

**An Evaluation of the Delivery and
Monitoring of Water Fluoridation in
Ireland**

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**The report of an evaluation carried out by the Department of Public & Child
Dental Health, Dublin Dental School and Hospital, Trinity College, Dublin.**

This report was commissioned by the Department of Health & Children.

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1 Introduction:

In 2000 the Department of Health & Children, through the Eastern Regional Health Authority awarded contracts (in 10 lots) to carry out an extensive evaluation of oral health services in Ireland. As part of Lot 2, a contract was awarded to the Dublin Dental School & Hospital to evaluate specific aspects of the fluoridation of public water supplies. A management consultant company (Promech Limited) was employed as a subcontractor in the evaluation because of its experience in accreditation (including ISO accreditation) of companies and organisations including some health board services.

The evaluation concentrated on the legislation, process and technical aspects of water fluoridation. It was not concerned with the health aspects of water fluoridation which were included in other lots of the evaluation of oral health services. In addition an overall evaluation of fluoridation was considered by the Forum on Fluoridation set up by the Minister for Health & Children, which reported in September 2002.

1.2 The Aims and Objectives of the Project

The aim of the project was to evaluate the quality and performance of the fluoridation of public water supplies in Ireland with regard to structure, process and outcomes, so as to determine best practice methodologies appropriate for all aspects of water fluoridation.

The objectives of the project were:

Objective 1

- ❑ **To analyse the results of testing of fluoride levels in public water supplies for the period 1990-2000.**

Objective 2

- ❑ **To obtain input about the operation of water fluoridation from key health board personnel and staff in the Public Analyst Laboratories.**

Objective 3

- ❑ **To carry out an in-depth analysis of the operation of water fluoridation in a sample of water treatment plants in order to make recommendations on aspects of plant operation and the supply of the fluoride additive.**

2 Executive Summary

2.1 Introduction

Fluoridation of water supplies commenced in Dublin in 1964 after the completion of the legal challenges to the Health (Fluoridation of Water Supplies) Act 1960. By 1977 there were one hundred and thirty five water supplies serving 1.76 million people with fluoridated water. Currently approximately 73% of the population receives fluoridated water from public water supplies.

Aims of the Project

The aims of the project were to evaluate the quality and performance of the fluoridation of public water supplies in Ireland, in order to determine best practice methodologies appropriate to all aspects of water fluoridation.

Methods

In order to achieve the aims of the project the following methods were used: data from the monthly tests on levels of fluoride in public water supplies for the period 1990-2000 were analysed, information from the relevant health board personnel on the operation of water fluoridation in all health board areas was obtained and analysed and an in-depth assessment of a small sample of water treatment plants was carried out.

2.2 Overall Conclusions

Objective 1: Levels of fluoride in water:

- The analysis of the monthly test results indicated that in general the fluoride levels in public water supplies were well controlled. Most of the test results fell within the statutory limits or were lower than required. Only a small percentage of the results exceeded the statutory limits. The data from the Environmental Protection Agency showed that between 0.07% and 0.32% of results exceeded 1.5ppm fluoride.

Objective 2: Overall operation of water fluoridation in health boards:

- The majority of health board personnel reported that the Fluoridation Monitoring Committees were working effectively. However there is a need to clarify the composition, role and remit of these committees to enhance their performance and to ensure that overall responsibility is identified. Key performance indicators should be identified by the Fluoridation Monitoring Committees for monitoring of water fluoridation in each water treatment plant.

Objective 3: Operation of fluoridation in the water treatment plants:

- In order to support and develop quality assurance in respect of the delivery of fluoridated water, current legislation, regulations and procedures should be formalised into a *"Best Practice Manual"* which should be made available to all personnel involved in water fluoridation. There is also a need to formalise current plant procedures into a Standard Operating Procedures Manual specific to each water treatment plant.

2.3 Results and Recommendations for each Objective

Objective 1: Analysis of the results of testing of fluoride levels in public water supplies

Summary of the Findings

The Department of Health & Children has for a number of years categorised the monthly test data and reported them in three categories, *Satisfactory*, *Marginal* and *Unsatisfactory*. The *Satisfactory* results are those which lie within the statutory limits of 0.80 to 1.00ppm. The *Marginal* results are those which are equal to 0.70ppm and less than 0.80 ($0.70 < 0.80$) as well as those which are greater than 1.00ppm up to and including 1.10ppm ($> 1.00 \leq 1.10$ ppm). *Unsatisfactory* results are those which are less than 0.70ppm (< 0.70) and greater than 1.10ppm (≥ 1.1 ppm).

The proportion of the results in the *Satisfactory* category varied from 57.9% in 1990 to 75.8% in 1998. There was a general trend that the more densely populated areas had higher percentages in the *Satisfactory* category though this was not universally the case. The percentage of the results in the *Unsatisfactory* category exceeding the statutory limit ranged from 2.7% in 2000 to 6.9% in 1999, with a trend towards lower percentages of unsatisfactory exceedances in later years. The *Marginal* exceedances ranged from 5.6% in 2000 to 13.7% in 1991. There was a trend over the period for the total percentage of *Marginal* and *Unsatisfactory* exceedances to decrease.

Summary of the Recommendations

Identification of supplies, daily & monthly testing

- ❑ A unique identifier is required for each plant and distribution network
- ❑ Detailed maps of all distribution networks are required
- ❑ Statutory Instruments need to be updated to reflect changes in names of networks
- ❑ Results should be recorded electronically in standard format
- ❑ Test samples should be taken at representative point and at a time when plant is fully operational
- ❑ Manual of all legislation, circular letters to be made available to relevant health board and local authority personnel
- ❑ A "*Control Range*" with targets for the proportion of tests within defined limits, along with agreed range of accuracy of results is required

Objective 2: Input from key personnel in the health board and Public Analyst Laboratories

Summary of the Findings

Information about the operation of water fluoridation within each of the health board areas was obtained by questionnaire sent to the Principal Environmental Health Officers and the Principal Dental Surgeons in each administrative area. Eighty three percent (83%) of respondents reported that the Fluoridation Monitoring Committee was moderately or very effective, 13% reported that it was not effective. Thirteen (13%) of respondents reported visiting water plants regularly and 59% reported visiting

occasionally. The Principal Environmental Health Officer was reported as being the key link person between health board and local authority. Seventy four percent (74%) of respondents reported receiving the monthly reports in four weeks or less.

Summary of the Recommendations

Fluoridation Monitoring Committees

- ❑ Key performance indicators should be identified for monitoring of water fluoridation
- ❑ Nationally agreed minimum protocols for a programme of assessment and visitation need to be developed
- ❑ The differing roles and responsibilities of the key health board personnel need to be defined and circulated to health boards and local authorities
- ❑ The key personnel both in the Sanitary Authority and the Health Board need to be identified by name and contact telephone numbers
- ❑ All Fluoridation Monitoring Committees should provide written reports on the outcomes of visits
- ❑ All Fluoridation Monitoring Committee should produce a standardised annual report for the health board and Department of Health & Children
- ❑ The composition of the Fluoridation Monitoring Committee needs to be redefined in light of changes in structures in health boards and local authorities

Public Analyst Laboratories

- ❑ The legislation should specify a requirement that the monthly test meet internationally recognised standards, and the distillation test should be removed from the Act
- ❑ The application of the "*uncertainty of measurement*" figure on the classification of the results as *Satisfactory*, *Marginal* or *Unsatisfactory* needs to be clarified
- ❑ The Public Analyst Laboratories in conjunction with the health boards should give consideration to introducing and evaluating an alert system for reporting unsatisfactory test results

Objective 3: Assessment of water treatment plants and the supply of the fluoride additive

Summary of the Results

Fourteen water treatment plants in six health board regions and seven local authority areas were visited. The plants were chosen based on the size of the population served and geographic spread around the country. The water treatment plants were assessed under the following headings: source water testing, intake & storage of acid, equipment & preventive maintenance, testing & calibration, incident management & monitoring visits, personnel & training. A series of detailed questions were asked of the plant and engineering personnel under each heading using a template questionnaire (Appendix 6).

Summary of the Recommendations

Source Water Testing

Source water testing is required every 12 months; the results should be retained and reviewed. The effect of interfering substances on source water measurements should be determined.

Dosing Equipment

- ❑ Standard operating procedures, specific to the locally installed dosing equipment are required.
- ❑ The feasibility of providing alarms on pumps should be explored.
- ❑ The minimum frequency of maintenance and calibration of weighing scales should be determined.
- ❑ The design of the room housing the day tank should take account of containment, ventilation, access and egress. The need for cut-out devices to avoid overfill should be examined.
- ❑ Daily records of the amounts of acid used and water treated should be recorded and retained in standard format.

Testing and Test Results

- ❑ A minimum specification for colorimetric test equipment should be devised.
- ❑ A standard operating procedure is required for the methods used to test the fluoride levels.
- ❑ A random or continuing method of verification of the test results could be considered.
- ❑ A standard format results recording sheet should be adopted, results should be retained, electronically.

Preventive Maintenance & Calibration

- ❑ Audit of the existing calibration and maintenance programmes should be undertaken.
- ❑ Preventive maintenance programmes should identify required frequency of maintenance and personnel responsible.

Training

- ❑ Evaluation of the existing formal training programmes in respect of water fluoridation is required.

Intake/Storage of Acid

- ❑ Current practices should be formalised into standard procedures in each plant.
- ❑ The feasibility of introducing low-level access for delivery of acid and non-return dedicated valves should be explored.
- ❑ Bunding or other containment measures sufficient to contain the full volume of the storage tank should be in place.
- ❑ The location and security aspects of storage tanks should be evaluated.
- ❑ The Safety Data Sheet for the acid should be available at all plants together with the emergency phone number for the current acid supplier.
- ❑ Audits of the available the Personal Protective Clothing/Equipment/materials should be undertaken in each plant.

General Recommendation for Water Treatment Plants

All records of calibration, maintenance (internal and external) should be retained at the water treatment plant as well as the Sanitary Authority offices.

Assessment of the controls and procedures used by the supplier of fluoride additive (Hydrofluosilicic Acid)

The company awarded the contract to supply hydrofluosilicic acid should:

- ❑ Consider the need for a product recall procedure
- ❑ Circulate the Safety Data Sheet to all plants on an annual basis
- ❑ Be approached to advise on or provide input into Hazchem Training for Local Authority personnel in handling fluoride products.
- ❑ Provide delivery dockets that indicate the tolerance in sample analysis

3. Background

3.1 Water fluoridation internationally

The history of water fluoridation goes back to 1901 when Dr. Frederick McKay a newly established dentist in Colorado Springs, Colorado, noted an unusual permanent stain or “mottled enamel” (termed “Colorado brown stain” by residents of the area) on the teeth of many of his patients. McKay also observed that teeth affected by this condition seemed less susceptible to dental caries (McKay 1928). In 1930, H. V. Churchill, a chemist with the Aluminium Company of America, used spectrographic analysis, (which had only recently become available) to measure the concentrations of fluoride in the water supplies of the area where extensive mottling was present. Samples were found to contain between 2 to 14 ppm fluoride (Churchill 1931).

