l Cu where Hardness is 100 mg/l $CaCO_3$.
95% of samples to be less than 0.112 mg/l Cu where Hardness is 300 mg/l $CaCO_3$.

Code	**River**	**Station**	**Location**	**No. of Samples**	**No > limit**	**% > limit**
01F01	FINN (DONEGAL)	700	Footbridge, Ballybofey	**7**	**1**	*14.3*
01F01	FINN (DONEGAL)	890	0.5 km u/s Br S of Killygordin	**8**	**1**	*12.5*
01F01	FINN (DONEGAL)	1080	u/s Castlefinn STW	**8**	**1**	*12.5*
22B03	BROWN FLESK	100	Rice Br	**27**	**2**	*7.4*
22B03	BROWN FLESK	250	Ford S of Ballybeg Ho	**27**	**4**	*14.8*
22B03	BROWN FLESK	300	Flesk Br, Currow	**27**	**2**	*7.4*
22B03	BROWN FLESK	400	O'Connell Br	**27**	**2**	*7.4*
23F01	FEALE	400	2.3 km d/s Abbeyfeale	**26**	**2**	*7.7*
39S02	SWILLY	370	d/s Sprack Burn	**13**	**2**	*15.4*

Notes:

Exceedances of the Temperature and Total Zinc criteria were not recorded in this cycle.

Assessment of compliance with criteria for phenols, petroleum hydrocarbons, residual chlorine and suspended solids has not been determined largely because of a general scarcity of information on these parameters.

The nitrite criterion is considered to be set too low for Irish conditions.

APPENDIX III

Summary of results of measurements for metals and organic substances on samples taken in the surveys in 2002-2003.

A. Summary of results for metals analyses on samples taken in 2002-2003

Metal	Concentration unit	Minimum	Maximum
Aluminium	µg/l	<50	1193
Antinomy	µg/l	<1	3.9
Arsenic	µg/l	<1	28.3
Barium	µg/l	13.0	707
Beryllium	µg/l	<1	<1
Boron	µg/l	<50	82.9
Cadmium	µg/l	<0.1	1.2
Calcium	mg/l	4.2	150
Chromium	µg/l	<1	54.4
Cobalt	µg/l	<1	38.9
Copper	µg/l	<1	27.7
Iron	µg/l	<50	2111
Lead	µg/l	<1	27.9
Magnesium	mg/l	1.0	36.4
Manganese	µg/l	4.9	244.2
Mercury	µg/l	<0.1	<0.1
Molybdenum	µg/l	<1	3.8
Nickel	µg/l	<1	39.0
Potassium	mg/l	0.5	12.5
Selenium	µg/l	<1	7.1
Silver	µg/l	<50	<50
Sodium	mg/l	3.9	106
Tin	µg/l	<50	<50
Uranium	µg/l	<1	8.5
Vanadium	µg/l	<1	4.9
Zinc	µg/l	0.8	586

APPENDIX III Contd.

B. Summary of results of analyses for organic compounds in samples taken in 2002-2003

Substance	Concentration unit	Minimum	Maximum
1,1,1,2-Tetrachlorethane	µg/l	<0.5	<0.5
1,1,1-Trichloroethane	µg/l	<0.5	<0.5
1,1,2,2-Tetrachloroethane	µg/l	<0.5	<0.5
1,1,2-Trichloroethane	µg/l	<0.5	<0.5
1,1-Dichloroethane	µg/l	<0.5	<0.5
1,1-Dichloroethene	µg/l	<0.5	<0.5
1,1-Dichloropropene	µg/l	<0.5	<0.5
1,2,3-Trichlorobenzene	µg/l	<0.5	<0.5
1,2,3-Trichloropropane	µg/l	<0.5	<0.5
1,2,4-Trichlorobenzene	µg/l	<0.5	<0.5
1,2,4-Trimethylbenzene	µg/l	<0.5	<0.5
1,2-Dibromo-3-Chloropropane	µg/l	<0.5	<0.5
1,2-Dibromoethene	µg/l	<0.5	<0.5
1,2-Dichlorobenzene	µg/l	<0.5	<0.5
1,2-Dichloroethane	µg/l	<0.5	<0.5
1,2-Dichloropropane	µg/l	<0.5	<0.5
1,3,5-Trimethylbenzene	µg/l	<0.5	<0.5
1,3-Dichlorobenzene	µg/l	<0.5	<0.5
1,3-Dichloropropane	µg/l	<0.5	<0.5
1,4-Dichlorobenzene	µg/l	<0.5	<0.5
2,2-Dichloropropane	µg/l	<0.5	<0.5
2-Chlorotoluene	µg/l	<0.5	<0.5
4-Chlorotoluene	µg/l	<0.5	<0.5
4-Isopropyltoluene	µg/l	<0.5	<0.5

Contd.

APPENDIX III contd.

Aldrin	µg/l	<0.05	<0.05
Alpha-BHC	µg/l	<0.05	<0.05
Atrazine	µg/l	<0.05	7.9
Benzene	µg/l	<0.5	<0.5
Beta-BHC	µg/l	<0.05	<0.05
Bromobenzene	µg/l	<0.5	<0.5
Bromochloromethane	µg/l	<0.5	<0.5
Bromodichloromethane	µg/l	<0.5	<0.5
Bromoform	µg/l	<0.5	<0.5
Bromomethane	µg/l	<0.5	<0.5
1,2-Dichloroethene	µg/l	<0.5	<0.5
1,3-Dichloropropene	µg/l	<0.5	<0.5
Carbon Tetrachloride	µg/l	<0.5	<0.5
Chlorobenzene	µg/l	<0.5	<0.5
Chloroform	µg/l	<0.5	<0.5
Cyanide	mg/l	<0.01	<0.01
Dibromochloromethane	µg/l	<0.5	<0.5
Dibromomethane	µg/l	<0.5	<0.5
Dichlorodifluoromethane	µg/l	<0.5	<0.5
Dieldrin	µg/l	<0.05	<0.05
Endrin	µg/l	<0.05	<0.05
Ethylbenzene	µg/l	<0.5	<0.5
Fluoride	mg/l	<0.1	0.56
Heptachlor	µg/l	<0.05	<0.05
Heptachlor epoxide	µg/l	<0.05	<0.05
Hexachlorobutadiene	µg/l	<0.5	<0.5
Isopropylbenzene	µg/l	<0.5	<0.5
Lindane	µg/l	<0.05	<0.05
m,p-Xylene	µg/l	<0.5	<0.5
Methylene Chloride	µg/l	<0.5	<0.5
Naphthalene	µg/l	<0.5	<0.5
n-Butylbenzene	µg/l	<0.5	<0.5
n-Propylbenzene	µg/l	<0.5	<0.5
o-Xylene	µg/l	<0.5	<0.5
p,p-DDE	µg/l	<0.05	<0.05

Contd.

APPENDIX III Contd.

PCB* 101	µg/l	<0.05	0.075
PCB 118	µg/l	<0.05	<0.05
PCB 138	µg/l	<0.05	<0.05
PCB 153	µg/l	<0.05	<0.05
PCB 180	µg/l	<0.05	<0.05
PCB 52	µg/l	<0.05	0.7
sec-Butylbenzene	µg/l	<0.5	<0.5
Simazine	µg/l	<0.05	2.0
Styrene	µg/l	<0.5	<0.5
t-1,2-Dichloroethene	µg/l	<0.5	<0.5
t-1,3-Dichloropropene	µg/l	<0.5	<0.5
tert-Butylbenzene	µg/l	<0.5	<0.5
Tetrachloroethene	µg/l	<0.5	<0.5
Toluene	µg/l	<0.5	<0.5
Trichloroethene	µg/l	<0.5	<0.5
Trichlorofluoromethane	µg/l	<0.5	<0.5
Vinyl Chloride	µg/l	<0.5	<0.5

* PCB is the acronym for polychlorinated biphenyls. The congeners listed are among the most abundant PCBs in the environment.