In 1931 the Dental Hygiene Unit at the National Institute of Health was established and headed by Dr. H. Trendley Dean. The unit's primary responsibility was to investigate the association between fluoride and mottled enamel. Dean adopted the term “fluorosis” to replace “mottled enamel,” and then developed Dean's Index of Fluorosis in order to measure and classify this condition. He conducted extensive epidemiological surveys of fluorosis levels throughout most of the US (Dean 1942). When data on dental caries prevalence among children in 26 states were compared by Dean with the prevalence of fluorosis, he noted a strong inverse relationship. (Dean 1938). This cross-sectional relationship was subsequently confirmed in a series of studies (the 21 Cities Studies) in Colorado, Illinois, Indiana, and Ohio. Caries among children was lower in cities with concentrations of approximately 1ppm fluoride in their community water supplies while at these levels the prevalence of dental fluorosis was low and mostly in the questionable and very mild categories. (Dean et al 1941, Dean et al 1942)

A prospective study was carried out to test the hypothesis that dental caries could be prevented by adjusting the fluoride level of public water supplies (Ast et al 1956). Four pairs of cities (intervention and control) were included in the study which started in 1945, they were: Grand Rapids and Muskegon, in Michigan; Newburgh and Kingston, in New York; Evanston and Oak Park, in Illinois; and Brantford and Sarnia, in Ontario, Canada. Cross-sectional surveys in these communities, which were carried out over the subsequent 13–15 years, demonstrated that caries was reduced by 50%–70% among children in the communities with fluoridated water. The prevalence of dental fluorosis in the intervention cities was similar to that in areas with naturally occurring levels of approximately 1ppm fluoride.

The current recommended concentrations of fluoride in water supplies are based on the original Galagan formula which relates water consumption (fluid oz/lb.) to mean daily maximum temperatures (Galagan & Vermillion 1957). The Galagan studies on the relationship between annual air temperatures and water intake showed a 60% difference in intake of water between warmer regions and cooler regions of the US (Galagan, Vermillion & Nevitt 1957). In 1962 the US Public Health Service recommended that the level of fluoride in the water should be in the range 0.6-0.8ppm in areas with higher mean daily temperatures (26.3-32.5°C) and 0.9-1.7ppm in areas with mean daily temperatures of 10.0-12.1°C. More recent studies (Heller et al 1999) have reported differences in water consumption of less than 20%, but these related to particular regions and times of the year in the US. In Hong Kong fluoride levels were initially set at 0.9ppm for the cooler months and 0.7ppm for the warmer months. Using the US Public

Health Service guidelines of 1962, the most appropriate concentration for Hong Kong would be 0.8ppm. In 1978 the levels were set at 0.7ppm all year round but it was reduced in 1988 to 0.5ppm, which was found to reduce levels of fluorosis from 64% to 47% (Evans & Stamm 1991). Similarly in Toronto, Canada where fluoridated water has been provided since 1963, the level was reduced from 1.2ppm to 1.0ppm initially and then to 0.8ppm in 1999. The WHO in 1994 recommended a range of 0.5-1.0ppm fluoride. (WHO 1994)

Currently throughout the US, 162 million residents (65.8% of the population) in more than 10,500 communities receive fluoridated public water supplies (CDC 2002). Twenty-six states as well as the District of Columbia have already achieved the *"Healthy People 2010"* national health goal for the US, of providing 75 percent of the population with fluoridated public water systems. Water fluoridation has been selected by the US Centres for Disease Control as one of the 10 great public health achievements of the 20th century.

3.2 History of Water Fluoridation in Ireland

A national dental survey in 1955 highlighted the high levels of dental caries in Ireland at that time (MRC 1955). The then Minister for Health established a *"Fluorine Consultative Council"* in 1956 to examine *"whether it is desirable to provide for an increased intake of fluorine"*. The Council reported back in 1958 recommending the implementation of fluoridation of public water supplies at a level of 1 part per million of fluoride.

The Minister for Health introduced the Health (Fluoridation of Water Supplies) Act in 1960 (Health Act 1960). The legislation withstood legal challenges at both High Court and Supreme Court level before being enacted in 1964. In a High Court hearing lasting 65 days, the counsel for the plaintiff argued that the Act had overridden the inalienable rights of the individual citizen, which the State had a duty to respect and, as far as practicable, to defend by its laws. In his final judgement, delivered in 1963, Mr. Justice Kenny stated: *"None of the personal rights of the citizen are unlimited: their exercise may be limited by the Oireachtas when the common good requires this."* On the question of bodily integrity, Mr. Justice Kenny accepted that it would be oppressive to impose on a country's citizens any process which might be dangerous. But he also accepted arguments that fluoridation was safe and that it constituted no danger to individuals' bodily integrity. He concluded: *"In my judgement, the fluoridation of the public water supplies in this country is not a violation of any of the plaintiff's constitutional rights and this action must be dismissed."* (Kenny 1972)

The judgement of Mr. Justice Kenny was upheld by the Supreme Court in July 1964. Chief Justice O'Dalaigh commented: *"The effect on the teeth (of fluoridation) is demonstrably beneficial. The purpose and the effect of fluoridation is to improve children's teeth and so, indirectly, their health. These benefits are to a great extent carried forward into adult life."* (Ryan v Attorney General 1965)

3.3 Legislation Governing Water Fluoridation in Ireland

The various sections of the Act describe the specific responsibilities of the Minister for Health (now Health & Children), the health authorities and the local authorities in respect of water fluoridation. For example the Minister may fix a date before which the health

authorities are required to arrange for fluoridation of a particular public water supply (Health Act 1960). Prior to making any regulations under this legislation, the Minister for Health was required to fulfil certain conditions:

“(a) cause to be made

- (i) a survey of the incidence of dental caries in a representative sample of pupils attending full-time day schools in the functional area or functional areas of the health authority or health authorities to whom the regulations relate.*
- (ii) An analysis or series of analyses of the quantities of fluorine ...in the water supplied by sanitary authorities through pipes to the public in the functional area of the health authority...”*

To meet this requirement a very large epidemiological study (96,847 children and adolescents aged between 3 and 18 years) representative of each county was undertaken between 1961-63. (Minister for Health 1961-1965) The legislation also requires that source water analysis be carried out prior to introducing water fluoridation into any scheme (Health Act 1960). More than 660 water supplies were sampled and only 5 were found to have levels greater than 0.3ppm of naturally occurring fluoride. (Minister for Health 1961-65)

Section 4 (1) (b) states that: *Every sanitary authority shall, notwithstanding anything contained in the Local Government (Sanitary Services) Acts, 1879 to 1952, or in any local Act relating to the supply of water to the public, comply with any regulations made under this subsection which are applicable to that sanitary authority.*

Section 4 (1) (e) states that: *The appropriate health authority shall pay on demand to a sanitary authority any expense (including payment of loan charges) incurred in a local financial year by that authority under regulations made under this subsection.*

Section 7 enshrines in the legislation the responsibility of the health authorities to estimate the levels of dental caries in their functional areas, so often as the Minister so requires.

3.3.1 Regulations

Regulations in respect of named water supplies were made by Statutory Instrument (SI) for named local authorities (City Corporations, County Councils or Urban District Councils). The Statutory Instrument lists the requirements common to all Statutory Instruments in relation to provision, installation and maintenance of equipment, the arrangements for the addition of fluoride, that water supplies should be fluoridated to a level of between 0.8 to 1ppm fluoride and the testing of the water (daily colorimetric and monthly distillation).

The First Schedule names the specific water supplies being regulated, the supplies are grouped according to county, for example SI Number 71 of 1965 (SI 71/65) relates to supplies in County Meath under the control of Meath County Council, Trim Urban District Council and Ceanannus Mór Urban District Council. Statutory Instrument Number 69 of 1987 (SI 69/87) amended the names of many supplies around the country and added some new schemes. The Second Schedule gives details of the specifications

for the different forms of fluoride which may be added in one of three forms, sodium fluoride, sodium silicofluoride or hydrofluosilicic acid.

3.4 Role of Government Departments, Health Boards & Local Authorities

Within each County Council area there is one or more Sanitary Authority charged with the provision of public water supplies. Sanitary Authorities are a section of the Local Authority organisation and in some urban areas the Sanitary Authority is part of the Urban District Council or the County Borough Corporation rather than the County Council. There are 45 Sanitary Authorities in the original 26 counties of the Republic of Ireland. A recent reorganisation of local government in the County Dublin area has led to the creation of three local authorities in addition to Dublin Corporation. The various roles of the Department of Health & Children and the Department of Environment & Local Government in respect of water fluoridation are defined in the Health Act 1960. These roles are further clarified in circular letter 14/1977 from the Department of Health which includes circulars L9/62 and L6/65 from the Department of Local Government in its appendices (Appendix 1). The National Water Study (2000) estimated that there are at least 6,643 public and privately operated water supply schemes outside the Greater Dublin area.

Currently each health board has a Department of Public Health under the direction of a Director of Public Health who advises the Chief Executive Officer on all aspects of Public Health, including matters relating to public water supplies. The Director of Public Health has considerable legal powers concerning the health aspects of food and water supplies. Formerly these powers rested with the Director of Community Care & Medical Officer of Health in each health board Community Care (administrative) Area. Circular 14/1977 outlined the role of the Director of Community Care in respect of water fluoridation, it also stated that the responsibility for *"monitoring the general operation of the service should be assigned to the Senior Dental Surgeon"*, which is the current position of Principal Dental Surgeon.

In each health board Community Care area there is a Principal Dental Surgeon (PDS) who is head of the dental services and a Principal Environmental Health Officer (EHO) who is head of the Environmental Health Services for that area. Both play key roles in water fluoridation at local level for the health boards. The Principal Dental Surgeon (there are 30 in 10 health boards) has local responsibility for water fluoridation. A more recent development has been the appointment of a Principal Dental Surgeon with regional responsibility for water fluoridation, the responsibilities of this position may require clarification.