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					Category a: Nutrient Enrichment								Category b: Accelerated Growth				Category c: Undesirable Disturbance				
	Salinity				DIN				MRP				Chl a (Summer)				DO (Summer)				A
Water Body	W	*n*	S	*n*	W		S		W		S		Median		90%ile		5%ile		95%ile		
Castletown River	0.1	14	0.1	19	2.6	B	2.5	C	40	C	70	B	6.5	C	12.4	C	96	C	128	C	I
Castletown Estuary	8.3	21	20.0	119	2.1	B	0.9	C	60	C	80	B	20.5	B	55.5	B	33	B	124	C	E
Inner Dundalk Bay	31.0	6	32.6	87	0.3	C	0.1	C	35	C	20	C	10.0	C	30.9	B	68	B	114	C	I
Outer Dundalk Bay	33.4	30	33.7	21	0.2	C	0.0	C	24	C	10	C	3.0	C	9.0	C	93	C	117	C	U
Circumcoastal Dundalk Bay	34.0	64		0	0.1	C			20	C											U
Offshore Dundalk Bay	34.3	23		0	0.1	C			18	C											U
Boyne River	0.4	87	0.4	101	2.9	B	2.1	C	52	C	33	C	10.5	C	15.5	C	91	C	126	C	I
Boyne Estuary [1]	0.3	8	14.0	199	0.1	C	0.8	C	60	C	70	B	7.0	C	15.1	C	80	C	105	C	P-E
Boyne Estuary Plume Zone	33.2	27	33.7	33	0.2	C	0.1	C	23	C	10	C	3.0	C	9.1	C	90	C	106	C	U
Circumcoastal Boyne	34.2	133		0	0.1	C			20	C											U
Offshore Boyne	34.3	24		0	0.1	C			17	C											U
Ballyboghill River		0	0.3	6			2.5	C			179	B	4.8	C	7.3	C	74	C	97	C	I
Rogerstown Estuary [2]	5.2	3	31.2	26	6.5	B	0.2	C	180	B	75	B	9.3	C	19.1	M	74	B	150	B	E
Outer Rogerstown Estuary	33.1	3	33.1	45	0.4	B	0.0	C	37	C	22	C	2.8	C	6.1	C	90	C	141	B	I
Adjacent Coastal	33.8	15	33.7	59	0.1	C	0.0	C	19	C	10	C	4.0	C	7.4	C	93	C	114	C	U
Circumcoastal Rogerstown	34.3	87		0	0.1	C			18	C											U
Offshore Rogerstown	34.5	20		0	0.1	C			16	C											U

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Broadmeadow / Ward River	0.5	19	0.3	41	3.8	B	1.4	C	100	B	115	B	8.9	C	48.7	B	78	C	194	B	E
Broadmeadow Estuary (Inner)	27.6	6	31.7	214	1.4	B	0.0	C	46	C	50	B	28.0	B	83.4	B	79	C	204	B	E
Broadmeadow Estuary (Outer)	29.4	5	33.1	46	1.1	B	0.0	C	40	C	19	C	6.4	C	14.0	C	83	C	106	C	I
Adjacent Coastal	33.8	15	33.7	59	0.1	C	0.0	C	20	C	10	C	4.0	C	7.4	C	93	C	114	C	U
Circumcoastal Broadmeadow	34.3	87		0	0.1	C			18	C											U
Offshore Broadmeadow	34.5	20		0	0.1	C			16	C											U
Liffey River	0.2	288	0.3	194	2.5	C	1.9	C	74	B	74	B	12.1	C	18.1	C	89	C	133	B	I
Liffey Estuary	31.6	808	32.8	1890	0.4	C	0.2	C	40	C	34	C	3.3	C	8.1	C	78	B	117	C	I
Dublin Bay	33.7	375	34.0	462	0.2	C	0.0	C	25	C	10	C	3.5	C	6.9	C	95	C	114	C	U
Adjacent Coastal	34.1	47	33.6	147	0.1	C	0.0	C	19	C	10	C	3.6	C	8.1	C	95	C	111	C	U
Circumcoastal Dublin Bay	34.3	91		0	0.1	C			18	C											U
Offshore Dublin Bay	34.4	67		0	0.1	C			15	C											U
Avoca River	0.0	1	0.0	8	2.5	C	2.1	C	11	C	10	C	2.4	C	3.7	C	91	C	101	C	U
Avoca Estuary	0.0	14	4.0	47	2.0	C	1.2	C	14	C	16	C	4.4	C	12.5	C	78	C	98	C	U
Adjacent Coastal	34.1	17	33.9	3	0.1	C	0.1	C	14	C	27	C	4.4	C	4.4	C	90	C	92	C	U
Circumcoastal Arklow Harbour	34.4	41		0	0.1	C			14	C											U
Offshore Arklow Harbour	34.7	11		0	0.1	C			13	C											U
Slaney River	0.0	67	0.0	34	4.6	B	4.1	B	31	C	21	C					93	C	132	B	I
Upper Slaney Estuary	0.0	8	0.0	34	5.7	B	3.0	B	22	C	23	C	2.7	C	15.4	C	90	C	140	B	I

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Lower Slaney Estuary	19.9	34	25.4	208	2.3	B	0.6	C	6	C	6	C	9.8	C	25.9	B	89	C	137	B	E
South Wexford Harbour	19.7	4	28.3	67	2.2	B	0.2	C	6	C	6	C	17.4	B	58.1	B	96	C	143	B	E
Wexford Harbour	33.1	18	32.8	84	0.5	B	0.1	C	6	C	5	C	4.4	C	14.4	C	93	C	119	C	I
Adjacent Coastal	34.1	23		0	0.2	C			14	C											U
Circumcoastal Wexford Harbour	34.6	80		0	0.1	C			16	C											U
Offshore Wexford Harbour	34.9	62		0	0.1	C			13	C											U
Barrow River	0.3	67	0.0	0	4.6	B	3.7	B	64	B	50	C	2.5	C	7.1	C	92	C	112	C	I
Barrow Estuary		0	0.3	36			3.0	B			46	C	6.0	C	28.5	M	89	C	137	B	P-E
Nore River	0.3	94	0.0	0	3.4	B	3.0	B	48	C	52	C	2.5	C	7.1	C	92	C	112	C	I
Nore Estuary		0	0.3	12			2.9	B			29	C	8.6	C	23.2	C	90	C	154	B	I
Barrow Nore Estuary		0	14.0	133			2.2	B			40	C	8.8	C	32.9	B	83	C	108	C	I
Suir River	0.2	90	0.0	0	2.9	B	2.4	C	43	C	27	C	2.5	C	7.1	C	92	C	112	C	I
Suir Estuary (Upper)		0	0.2	115			2.5	C			20	C	7.6	C	40.6	B	79	C	131	B	I
Suir Estuary (Lower)	13.1	5	11.9	480	2.3	B	1.8	B	35	C	30	C	6.3	C	16.0	C	75	C	98	C	I
Barrow Nore Suir Estuary (Outer)	23.9	8	29.0	312	1.2	B	0.4	C	28	C	10	C	6.3	C	14.0	C	85	C	115	C	I
Outer Waterford Harbour	28.7	8	33.9	265	0.5	C	0.1	C	25	C	10	C	2.4	C	7.5	C	88	C	118	C	U
Adjacent Coastal	34.6	33		0	0.2	C			19	C											U
Circumcoastal Waterford Harbour	34.7	38		0	0.1	C			16	C											U
Offshore Waterford Harbour	34.9	18		0	0.1	C			15	C											U
Colligan River	0.0	12	0.0	22	3.0	B	2.4	C	11	C	10	C	1.8	C	3.1	C	99	C	112	C	I
Colligan Estuary	29.6	35	32.8	210	0.5	C	0.2	C	6	C	10	C	4.0	C	13.9	C	84	C	122	B	I

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Dungarvan Harbour	34.6	17	34.2	193	0.1	C	0.1	C	6	C	6	C	2.0	C	4.0	C	85	C	113	C	U
R Blackwater	0.0	90	0.1	46	3.1	B	3.1	B	44	C	43	C	4.1	C	13.2	C	90	C	117	C	I
Tributaries	0.0	27	0.0	33	4.4	B	3.7	B	30	C	27	C	3.6	C	16.4	C	86	C	108	C	I
Blackwater Estuary Upper	0.0	5	0.1	70	2.9	B	2.8	B	38	C	46	C	9.1	C	38.1	B	70	M	105	C	P-E
Blackwater Estuary Lower	5.2	13	18.6	171	2.4	B	1.3	C	39	C	19	C	12.1	C	67.1	B	74	C	133	B	E
Youghal Harbour	35.0	1	33.7	23	0.2	C	0.1	C	10	C	10	C	3.1	C	14.3	C	86	C	120	C	U
Lee River	0.1	44	0.1	79	2.4	C	1.8	C	30	C	18	C	6.7	C	10.4	C	84	C	114	C	U
Lee Estuary	0.0	7	8.2	165	3.1	B	1.9	C	15	C	45	C	4.6	C	15.7	C	31	B	109	C	I
Lough Mahon	23.6	9	30.7	135	1.4	B	0.4	C	14	C	28	C	5.6	C	23.8	B	62	B	114	C	E
Owenacurra River	0.1	24	0.0	20	6.6	B	6.2	B	32	C	59	C	6.7	C	10.4	C	84	C	114	C	I
Owenacurra Estuary	11.6	2	17.6	51	3.2	B	1.3	C	14	C	18	C	8.4	C	35.9	B	80	C	134	B	E
North Channel Great Island		0	31.6	45			0.2	C			11	C	7.3	C	29.3	B	89	C	123	B	I
Cork Harbour	21.6	2	34.1	71	2.5	B	0.0	C	7	C	5	C	4.5	C	12.9	C	89	C	112	C	I
Bandon River	0.0	95	0.0	42	3.6	B	2.7	B	34	C	44	C	5.0	C	21.3	C	93	C	125	C	I
Upper Bandon Estuary [2]	0.0	1	10.6	28	5.2	B	1.7	C	16	C	42	C	29.3	B	107.6	B	78	C	146	B	E
Lower Bandon Estuary	18.3	16	29.2	209	2.0	B	0.3	C	15	C	11	C	12.9	B	74.0	B	79	C	129	B	E
Kinsale Harbour	25.6	2	34.2	49	1.3	B	0.1	C	12	C	8	C	4.4	C	10.5	C	80	C	129	B	I
Argideen Estuary [3]																					E
Riverine Inflows	0.1	13	0.0	10	0.5	C	0.4	C	6	C	10	C	1.0	C	1.6	C	89	C	113	C	U
Inner Bantry Bay	27.4	11	32.6	40	0.2	C	0.0	C	10	C	10	C	1.6	C	4.2	C	59	B	106	C	I
Outer Bantry Bay	31.0	4	33.2	18	0.1	C	0.0	C	10	C	10	C	1.3	C	4.0	C	67	B	103	C	I

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Lee River and tributaries	0.1	11	0.1	26	2.0	C	1.3	C	60	M	67	B	4.4	C	25.8	M	91	C	140	B	P-E
Upper Lee (Tralee) Estuary	0.1	4	1.9	74	2.6	C	1.6	C	42	C	124	B	15.5	B	46.2	B	45	B	134	B	E
Lower Lee (Tralee) Estuary		0	31.4	19			0.0	C			24	C	8.5	C	18.1	C	92	C	116	C	U
Tralee Bay	30.6	2	33.8	84	0.4	C	0.0	C	10	C	10	C	2.1	C	4.7	C	94	C	105	C	U
Feale River	0.0	41	0.0	44	1.1	C	0.7	C	37	C	29	C	3.1	C	3.2	C	86	C	126	C	U
Upper Feale Estuary	0.0	12	0.0	12	1.1	C	1.0	C	37	C	63	B	3.6	C	3.6	C	89	C	110	C	I
Cashen Feale Estuary	0.5	56	7.9	88	1.3	C	0.7	C	36	C	44	C	17.1	B	52.8	B	74	C	109	C	I
Shannon River	0.1	165	0.2	60	1.2	C	0.9	C	27	C	12	C	3.4	C	4.5	C	91	C	100	C	U
Tidal Shannon River		0	0.2	52			1.0	C			62	B	9.1	C	17.7	C	70	C	101	C	I
Maigue River	0.3	73	0.3	40	2.2	C	1.5	C	107	B	76	B	3.8	C	8.4	C	95	C	145	B	I
Maigue Estuary	0.4	6	0.4	62	3.2	B	1.2	C	47	C	112	B	5.6	C	12.1	C	75	C	127	C	I
Upper Shannon Estuary	4.6	2	16.7	106	1.5	C	0.6	C	25	C	43	C	7.3	C	13.6	C	80	C	104	C	U
Deel River	0.2	80	0.3	43	2.4	C	1.8	C	126	B	169	B	6.4	C	63.2	B	88	C	179	B	E
Deel Estuary	0.0	5	7.6	92	3.3	B	1.0	C	67	B	154	B	8.5	C	19.1	C	82	C	153	B	I
Fergus River	0.2	87	0.2	62	0.7	C	0.5	C	30	C	20	C	3.2	C	15.8	C	73	C	118	C	U
Fergus Estuary	0.3	5	2.0	35	0.7	C	0.5	C	10	C	64	B	5.7	C	14.0	C	72	C	101	C	I
Shannon Estuary Lower	22.3	7	29.2	97	1.0	C	0.2	C	27	C	13	C	3.6	C	6.0	C	87	C	106	C	U
Corrib River	0.1	97	0.0	47	0.7	C	0.1	C	9	C	7	C	3.5	C	4.9	C	96	C	116	C	U
Corrib Estuary		0	29.0	83			0.1	C			8	C	3.6	C	7.8	C	91	C	117	C	U
Inner Galway Bay North		0	31.4	153			0.0	C			5	C	3.3	C	9.5	C	89	C	117	C	U

APPENDIX IV

Assessment of Trophic Status of Irish Estuaries, Bays and Marine Waters 1999 - 2003: Details of the outcome of the analysis A: ATSEBI Outcome U: Unpolluted I: Intermediate Status P-E Potentially Eutrophic E: Eutrophic W: Winter S: Summer B: Breach C: Compliance M: Marginal

Moy River	0.1	108	0.1	54	0.5	C	0.3	C	16	C	17	C	3.2	C	56.1	B	90	C	108	C	I
Moy Estuary	0.0	5	11.6	102			0.1	C	17	C	14	C	7.2	C	21.0	C	85	C	109	C	U
Killala Bay	25.5	2	33.4	34			0.1	C	24	C	12	C	6.0	C	13.0	C	95	C	115	C	U
R Garavoge	0.0	31	0.0	20	0.4	C	0.3	C	34	C	21	C	0.0	C	0.0	C	94	C	110	C	U
Garavoge Estuary	0.0	2	27.4	128	0.4	C	0.1	C	14	C	13	C	6.4	C	14.0	C	76	C	124	B	I
Sligo Harbour	14.9	2	33.0	39	0.5	C	0.1	C	37	C	8	C	3.3	C	6.4	C	96	C	118	C	U
R Ballisodare	0.0	31	0.0	20	0.4	C	0.3	C	34	C	21	C	0.0	C	0.0	C	94	C	110	C	U
Ballysadare Bay	12.6	1	33.9	44	0.5	C	0.0	C	24	C	8	C	2.3	C	3.4	C	96	C	114	C	U
Sligo Bay	24.8	5	34.0	92	0.2	C	0.0	C	21	C	5	C	2.0	C	3.0	C	95	C	113	C	U
Killybegs Harbour	33.5	24	33.7	278	0.3	C	0.1	C	45	B	10	C	7.0	C	14.0	C	67	B	119	C	I
McSwyne's Bay	33.8	6	34.2	93	0.0	C	0.1	C	10	C	10	C	4.0	C	7.9	C	61	B	110	C	I
Swilly and Leannan Rivers	0.1	21	0.0	24	0.1	C	0.1	C	5	C	10	C	4.0	C	11.9	C	65	B	102	C	I
Upper Swilly Estuary		0	28.0	61			0.1	C			20	C	22.5	B	81.4	B	38	B	113	C	I
Lower Swilly Estuary		0	33.0	103			0.1	C			10	C	5.0	C	9.2	C	91	C	110	C	U
Lower Lough Swilly		0	34.0	139			0.1	C			10	C	3.0	C	7.0	C	92	C	110	C	U

Notes

1 The Boyne Estuary was classed as Intermediate according to the water quality module of the ATSEBI analysis, but is considered Potentially Eutrophic arising from observations of macroalga distribution and abundance

2 The Rogerstown Estuary was classed as Potentially Eutrophic according to the water quality module of the ATSEBI analysis, but is considered Eutrophic arising from observations of macroalga distribution and abundance

3 The Argideen Estuary was not classified by ATSEBI as no water quality data are available for this water body, but is considered Eutrophic arising from observations of macroalgal distribution and abundance

APPENDIX V

Classification of Shellfish Production Areas under Directive 91/492/EEC (CEC, 1991c) in July and November 2003 (Minister for Communications, Marine & Natural Resources, 2003a; 2003b).