The Environmental Health Services of the health boards take the samples for monthly testing of fluoride levels in the water supplies, as required under the Health Act 1960. This testing is carried out by the Public Analyst Laboratories in Dublin, Cork and Galway. In 1992 the Department of Health requested that the Health Boards set up Fluoridation Monitoring Committees in each health board administrative area. The recommended composition of these committees includes senior health board managers, the Principal Dental Surgeon and the Principal Environmental Health Officer as well as representatives of the Local/Sanitary Authorities. The remit of these committees is *"to*

ensure a full exchange of information and a high degree of co-ordination" between the Health Boards and Local Authorities (Appendix 5).

Local Authorities

Only water supplies under the full control of a particular local authority are fluoridated. Some semi-private group water schemes may purchase water from a county council source while the distribution network remains under the control of the private group. Other private group schemes provide their own sources of water. The group water schemes do not come under the scope of the Health Act 1960.

The National Water Study (National Water Study 2000) identified important deficiencies in respect of staffing structures within the Sanitary Authorities which also impact on the provision of fluoridated water:

- ❑ *"Many Sanitary Authority staff work in other sectors, particularly roads, housing and drainage. They therefore can only spend part of their time working on water supply.*
- ❑ *Local Authority staff move around departments changing their roles and responsibilities quite regularly. This has the effect that some staff working in water supply may not have the experience or knowledge of water supply systems to carry out their work efficiently.*
- ❑ *The Sanitary Authorities are under staffed to run effective and efficient water supply systems providing modern standards of service."*

Changes in the administrative structures in local government have taken place in recent years. There is been a trend towards management of geographic areas rather than services as previously. There are variations between local authorities in the manner in which these changes have been implemented. Given the small numbers of water treatment plants in any local authority area it is important that the key personnel at management, engineering and operative level with responsibility for water fluoridation are identified and trained to an acceptable level.

3.4.2 Health Authorities

The roles of the Departments of Health (now Health & Children) and Local Government (now Environment & Local Government), health boards and local authorities were defined in the Health Act 1960. These roles and responsibilities were further clarified and defined by the various Departmental circular letters (Appendix 1), which were issued in the early years of water fluoridation.

Department of Health Circular 14/1977 dated 1st July 1977 (Appendix 1)

This circular letter to all Chief Executive Officers of Health Boards was issued following a review of the progress made in implementing water fluoridation. By that time 135 water supplies serving 1.76 million people were equipped to fluoridate public water supplies. The letter attached to the circular emphasised the importance of monitoring of fluoride levels in water supplies, clarified the responsibilities of the Senior Dental

Surgeon (now Principal Dental Surgeon) as well as making it clear that the circular superseded previous circulars 32/65 and 18/69.

Though restructuring of public health and public dental health services as well as in the local authorities has occurred since these circulars were issued the principles outlined in these circulars remain in force and as relevant now as then. It is very informative to examine some of these sections in more detail.

The circular covers the following issues:

- ❑ Legal and administrative position
- ❑ Financial arrangements
- ❑ Addition of fluoride to water and monitoring fluorine concentration
- ❑ Fluoridation plant maintenance
- ❑ Fluoride supplies
- ❑ Fluoridation of further supplies

Legal and administrative position

This section restated the legal position of the health boards and local authorities as defined in the Health Act. It went on to explain how the changes in the health board structure affected the fluoridation of public water supplies. The memorandum circulated to all health boards and local authorities with Circular 14/1977 states that *"the Department of Health envisages that the responsibility for day to day monitoring of the fluoride content of fluoridated water supplies and generally for implementing the fluoridation programme will normally be assigned to the Chief or Senior Dental Surgeon"*. The local authorities were identified as having responsibility for the installation, maintenance and operation of fluoridation plants.

Financial arrangements

This section identified the areas of expenditure both operational (including maintenance) and capital for which the local authorities would be reimbursed.

Addition of fluoride to water and monitoring fluorine concentration

Section 7 of the Circular covers the issue of testing with subsection (a) restating the requirement for daily colorimetric testing. Section (b) refers to the Department of Local Government circulars on the requirement *"to keep records of the amount of water treated and fluorine used so that the fluorine content can be calculated."* Section (c) advises on actions to be taken in the event of variance between the colorimetric tests and the gravimetric calculation. Section (c) also requires that a report summarising the dosing rates and results of the colorimetric tests be forwarded to the then Director of Community Care & Medical Officer of Health (who had specific legal powers in respect of water at that time) who would then add the results of the monthly distillation test and forward the full report to the Department of Health. This report provided a record of the results of all three testing methods.

Section 7 (d) covers the monthly distillation test and makes it quite clear that *"the Health Inspector or other Health Board Officer, deputed to take the samples of water for the Public Analyst should make sure by consulting with the waterworks staff, that the sample is not taken at a time when the fluoridation plant is being repaired, overhauled or is not otherwise functioning adequately."*

Fluoridation plant maintenance

Section 8 recommends *“that every sanitary authority enter into an arrangement with the suppliers of each fluoridation plant to service the plant at least once a year”*

Fluoride supplies

Apart from advising on maintenance of supplies of acid Section 9 makes the following recommendation *“To ensure that the acid complies with the standard specification a sample of the acid should be taken at the injection point from time to time and sent to the Public Analyst for analysis.”*

Section 10 requires the local authorities to immediately report to the health board any breakdown in the supply of acid.

Circular 14/1977 (Appendix 1) includes as appendices the Department of Local Government circulars L9/62 and L6/65. Circular L9/62 is divided into the following areas: Specification for Chemicals, Specification for Equipment, Point of Application, Control and Testing, Precaution in Handling and Storing Fluoride Chemicals. Circular L6/65 is a memorandum on the use of hydrofluosilicic acid, the specifications for the acid and the injection equipment as well as recommendations about safe storage and handling.

Specifications for acid

The Statutory Instrument also describes the specifications for the hydrofluosilicic acid. *“The acid as supplied shall contain 14 per cent by weight of fluosilicic acid (H_2SiF_6), subject to a tolerance of 0.5 per cent above or below that strength, and shall contain not more than 0.012 per cent by weight “heavy metals” expressed as lead (Pb) and no other soluble mineral or organic substance in quantities capable of a deleterious or injurious effect upon health”.*

Circular L6/65 provided the characteristics of the acid for the above specifications in terms of fluoride ion concentration, specific gravity, weight of 1 litre of acid, weight of fluoride ion in 1 litre of acid and the volume of acid of different specific gravities required to treat 106 litres of water.

3.5 Technical Aspects of Water Fluoridation

The fluoridation of water is only one part of a treatment process involved in the provision of a potable drinking water supply. The general principals of the process are as shown in Figure 1. The CDC Manual for Engineers and Technicians (CDC 1986) lists 49 chemicals that are commonly used in water treatment plants in the US, of which three are different forms of fluoride compounds for use in water fluoridation.

Water treatment may involve several stages, including pre-treatment, clarification, filtration, disinfection, and fluoridation which is usually at the final stage. Where source water is of a very high quality some of these stages may not be required. The concentration of fluoride is monitored daily at the water treatment plant by colorimetric testing and using calculations based on the weight of fluoride compound added to a known volume of water, the gravimetric-volumetric calculation. In some more modern water treatment plants ion specific probes or photospectrometers are used instead of colorimeters to measure fluoride concentrations.

The addition of fluoride is normally the final process in the production of a quality water supply. This is to ensure that there are no undesirable reactions with other chemicals such as alum and lime used in water treatment (CDC 1986). The amount of fluoride added to the water is based on a gravimetric-volumetric formula. Originally the chemical of choice was a sodium silicofluoride, a solid fluoride salt compound fed into the end stage of the water treatment process by a hopper.

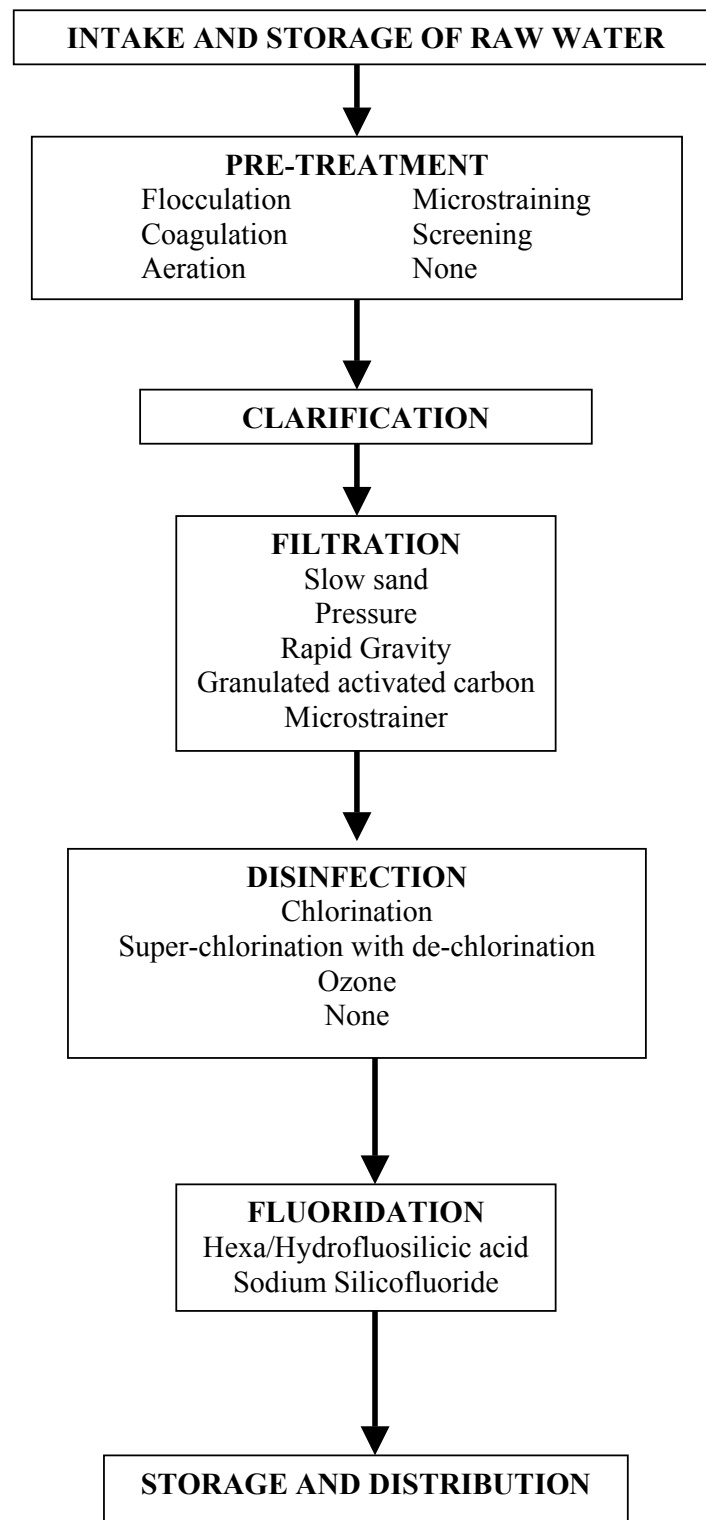
The current agent of choice is liquid hydrofluosilicic acid. This is generally stored in a bulk storage external tank which is banded sufficiently to retain the full contents of the tank in the event of a leak allowing a discharge of the contents. The acid is then pumped to an internal day tank which holds 24-30 hours supply. This tank is usually sited on a platform weighing scales so as to provide a record of the weight of acid fed into the supply, both should be sited in a banded area. The acid is then added to the water proportionate to the rate or flow of water by means of variable flow rate dosing pumps.