Production Area	Bed Name	Species Harvested	Classification
Lough Foyle	All Beds	Oysters Mussels	B
Tra Breaga	All Beds	Oysters	B
Lough Swilly	All Beds	Oysters Mussels	B
Mulroy Bay	All Beds	Mussels Oysters	A
Sheephaven	All Beds	Oysters	B
Gweedore	All beds	Oysters	B
Burtonport	Sally's Lough	Oysters	B
Dungloe	Dungloe	Oysters	B
Traweenagh	All beds	Oysters Mussels	A
Gweebara	All beds	Oysters	A
Loughras Mor	All beds	Oysters Clams	B
Loughras Beg	All beds	Oysters	A
Teelin	All beds	Oysters	B
McSwynes Bay	Bruckless - All Beds	Mussels Oysters	B
Donegal Harbour (Area bound to W by a line from The Hassans to Murvagh Pt)	All beds	Oysters Mussels	B
Donegal Harbour (Doorin Pt to Rossnowlagh Pt)		Oysters Mussels	A B

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Drumcliff Bay		Oysters Clams Mussels	A B B
Sligo Harbour		Oysters Clams	B
Ballysodare Bay		Mussels	A
Killala Bay		Oysters	B
Blacksod Bay (Belmullet)		Oysters	A
Achill		Oysters Mussels	B
Clew Bay (Newport Bay)		Oysters Mussels	B
Clew Bay (Westport Bay)		Oysters Mussels	B
Clew Bay (All Other Beds)		Oysters Mussels	A
Killary Harbour		Mussels	B
Ballynakill		Oysters	B
Aughrus		Oysters	A
Streamstown Bay		Oysters	A
Clifden Bay Inner		Mussels	B
Clifden Bay Outer		Clams	B
Mannin Bay		Oysters	A
Kilkieran		Oysters	A
Galway Bay	Inverin	Mussels	B
Galway Bay	Mweelon Bay	Oysters	B
Galway Bay	Clarenbridge	Oysters Clams Mussels	A B B
Galway Bay	Kinvarra	Oysters Mussels	B
Galway Bay	Aughinis	Oysters	A

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Galway Bay	Poulnaclough Bay	Oysters Mussels	A
Carraigaholt	All Beds	Oysters	A
Poulnasharry	All Beds	Oysters	A
Trummera Bay, Askeaton	All Beds	Oysters	B
Ballylongford	All Beds	Oysters	B
Tralee Bay	All Beds	Oysters	B
Castlemaine Harbour	All Beds	Oysters Mussels	B
Valentia River	All Beds	Oysters	B
Kenmare River	Ardgroom	Mussels	A
	Cleandra	Mussels	A
	Kilmakilloge	Mussels	B
	Sneem/Tahilla	Mussels	B
	All other Beds	Mussels	B
		Oysters	B
Bantry Bay	Castletownbere	Mussels	A
	All Other Beds	Mussels	B
		Sea Urchins	A
Dunmanus Bay	All beds	Mussels	B
		Sea Urchins	A
Roaringwater Bay	All beds	Mussels	B
Baltimore Harbour	All beds	Oysters	B
Sherkin North	All Licensed Beds	Oysters	B
Sherkin Kinish	All Licensed Beds	Oysters	B
Rosscarbery	All beds	Oysters	B
Kinsale	All beds	Oysters	B
Oysterhaven	All beds	Oysters	B
Cork Harbour	Nth Channel W	Oysters	B
	Nth Channel E	Oysters	B
Dungarvan Bay	All beds	Oysters	B
Waterford Harbour	All beds	Oysters Mussels	B
Bannow Bay	All beds	Oysters	B

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Ballyteigue Bay	All beds	Oysters	B
Wexford Harbour	Stats 1, 2, 3, 4, 6, 13, 15, 16, 19, 24	Mussels	C
	All other beds	Mussels	B
Malahide	All Beds	Razor Clams	C
Gormanstown/ Laytown	All beds	Razor Clams	B
Dunany/ Salterstown	All beds	Razor Clams Clams	B
Carlingford Lough (Irish Waters)	Ballagan	Razor Clams	A
	Ballagan	Oysters	B
	Carlingford	Oysters	B
	Carlingford	Mussels	B

APPENDIX VI

Quality Requirements For Bathing Water

No	Parameters	Directive 76/160/EEC G (Guide)	I (Mandatory)	National Limit Values (SI 155 of 1992)
Microbiological				
1	Total coliforms (no/100ml)	≤ 500	≤ 10,000	see notes
2	Faecal coliforms (no/100ml)	≤ 100	≤ 2,000	see notes
3	Faecal streptococci (no/100ml) *	≤ 100	-	≤ 300
4	Salmonella (no/ 1 litre) *	-	0	0
5	Enteroviruses (PFU/ 10 litres) *	-	0	0
Physicochemical				
6	pH *	-	6 to 9	≥ 6 and ≤ 9
7	colour	-	No abnormal change in colour	No abnormal change in colour
8	Mineral oils (mg/l)	≤ 0.3	No film visible on the water surface and no odour	No film visible on the water surface and no odour
9	Surface active substances (mg/l)	≤ 0.3	No lasting foam	No lasting foam
10	Phenol ($mg/l\ C_4H_3OH$)	≤ 0.005	≤ 0.05 and no specific odour	≤ 0.05 and no specific odour
11	Transparency (m)	≥ 2	≥ 1	≥ 1
12	Dissolved oxygen * (per cent saturation O_2)	80 to 120	-	≥ 70 and ≤ 120
13	Tarry residues and floating material	Absence	-	No offensive presence
14	Ammonia ($mg/l\ NH_4$)**	-	-	-
15	Nitrogen Kjeldahl (mg/l N)**	-	-	-
Other Substances				
16	Pesticides (mg/l) *	-	-	-
17	Heavy metals (mg/l Cd, Cr VI, Pb, Hg) *	-	-	-
18	Cyanides (mg/l Cn) *	-	-	-
19	Nitrates and phosphates ($mg/l\ NO_3$, PO_4) *	-	-	-

* to be sampled where an investigation shows or where there are other grounds for believing that water quality has deteriorated in respect of this parameter.

** to be sampled where there is a tendency towards eutrophication of bathing water.

Note (see over)

Note:

1. In addition, the following levels of compliance must be achieved with the values for individual parameters:

Guide Values (G):

Parameters Nos. 1 and 2	≥ 80 per cent of samples
Parameters Nos. 3 and 12	≥ 90 per cent of samples
Parameters Nos. 8, 9, 10, 11, and 13	≥ 90 per cent of samples

(In addition it is a requirement that results in respect of individual samples for these five parameters which breach the Guide Value do not exceed that value by more than 50%).

Mandatory Values (I):

Parameters Nos. 1, 2, 4, 5, and 6	≥ 95 per cent of samples
Parameters Nos. 7, 8, 9, 10, and 11	≥ 95 per cent of samples

(In addition it is a requirement that results in respect of individual samples for these five parameters which breach the Mandatory Value do not exceed that value by more than 50%.)