The fluoride level in the water at plant level is measured daily so that appropriate adjustments can be made to the dosing pumps if the levels are outside the statutory requirements. In most plants measurements are made with colorimeters, ion specific probes are used in water schemes with their own laboratory facilities.

3.6 Current situation

Initially fluoridation of public water supplies was confined to major centres of population, commencing with Dublin in 1964, followed by Cork in 1965. The percentage of population nationally covered by fluoridated water schemes gradually increased to the current level of 73% coverage with fluoridated water supplies. The remaining 27% of the population is served by group schemes and other private sources of water which do not come under the control of the Health Act 1960. Ongoing upgrading of group schemes by local authorities taking over responsibility for them is occurring. This may result in a continuing increase in the percentage of the population receiving fluoridated water.

Figure 3.1 Water treatment process



4. Assessment of the Testing of Fluoride Levels in Public Water Supplies

Objective 1

- **To analyse the results of testing of fluoride levels in public water supplies for the period 1990-2000.**

4.1 Introduction

Fluoride levels in drinking water are monitored under the Health Act 1960 and the EU Drinking Water Quality Regulations. The Statutory Regulations which implement the Health Act 1960 require mandatory testing of fluoride levels in water supplies on a daily (colorimetric) and monthly (distillation) basis. Monthly test data are collated at health board level by either the Principal Dental Surgeon or the Principal Environmental Health Officer and are sent on a quarterly basis to the Department of Health & Children.

Role of the Environmental Protection Agency (EPA)

Testing of water supplies for a wide variety of parameters (50) including fluoride is carried out by Local Authority or Environmental Health Services personnel. This testing is carried out under the Statutory Instrument 81/1988, which implements the EU Drinking Water Quality Regulations (Directive 80/778/EEC). These regulations specify the parameters to be monitored, the type and frequency of monitoring. The parameters are grouped under the following headings, *Organoleptic*, *Physicochemical*, *Undesirable*, *Toxic* and *Microbiological*. The monitoring may be *Minimum (C1)*, *Current (C2)*, *Periodic (C3)*, *Occasional (C4)*. For the purpose of the Drinking Water Quality Regulations, water supplies are classified according to the volume of water distributed and the population served; these are then used to determine the minimum testing frequency. For example a water supply serving a population of 5,000 people and supplying 2,000m³/day, should have six *Minimum (C1)*, two *Current (C2)* and one *Periodic (C3)* analyses. Whereas a supply serving a population of 500,000 would have minimum of three hundred and sixty C1, sixty C2 and ten C3 analyses carried out each year. The minimum population designated is 1,000, for supplies serving smaller populations the local authority is given discretion depending on whether there were previous problems with the water quality.

It is important to note that these regulations are only concerned with results for the parameters that exceed the maximum admissible concentration (MAC). The Department of the Environment handbook on the implementation of the EU regulations on Drinking Water Quality provides very valuable guidance on practical aspects of the sampling process (Flanagan 1989). The Environmental Protection Agency receives the results of Drinking Water Quality testing; it then collates and comments on them in an annual report.

Materials & Methods:

To meet this objective the following sources of information were available: the monthly test results from the Department of Health & Children's files; the Environmental Protection Agency Annual Reports; the Society of Chief & Principal Dental Surgeons annual reports on the monthly test results for the years 1980-1995. Apart from covering different time periods, each of these three reports presents the data differently. The

Department of Health reports used the terms *Satisfactory*, *Marginal* and *Unsatisfactory*. The EPA reports only exceedances (>1.00ppm) but in different bands from the Department of Health. The Society of Chief & Principal Dental Surgeons reported results in the early years as *Satisfactory* (0.80ppm-1.00ppm) and *Unsatisfactory* (<0.80ppm and >1.00ppm). It was decided to use the data from Department of Health & Children's files, using the records of the actual test values for the analysis of the period 1990-2000. Where some data were missing the various health boards provided some of these data from their own files. The EPA annual reports for 1995-2000 were also examined and are reported on. The Society of Chief & Principal Dental Surgeons reports were used in a limited way in some of the analysis where no other data were available.

4.2 Results of the analysis of Department of Health & Children data

These results were categorised as *Satisfactory*, *Marginal* or *Unsatisfactory*. The *Satisfactory* results were those which lie within the statutory limits of 0.80 to 1.00ppm. The *Marginal* results were those which were equal to 0.70ppm and less than 0.80 (0.70<0.80) as well as those greater than 1.00ppm and up to an including 1.10ppm (>1.00 ≤1.10ppm). *Unsatisfactory* results were those which are less than 0.70ppm (<0.70) and greater than 1.10ppm (≥1.11ppm).

The number of missing results is also reported in this analysis as well of the number of repeat tests. It should be borne in mind that an industrial dispute in the Environmental Health Services of the health boards which occurred in 1996 and 1997 severely disrupted the testing programme in those years. This industrial action accounts for most of the missing results in the analysis. The results are presented by health board.

(i) Eastern Health Board/Eastern Regional Health Authority (EHB/ERHA)

Counties	Dublin, Kildare, Wicklow	
Local Authorities	Dublin Corporation Fingal Co. Council South Dublin Co. Council Dun Laoghaire-Rathdown Co. Council Kildare Co. Council Wicklow Co. Council	Athy UDC Naas UDC Arklow UDC Bray UDC Wicklow UDC
Population (2002)	1.4 million	
Number of Principal Dental Surgeons	3 (of 8) with responsibility for water fluoridation	
Number of water treatment plants	14-21	

In the Eastern Health Board (now the Eastern Regional Health Authority) there are 8 Principal Dental Surgeons but only three with responsibility for water fluoridation. There is one corporation area and 5 county councils with responsibility for water fluoridation. The number of water treatment plants in this health board in the period examined ranged from 14-21 supplies, serving a population of 1.3 million (Census 2002).

Figure 4.1 shows the percentages of the results in the different categories as well as the percentage of missing results for the years 1990-2000 for the Eastern Health Board region. The results for the individual areas of the Eastern Health board are shown in

Appendix 4. During this period in the Dublin area, the percentage of tests in the *Satisfactory* category ranged from 64.2% to 94%. The percentage of tests in the *Unsatisfactory* category ranged from 0% to 16.8%. Six of the years analysed had no *Unsatisfactory* results above 1.10ppm (U+), the range was 1.1% to 6.5%. In four years of the period examined there were no results *Missing*. In the other years the percentage of results *Missing* ranged between 1.2% and 93.8%.

For the period 1990-2000, Kildare and Wicklow had a wider variation in results than the Dublin area, which probably reflects the issues related to the size of the water treatment plants, a factor which is common to many other areas.

In Kildare the range of *Satisfactory* results was 33.3% to 76.7%, with *Unsatisfactory* ranging from 4% to 33%. The range of results above 1.10ppm (U+) was 1.4% to 9.7% with only one year having no results greater than 1.10ppm (U+). Six of the years analysed had no *Unsatisfactory* results above 1.10ppm (U+), the range was 1.1% to 6.5%. In three years of the period examined there were no results *Missing*, in the other years the percentage of results *Missing* ranged between 3.2% and 26.4% there was one year for which no results were available.

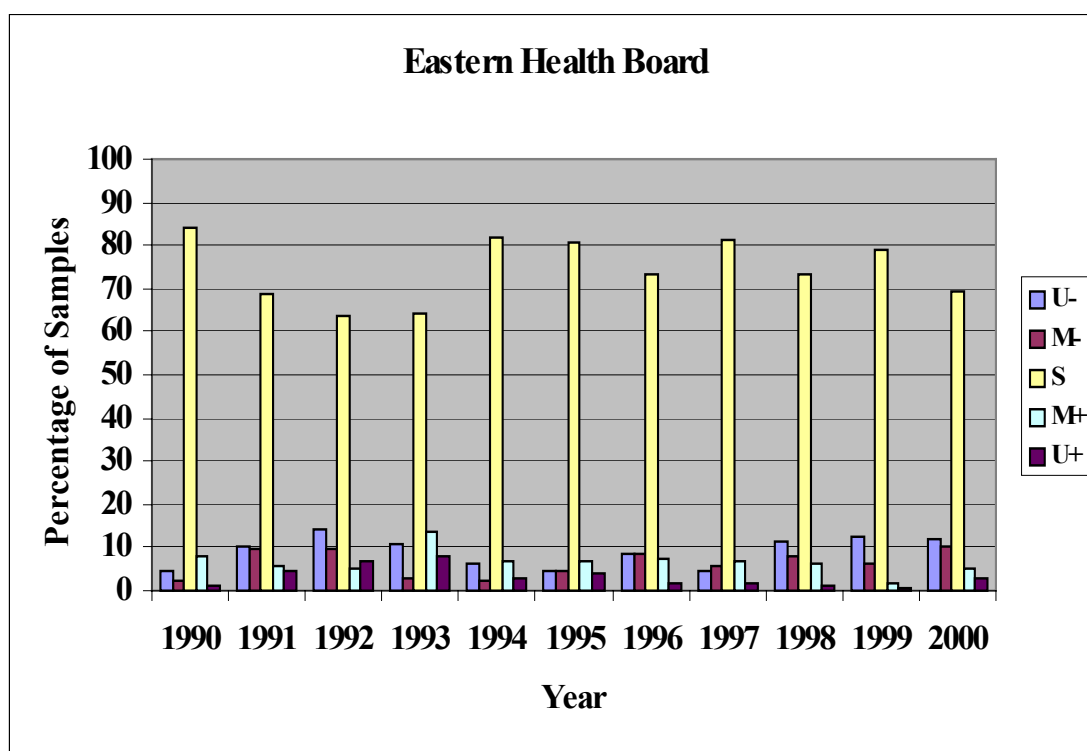


Figure 4.1 Test results by category in the Eastern Health Board by year

Legend: U- is unsatisfactory under the statutory limit. M- is marginal under the limit, S is within the statutory limits, M+ is marginal above the statutory limit, U+ is unsatisfactory above the statutory limit.