National Limit Values (NLV):

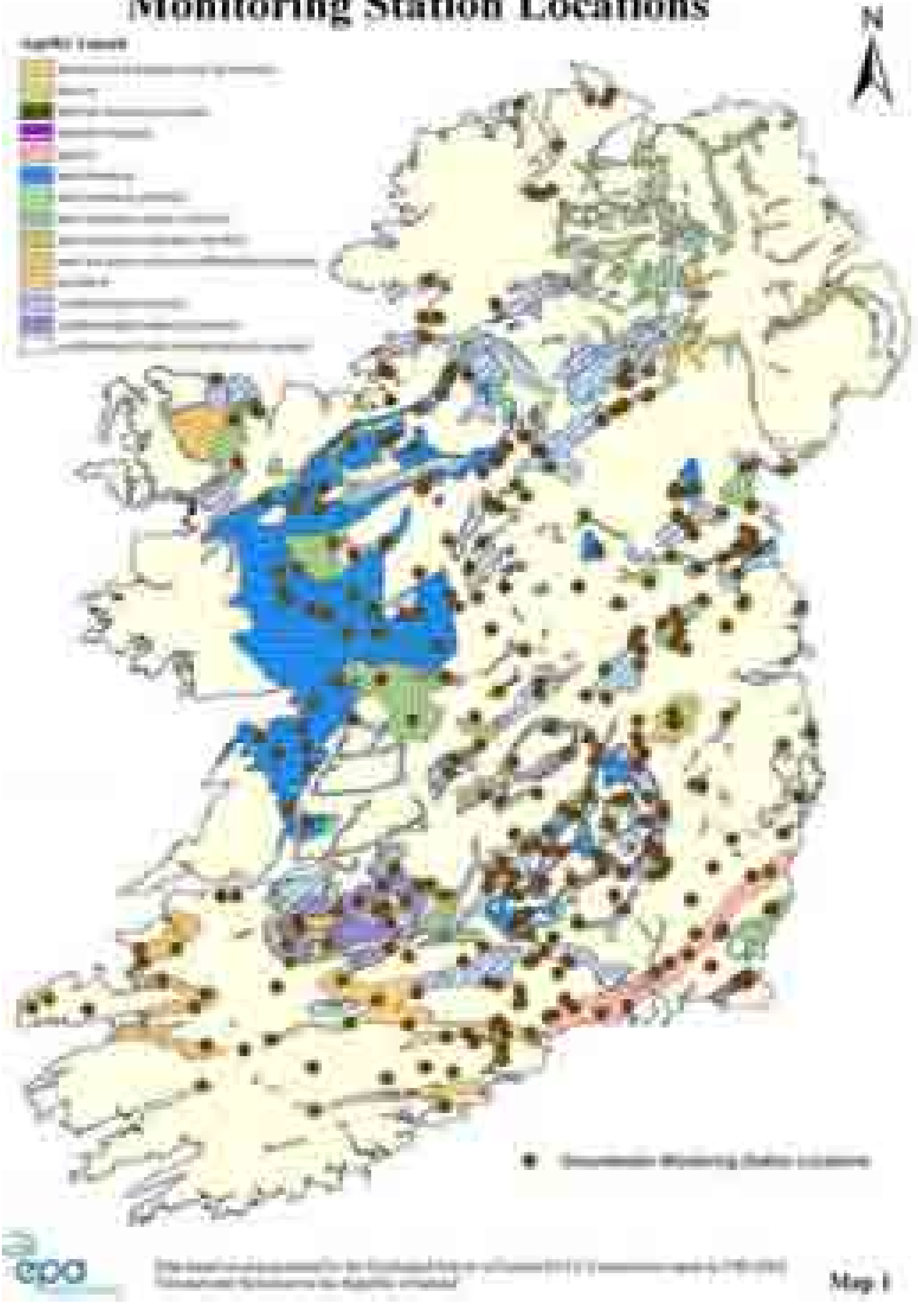
Parameter No. 1	≥ 80 per cent of samples must be ≤ 5,000/100ml; and ≥ 95 per cent of samples must be ≤ 10,000/100ml
Parameter No. 2	≥ 80 per cent of samples must be ≤ 1,000/100ml; and ≥ 95 per cent of samples must be ≤ 2,000/100ml
Parameters Nos. 3, 4, 5, 6, and 12	≥ 95 per cent of samples
Parameters Nos. 7, 8, 9, 10, 11, and 13	≥ 95 per cent of samples

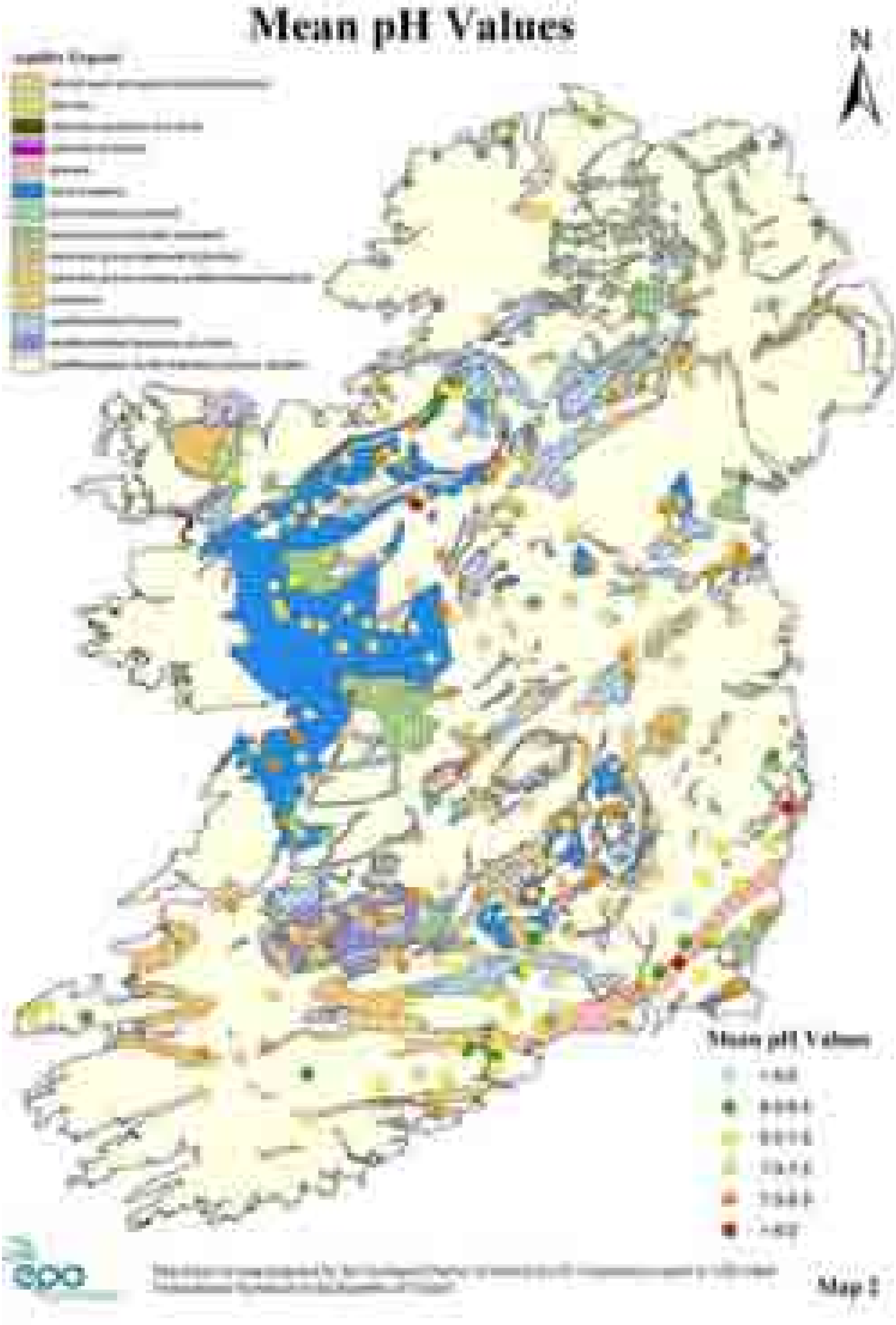
(In addition it is a requirement that results in respect of individual samples for these six parameters which breach the National Limit Value do not exceed that value by more than 50%).