In Wicklow the *Satisfactory* range was 41.7% to 81.7%, while the *Unsatisfactory* group ranged from 1.9% to 37.5%. In the 7 years with unsatisfactory results greater than 1.10ppm the range was 2.0% to 14% with three years having no results exceeding 1.10ppm. In two years of the period examined there were no results *Missing*, in the other years the percentage of results missing ranged between 1.4% and 29.2% and there was one year for which no results were available.

Data for the County Dublin area were not available for 1994, 1997 and 1998. For these years the data included in this report are that in respect of water supplies under the control of Dublin Corporation. In order to obtain some information about the years with all or much of the data missing the reports of the Society of Chief & Principal Dental Surgeons were examined. There was one such report for 1994 but not for 1997 and 1998. The 1994 report indicated that in the Dublin area 92% of results were in the *Satisfactory* range and 4% were in the *Marginal* category, with 1 result missing. The Society of Chief & Principal Dental Surgeons report for 1990 indicated that in Wicklow 75% of results were *Satisfactory* and 5% were over 1ppm. The same report indicated that in Kildare the figures were that 28% were satisfactory and 41% were over 1ppm.

(ii) Midland Health Board (MHB)

Counties	Laois, Offaly, Longford, Westmeath	
Local Authorities	Laois Co Council Offaly Co. Council Longford Co. Council Westmeath Co. Council	Longford UDC Birr UDC Tullamore UDC Athlone UDC
Population (2002)	225,588	
Number of Principal Dental Surgeons	2	
Number of water treatment plants	24-40	

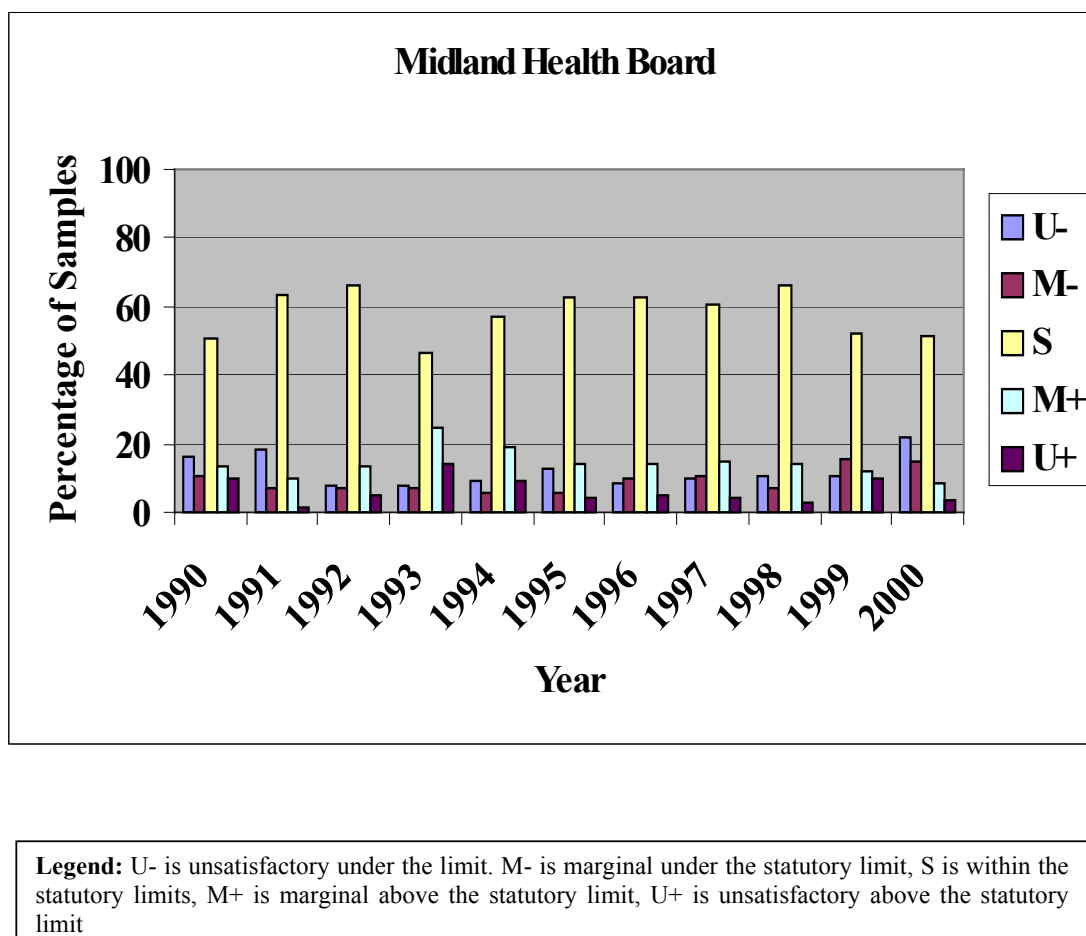
In the Midland Health Board there are 2 dental areas (Laois-Offaly and Longford-Westmeath) each with a Principal Dental Surgeon responsible for water fluoridation in their administrative area. There are 4 county councils with responsibility for providing fluoridated water supplies. The number of water treatment plants in this health board in the period examined ranged from 24 to 40 serving a population of 205,000 (Census 2002).

Figure 4.2 shows the results for the Midland Health Board region for 1990-2000, including the breakdown of the unsatisfactory and marginal results above and below the statutory limits.

The results for the individual areas of the Midland Health board are shown in Appendix 4. During this period in the Laois Offaly area, the percentage of tests in the *Satisfactory* category ranged from 41.6% to 65.7%. The percentage of tests in the *Unsatisfactory* category ranged from 14.9% to 32.8%, while between 0.74% and 12.4% of the unsatisfactory results were above 1.10ppm, with all years having some results in the this category. The percentage of results *Missing* for the period ranged between 3.1% and 78.8% with all years having some results missing.

In the Longford Westmeath area, the percentage of tests in the *Satisfactory* category ranged from 37.8% to 64.3%. The percentage of tests in the *Unsatisfactory* category ranged from 12.2% to 43.1%, with between 0.64% and 14.7% of the unsatisfactory results above 1.10ppm, with all years having some results in this category. In seven years of the period examined there were no results *Missing*, in the other years the percentage of results *Missing* ranged between 0.6% and 9.6%.

Figure 4.2 Test results by category in the Midland Health Board by year



(iii) Mid Western Health Board (MWHB)

Counties	Clare, Limerick, North Tipperary	
Local Authorities	Clare Co. Council Limerick Corporation Limerick Co. Council North Tipperary Co. Council	Ennis UDC Kilrush UDC Limerick CBC Nenagh UDC Templemore UDC Thurles UDC
Population (2002)	339,930	
Number of Principal Dental Surgeons	3	
Number of water treatment plants	24-32	

In the Mid Western Health Board there are 3 dental areas each with a Principal Dental Surgeon responsible for water fluoridation in their administrative area. There are 3 county councils providing fluoridated water. The number of water treatment plants in this health board in the period examined ranged from 24 to 32, serving a population of 317,000 (Census 2002).

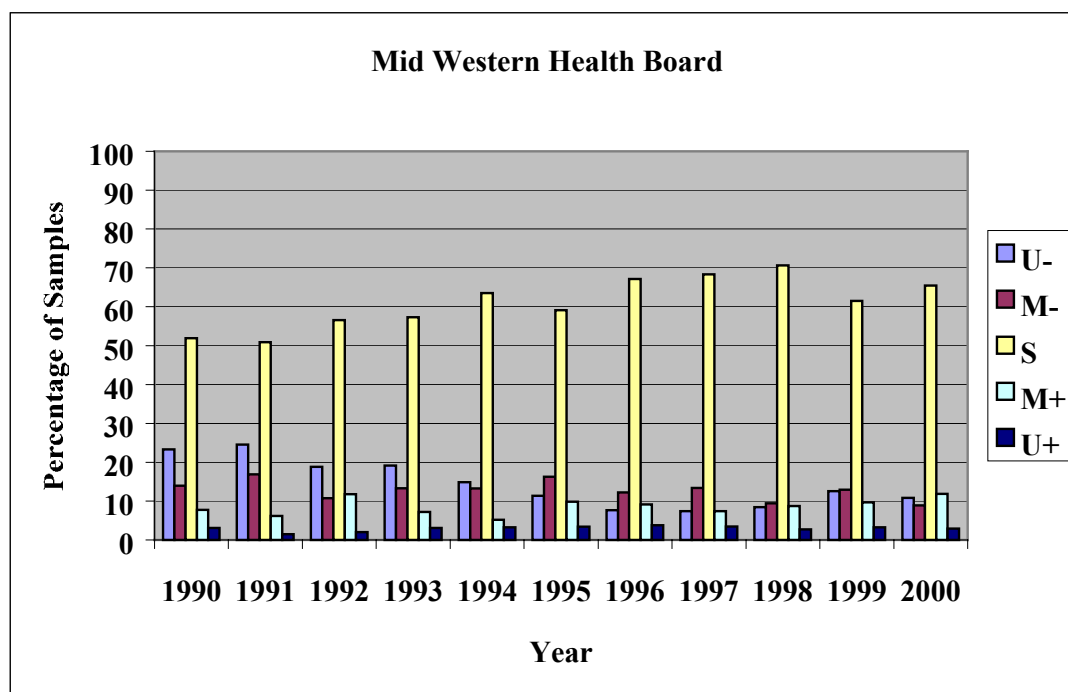
Figure 4.3 shows the results for the Mid Western Health Board region for 1990-2000, including the breakdown of the unsatisfactory and marginal results above and below the statutory limits. The results for the individual areas of the Mid Western Health board are shown in Appendix 4.

During this period in the Limerick area, the percentage of tests in the *Satisfactory* category ranged from 53.7% to 68.3%. The percentage of tests in the *Unsatisfactory* category ranged from 9.1% to 21.3%, between 3.7% and 7.6% of the unsatisfactory results were above 1.10ppm, with all years having some results in the this category. In four years of the period examined there were no results *Missing*, in the other years the percentage of results *Missing* ranged between 2.8% and 41.7%.

During this period in the Clare area, the percentage of tests in the *Satisfactory* category ranged from 49.6% to 79.1%. The percentage of tests in the *Unsatisfactory* category ranged from 6.1% to 23.5%, with between 1.0% and 5.1% of the unsatisfactory results were above 1.10ppm, with all years having some results in the this category. The percentage of results *Missing* for the period ranged between 0.8% and 60.4% with all years having some results missing.