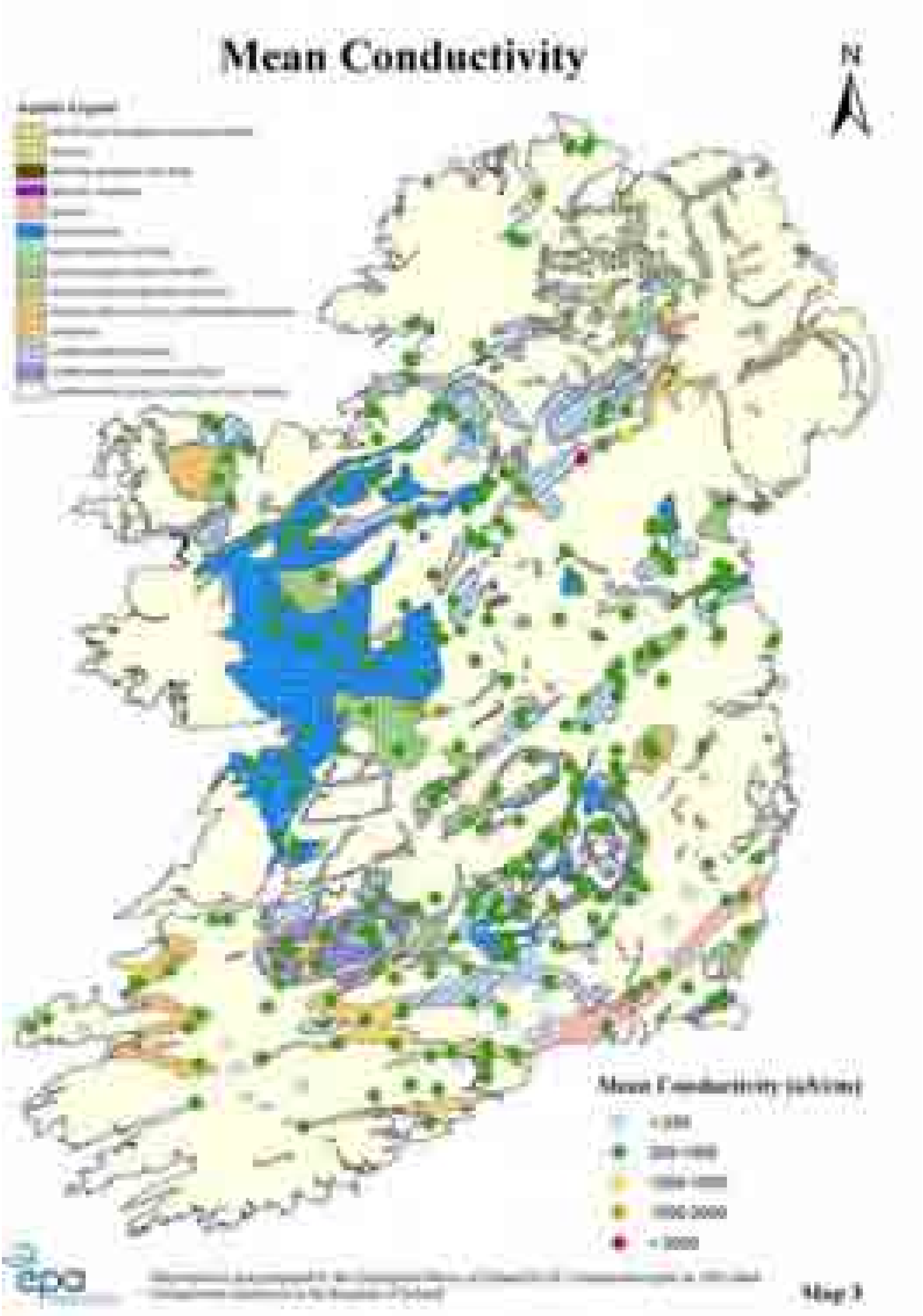
APPENDIX VII

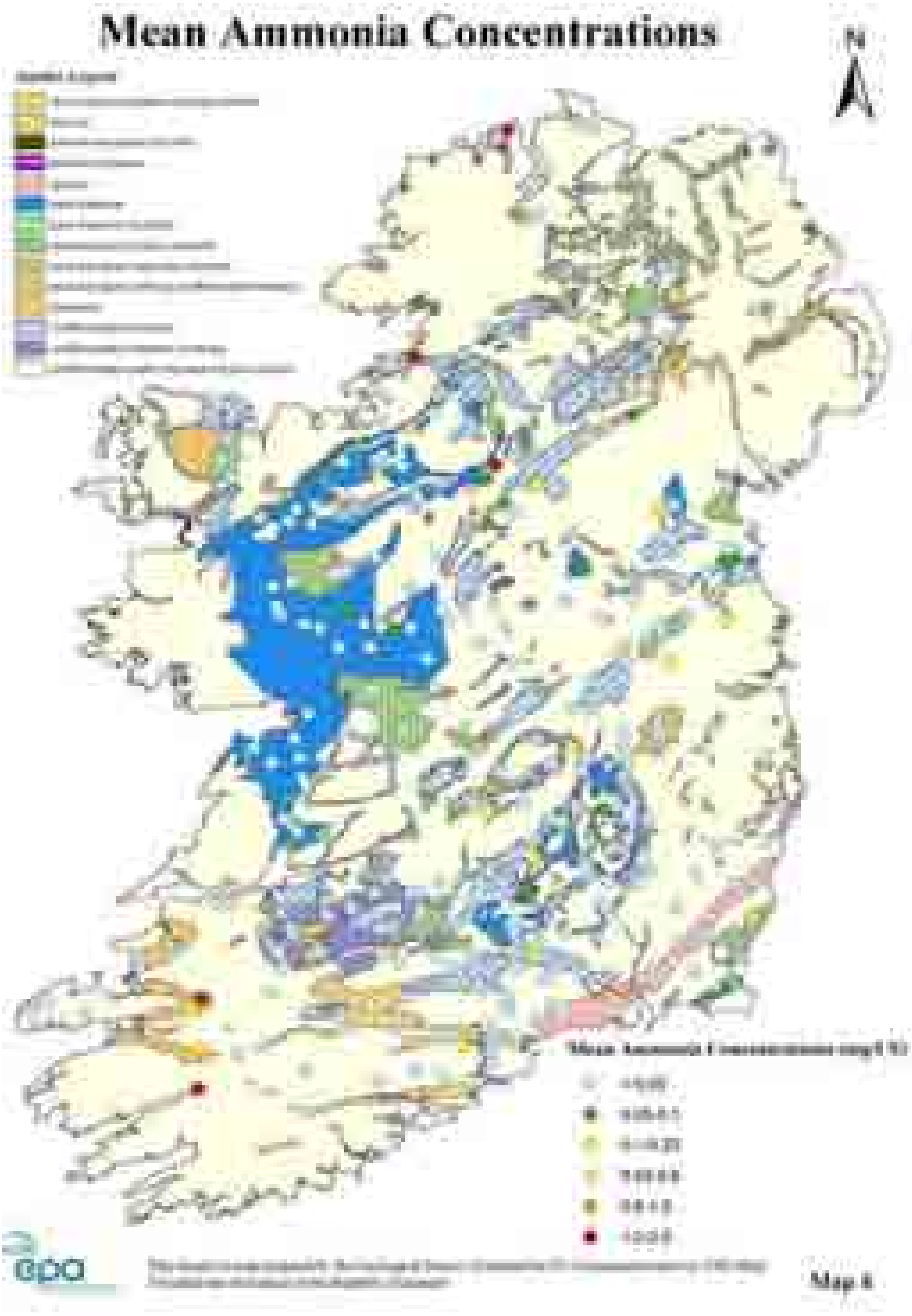
Groundwater Quality Maps

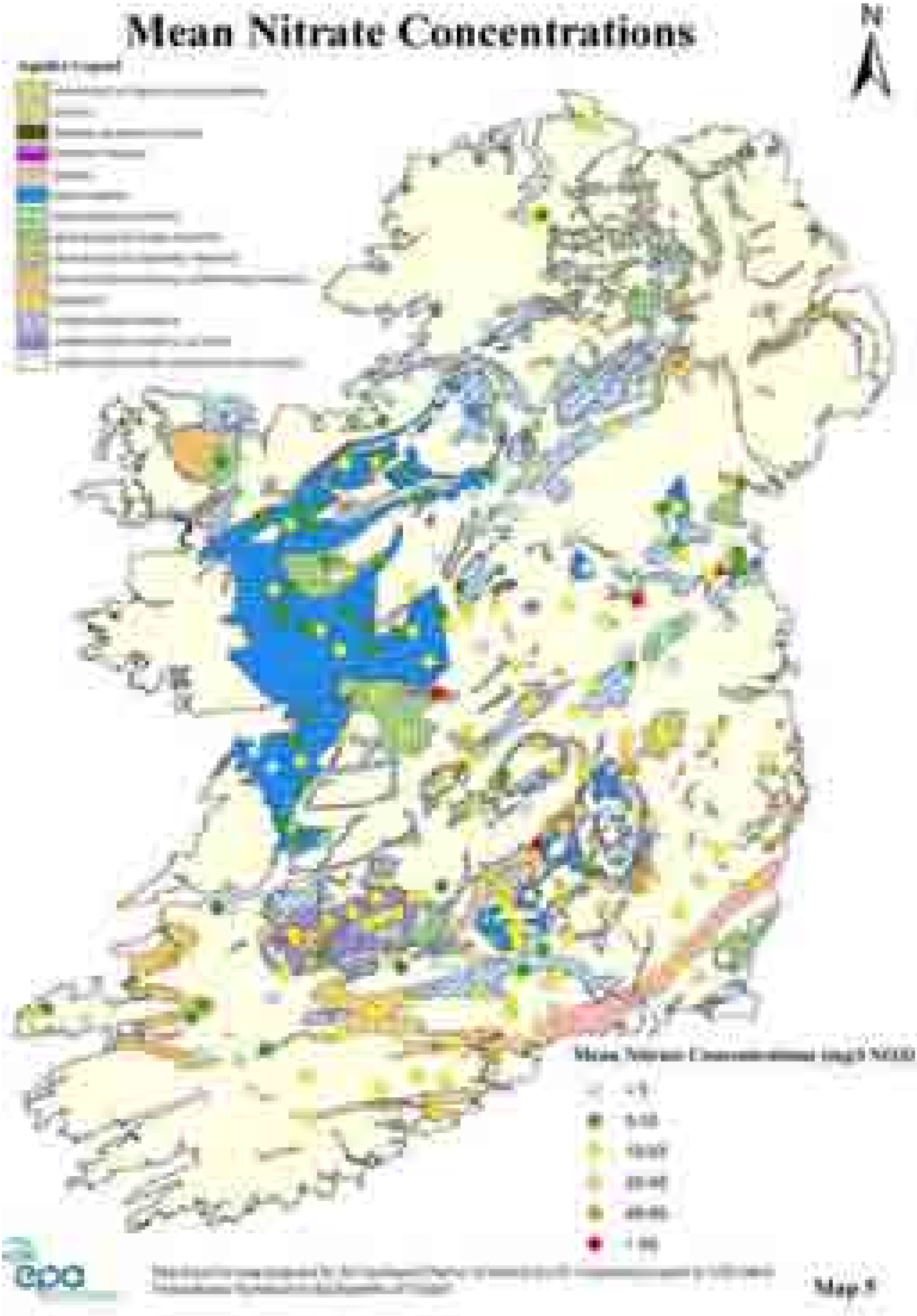
Monitoring Station Locations

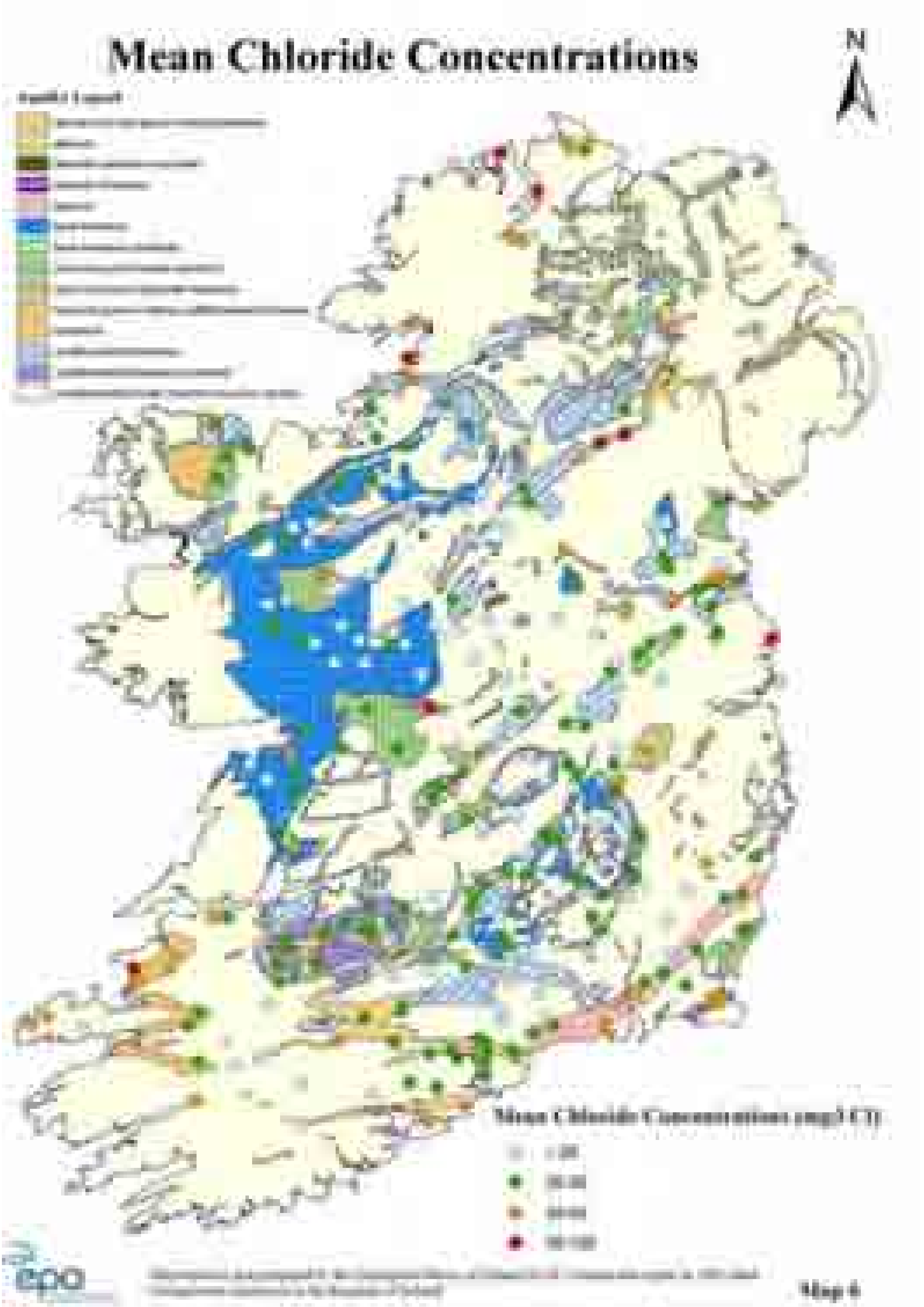


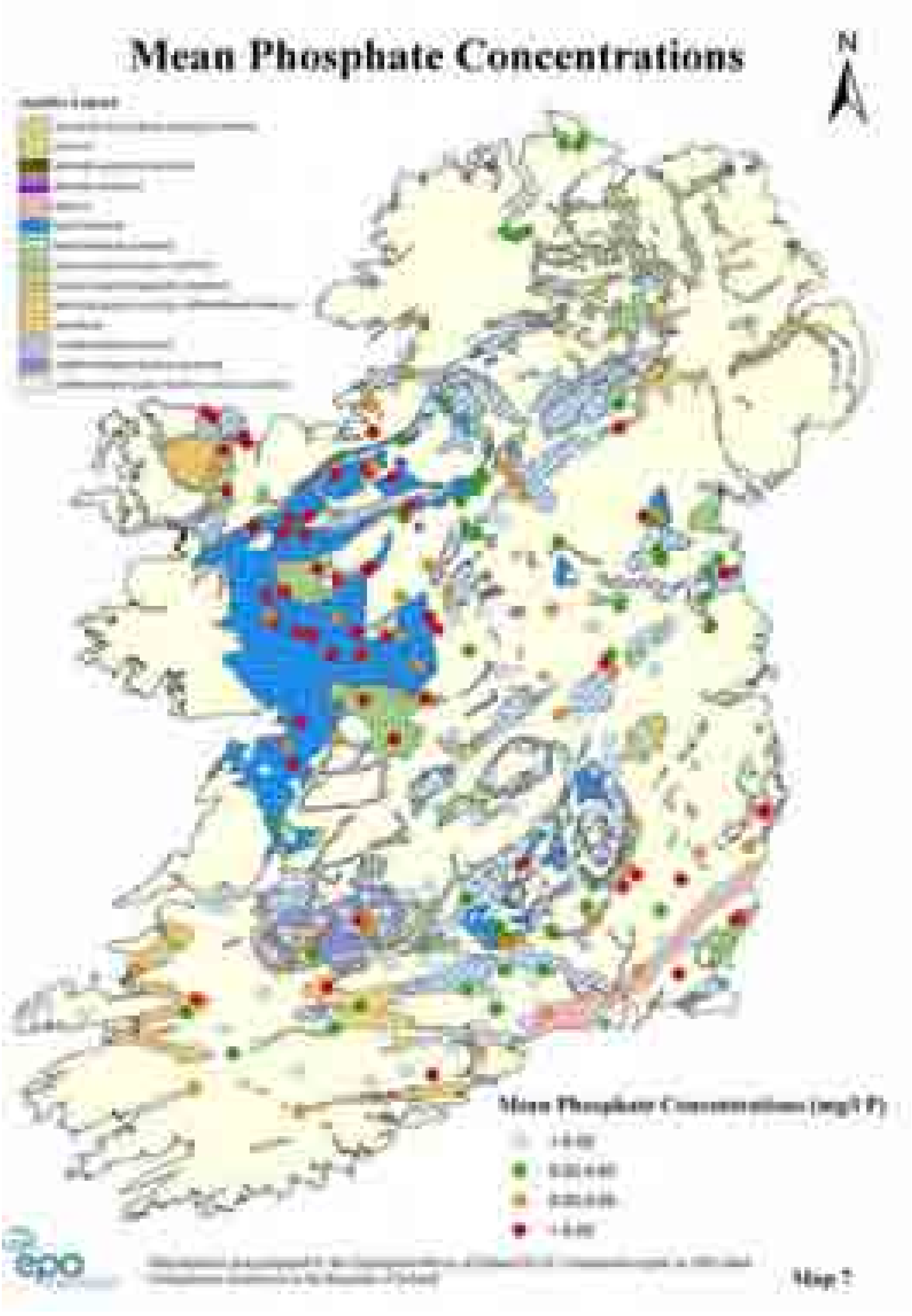

Mean pH Values
N


Mean Conductivity
N


Mean Ammonia Concentrations
N
Map 6

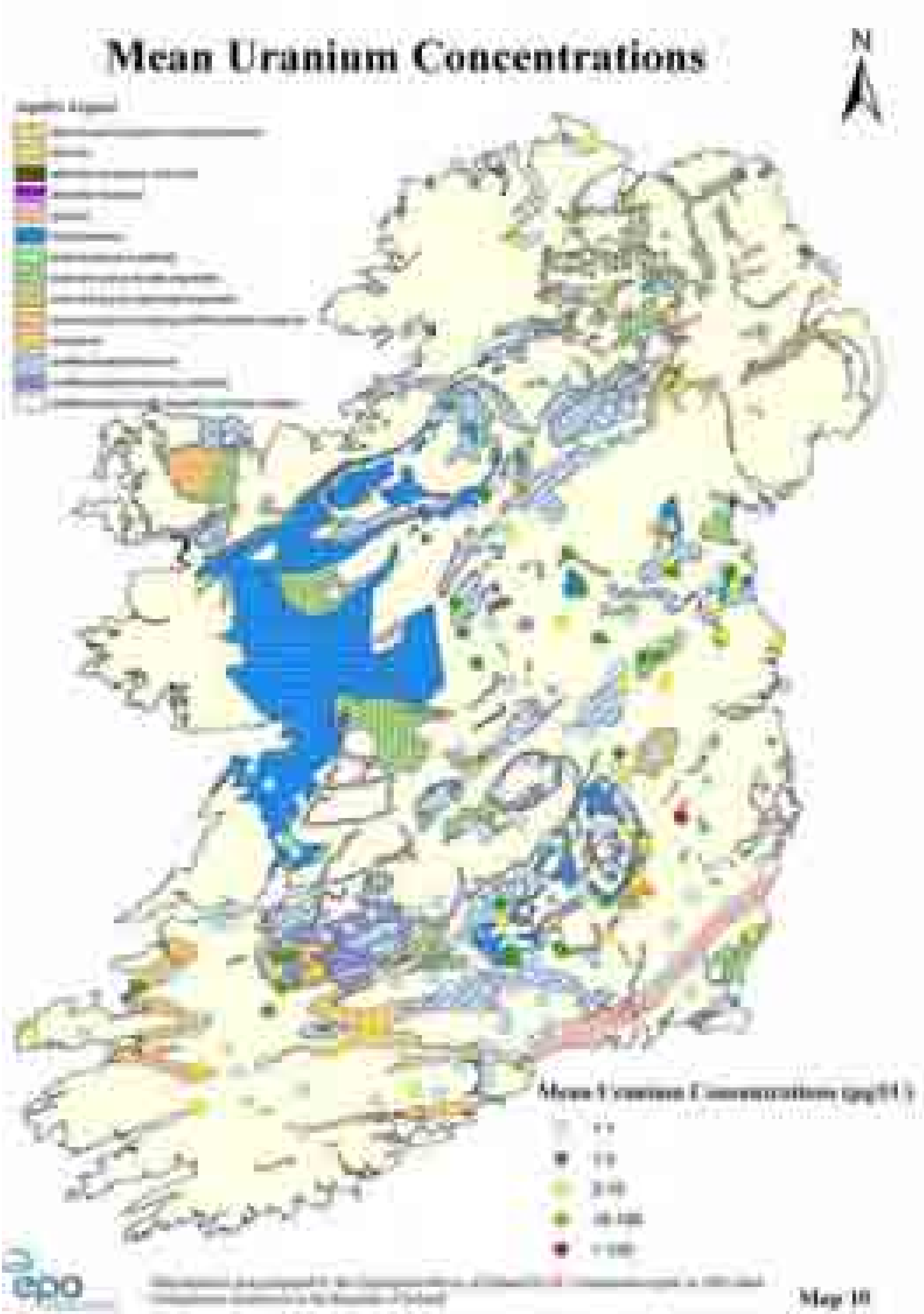

Mean Nitrate Concentrations
N


Mean Chloride Concentrations
N
Map 6


Mean Phosphate Concentrations
N


Mean Iron Concentrations
Mean Iron Concentration (mg/l Fe)


Mean Manganese Concentrations
N


Mean Uranium Concentrations
N
Map 10