In the North Tipperary area the availability of results was quite limited with between 6.3% and 85.4% of results missing with all years having some results missing. Of those results available for the analysis between 36.1% and 71.2% were *Satisfactory* and between 12.1% and 49.4 were *Unsatisfactory*. In only 3 of the 11 years examined were there results in excess of 1.10ppm, the range was 1.6% to 2.9%.

Figure 4.3 Test results by category in the Mid Western Health Board by year



Legend: U- is unsatisfactory under the limit. M- is marginal under the statutory limit, S is within the statutory limits, M+ is marginal above the statutory limit, U+ is unsatisfactory above the statutory limit

(iv) North Eastern Health Board (NEHB)

Counties	Cavan, Monaghan, Louth, Meath	
Local Authorities	Cavan Co. Council Monaghan Co. Council Louth Co. Council Meath Co. Council Drogheda Corporation Dundalk UDC Cavan UDC	Carrickmacross UDC Castleblaney UDC Clones UDC Monaghan UDC Kells UDC Navan UDC Trim UDC
Population (2002)	344,926	
Number of Principal Dental Surgeons	3	
Number of water treatment plants	23-29	

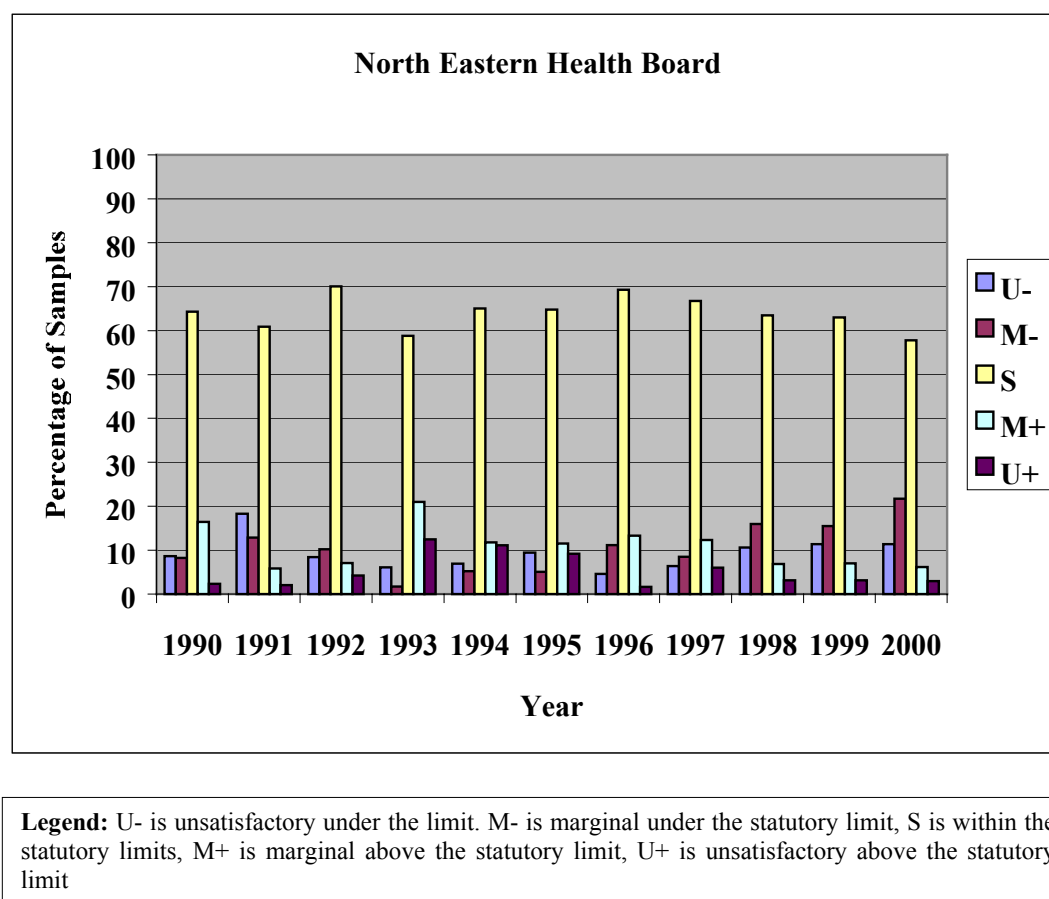
In the North Eastern Health Board there are 3 dental areas (Cavan-Monaghan, Louth & Meath) each with a Principal Dental Surgeon responsible for water fluoridation in their administrative area. There are 5 county councils with providing fluoridated water. The number of water treatment plants in this health board in the period examined ranged from 23 to 29, serving a population of 309,000 (Census 2002).

Figure 4.4 shows the results for the North Eastern Health Board region for 1990-2000, including the unsatisfactory and marginal results above and below the statutory limits. The results for the individual areas of the North Eastern Health board are shown in Appendix 4.

During this period in the Cavan-Monaghan area, the percentage of tests in the *Satisfactory* category ranged from 19.7% to 68.9%. The percentage of tests in the *Unsatisfactory* category ranged from 5.3% to 36.7%, between 2.3% and 25% of the unsatisfactory results were above 1.10ppm, with all years having some results in the this category. In five years of the period examined there were no results *Missing*, in the other years the percentage of results *Missing* ranged between 1.5% and 20.5%.

During this period in the Louth area, the percentage of tests in the *Satisfactory* category ranged from 50% to a very laudable 95%. The percentage of tests in the *Unsatisfactory* category ranged from 1.0% to 30%, with between 1% and 6.5% of the unsatisfactory results were above 1.10ppm, one year had no results in this category. In two years of the period examined there were no results *Missing*, in the other years the percentage of results *Missing* ranged between 2.1% and 9.4%.

Figure 4.4 Test results by category in the North Eastern Health Board by year



In the Meath area the percentage of tests in the *Satisfactory* category ranged from 46.2% to 78.3%. The percentage of tests in the *Unsatisfactory* category ranged from 6.3% to 24.6%, with between 1.1% and 12.5% of the unsatisfactory results were above 1.10ppm. In one year of the period examined there were no results *Missing*, in the other years the percentage of results *Missing* ranged between 4.1% and 94.4%.

(v) North Western Health Board (NWHB)

Counties	Donegal, Leitrim, Sligo	
Local Authorities	Donegal Co. Council Leitrim Co. Council Sligo Co. Council	Buncrana UDC Bundoran UDC Letterkenny UDC Sligo BDC
Population (2002)	221,376	
Number of Principal Dental Surgeons	2	
Number of water treatment plants	17-23	

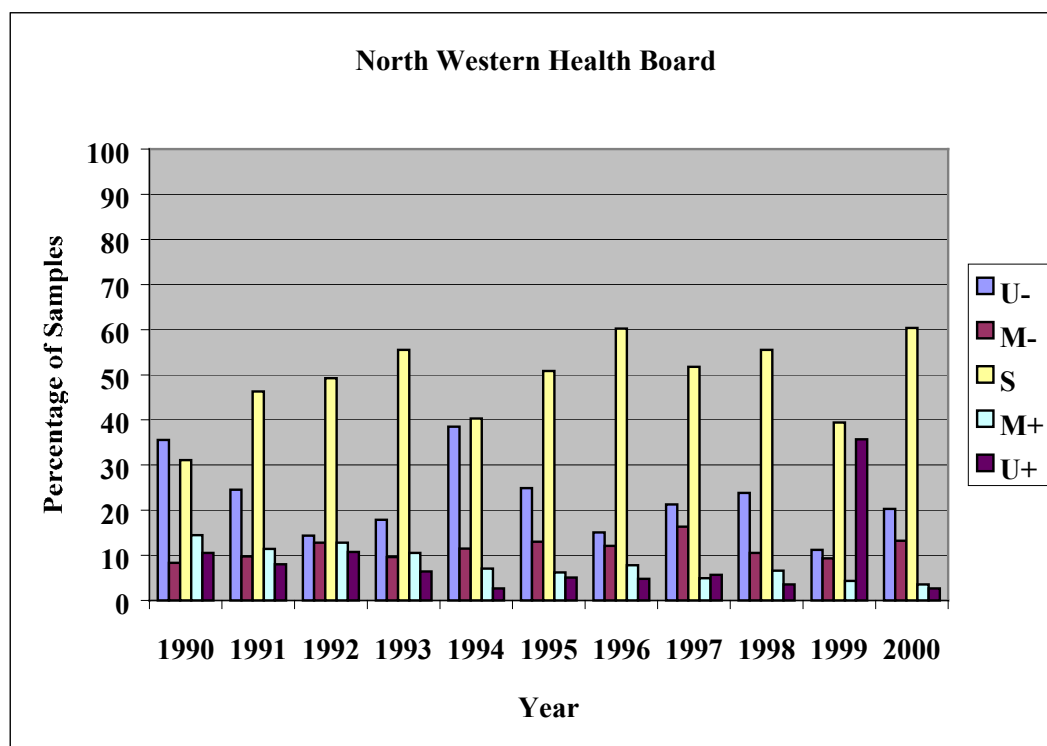
In the North Western Health Board area there are 2 dental areas (Donegal and Sligo-Leitrim) each with a Principal Dental Surgeon responsible for water fluoridation in their administrative area. There are 3 county councils with responsibility for water fluoridation. The number of water treatment plants in this health board in the period examined ranged from 17 to 23, serving a population of 210,000 (Census 2002).

Figure 4.5 shows the results for the North Western Health Board region for 1990-2000, including the breakdown of the unsatisfactory and marginal results above and below the statutory limits. The results for the individual areas of the North Western Health board are shown in Appendix 4.

During this period in the Donegal area, the percentage of tests in the *Satisfactory* category ranged from 30.5% to 67.1%. The percentage of tests in the *Unsatisfactory* category ranged from 18.1% to 52.1%, with between 3.4% and 12.7% of the unsatisfactory results were above 1.10ppm, with all years having some results in the this category. The percentage of results *Missing* for the period ranged between 9.1% and 50.7% with all years having some results missing.

During this period in the Sligo-Leitrim area, the percentage of tests in the *Satisfactory* category ranged from 29.0% to 74.7%. The percentage of tests in the *Unsatisfactory* category ranged from 3.8% to 51.6%, with between 1.2% and 7.5% of the unsatisfactory results above 1.10ppm, with all years having some results in the this category. In two years of the period examined there were no results *Missing*, in the other years the percentage of results missing ranged between 5.9% and 27.1%.

Figure 4.5 Test results by category in the North Western Health Board by year



Legend: U- is unsatisfactory under the limit. M- is marginal under the statutory limit, S is within the statutory limits, M+ is marginal above the statutory limit, U+ is unsatisfactory above the statutory limit

(vi) South Eastern Health Board (SEHB)

Counties	Carlow, Kilkenny, South Tipperary, Waterford, Wexford	
Local Authorities	Carlow Co. Council Kilkenny Co. Council Tipperary (SR) Co. Council Waterford Co. Council Wexford Co. Council Waterford CBC Kilkenny CBC Clonmel CBC	Carlow UDC Carrick-on-Suir UDC Cashel UDC Tipperary UDC Dungarvan UDC Enniscorthy UDC New Ross UDC
Population (2002)	523,540	
Number of Principal Dental Surgeons	4	
Number of water treatment plants	32-46	

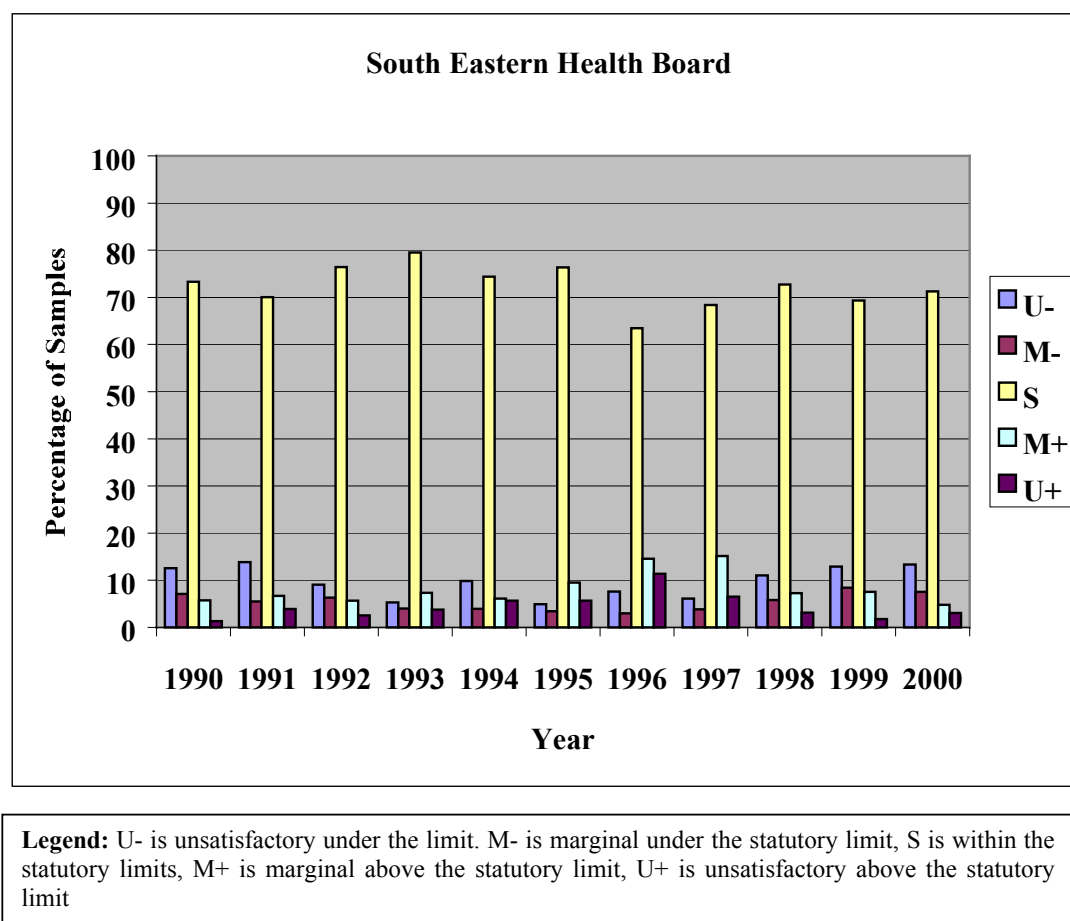
In the South Eastern Health Board area there are 4 dental areas (Carlow-Kilkenny, Tipperary South, Waterford, and Wexford) each with a Principal Dental Surgeon

responsible for water fluoridation in their administrative area. There are 5 county councils providing fluoridated water. The number of water treatment plants in this health board in the period examined ranged from 32 to 46, serving a population of 391,000 (Census 2002).

Figure 4.6 shows the results for the South Eastern Health Board region for 1990-2000, including the breakdown of the unsatisfactory and marginal results above and below the statutory limits. The results for the individual areas of the South Eastern Health board are shown in Appendix 4.

During this period in the Carlow-Kilkenny area, the percentage of tests in the *Satisfactory* category ranged from 54.2% to 80.5%. The percentage of tests in the *Unsatisfactory* category ranged from 9.8% to 34.5%, with between 1.2% and 13.3% of the unsatisfactory results were above 1.10ppm, with all years having some results in this category. In five years of the period examined there were no results *Missing*, in the other years the percentage of results *Missing* ranged between 1.2% and 20.2%.

Figure 4.6 Test results by category in the South Eastern Health Board by year



During this period in the South Tipperary area, the percentage of tests in the *Satisfactory* category ranged from 42.5% to 78.9%. The percentage of tests in the *Unsatisfactory* category ranged from 2.1% to 43.1%, with the range of *Unsatisfactory results* in excess of 1.10ppm from 0.81% to 8.98%, with all years having some results in the this category. The percentage of results *Missing* for the period ranged between 0.7% and 50.0% with all years having some results missing.

In the Waterford area the percentage of tests in the *Satisfactory* category ranged from 78.3% to a very laudable 92.2%. The percentage of tests in the *Unsatisfactory* category ranged from 2.4% to 9.6%, with the range of *Unsatisfactory results* in excess of 1.10ppm from 0.54% to 9.6%, one year had no results in this range. In two years of the period examined there were no results *Missing*, in the other years of the percentage of results *Missing* ranged between 1.0% and 30.2%.

In the Wexford area the percentage of tests in the *Satisfactory* category ranged from 58.8% to 87.8%. The percentage of tests in the *Unsatisfactory* category ranged from 3.3% to 21.1%, with the range of *Unsatisfactory results* in excess of 1.10ppm from 0.8% to 15.8%, two years had no results in this range. The percentage of results *Missing* for the period ranged between 1.7% and 36.7% with all years having some missing results.

(vii) Southern Health Board (SHB)

Counties	Cork, Kerry	
Local Authorities	Cork Co. Council Kerry Co. Council Cork CBC Clonakilty UDC Cobh UDC Fermoy UDC Kinsale UDC Fermoy UDC	Kinsale UDC Macroom UDC Mallow UDC Middleton UDC Skibbereen UDC Youghal UDC Killarney UDC Listowel UDC Tralee UDC
Population (2002)	580,605	
Number of Principal Dental Surgeons	5	
Number of water treatment plants	40-49	

In the Southern Health Board area there are 5 dental areas (Cork North, Kerry, North Lee, South Lee, and West Cork) each with a Principal Dental Surgeon responsible for water fluoridation in their administrative area. There are 2 county councils providing fluoridated water. The number of water treatment plants in this health board in the period examined ranged from 40 to 49, serving a population of 550,000 (Census 2002).

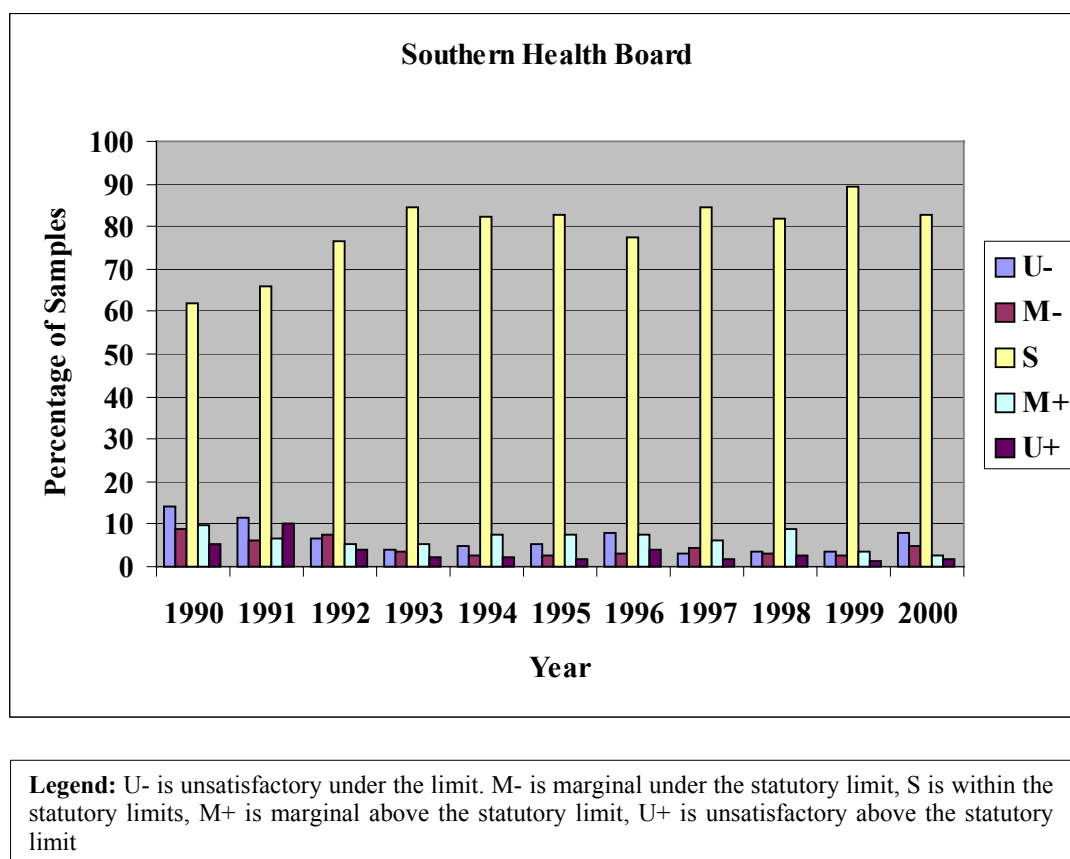
Figure 4.7 shows the results for the Southern Health Board region for 1990-2000, including the breakdown of the unsatisfactory and marginal results above and below the statutory limits. The results for the individual areas of the Southern Health Board are shown in Appendix 4.

During this period in the Cork North area, the percentage of tests in the *Satisfactory* category ranged from 75.0 % to 91.1%. The percentage of tests in the *Unsatisfactory* category ranged from 4.1% to 15.9%, between 0.58% and 3.2% of the unsatisfactory results were above 1.10ppm, three years had no results in this range. The percentage of results *Missing* for the period ranged between 1.5% and 33.3% with all years having some results missing.

During this period in the West Cork area, the percentage of tests in the *Satisfactory* category ranged from 57.7% to a very laudable 91.7%. The percentage of tests in the *Unsatisfactory* category ranged from 3.7% to 24.7%, between 1.2% and 4.8% of the unsatisfactory results were above 1.10ppm with 4 years having no results above that limit. In five years of the period examined there were no results *Missing*, in the other years the percentage of results *Missing* ranged between 1.2% and 3.6%.

In the Kerry area the percentage of tests in the *Satisfactory* category ranged from 37.5% to 84.1%. The percentage of tests in the *Unsatisfactory* category ranged from 9.5% to 45.4%, with between 2.3% and 30.0% of the unsatisfactory results above 1.10ppm, with all years having some results in the this category. In two years of the period examined there were no results *Missing*, in the other years the percentage of results *Missing* ranged between 1.5% and 45.4% and there was one year with no results available.

Figure 4.7 Test results by category in the Southern Health Board by year



In the North Lee area the percentage of tests in the *Satisfactory* category ranged from 55% to a very laudable 92.5%. The percentage of tests in the *Unsatisfactory* category ranged from 3.3% to 13.5%, with between 1.7% and 4.6% of the unsatisfactory results above 1.10ppm, two years had no results in this category. In seven years of the period examined there were no results *Missing*, in the other years the percentage of results *Missing* ranged between 0.83% and 75%.

In the South Lee area the percentage of tests in the *Satisfactory* category ranged from 60.7% to an exceptional 100%. The percentage of tests in the *Unsatisfactory* category ranged from 2.7% to 62.1% with one year having no unsatisfactory results. Between 2.7% and 10.7% of the unsatisfactory results were above 1.10ppm, with 5 years having no results above this limit. In three years of the period examined there were no results *Missing*, in the other years the percentage of results *Missing* ranged between 2.8% and 25%.

(viii) Western Health Board (WHB)

Counties	Galway, Mayo, Roscommon	
Local Authorities	Galway Co Council Mayo Co. Council Roscommon Co. Council Galway CBC	Ballinasloe UDC Ballina UDC Castlebar UDC Westport UDC
Population (2002)	380,057	
Number of Principal Dental Surgeons	3	
Number of water treatment plants	19-23	

In the Western Health Board area there are 3 dental areas (Galway, Mayo, and Roscommon) each with a Principal Dental Surgeon responsible for water fluoridation in their administrative area. There are 3 county councils providing fluoridated water. The number of water treatment plants in this health board in the period examined ranged from 19 to 23, serving a population of 352,000 (Census 2002).

Figure 4.8 shows the results for the Western Health Board region for 1990-2000 including the breakdown of the unsatisfactory and marginal results above and below the statutory limits. The results for the individual areas of the Eastern Health board are shown in Appendix 4.

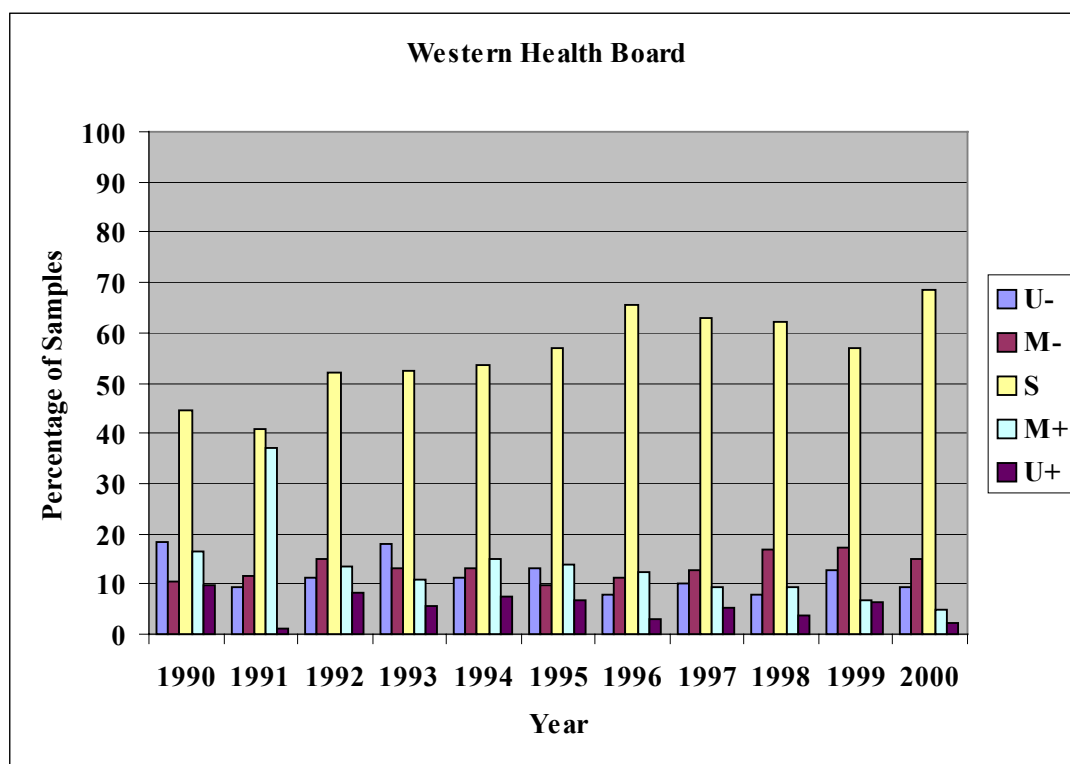
During this period in the Galway area, the percentage of tests in the *Satisfactory* category ranged from 52.0% to 76.1%. The percentage of tests in the *Unsatisfactory* category ranged from 3.3% to 23.4%, with between 3.0% and 13.4% of the unsatisfactory results were above 1.10ppm, one year had no results in this category. In three years of the period examined there were no results *Missing*, in the other years the percentage of results *Missing* ranged between 2.1% and 41.0%.

In the Mayo area, the percentage of tests in the *Satisfactory* category ranged from 37.3% to 68.2%. The percentage of tests in the *Unsatisfactory* category ranged from 10.9% to

39.0%, with between 3.1% and 16.1% of the unsatisfactory results were above 1.10ppm, with all years having some results in the this category. The percentage of results *Missing* for the period ranged between 0.8% and 12.1% with all years having some missing results.

In the Roscommon area the percentage of tests in the *Satisfactory* category ranged from 42.2% to 74.5%. The percentage of tests in the *Unsatisfactory* category ranged from 7.2% to 29.4%, with between 2.1% and 6.5% of the unsatisfactory results were above 1.10ppm and 2 years having no results above that limit. In one year of the period examined there were no results *Missing*, in the other years the percentage of results *Missing* ranged between 0.9% and 64.8.1%.

Figure 4.8 Test results by category in the Western Health Board by year



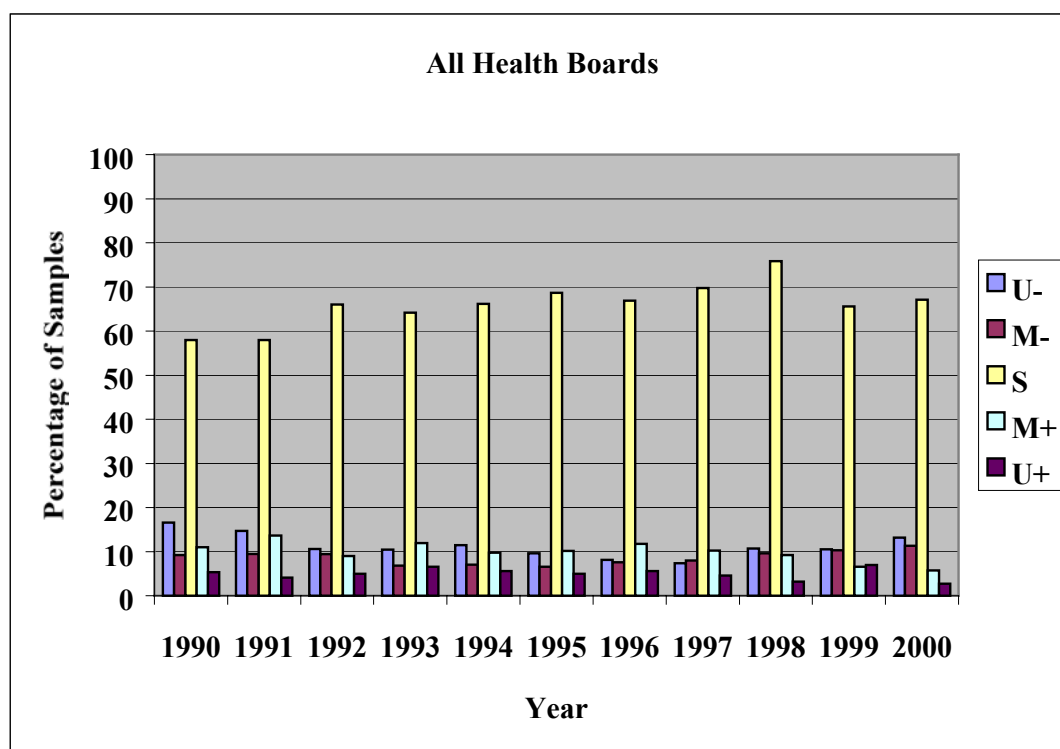
Legend: U- is unsatisfactory under the limit. M- is marginal under the statutory limit, S is within the statutory limits, M+ is marginal above the statutory limit, U+ is unsatisfactory above the statutory limit

(ix) All Health Boards

The data for the eight health boards were collated to give a composite result for the whole country as seen in Figure 4.9. The percentage of results within the statutory limits ranged from 57.9% to 75.8%. The percentage in the *Unsatisfactory* category exceeding the statutory limit ranged from 2.7% in 2000 to 6.9% in 1999, with a trend towards fewer unsatisfactory exceedances in later years. The *Marginal* exceedances ranged from 5.6% in 2000 to 13.7% in 1991. There was a trend over the period for the total percentage of *Marginal* and *Unsatisfactory* exceedances to decrease.

The proportion of the results in the *Satisfactory* category varied widely over the period examined within and between areas. There was a general trend that the more densely populated areas had higher percentages in the *Satisfactory* category though this was not universally the case. The proportion of results in the *Unsatisfactory* category above the statutory limit also varied between areas and years though it was in general low.

Figure 4.9 Test results by category in all health boards by year



Legend: U- is unsatisfactory under the limit. M- is marginal under the statutory limit, S is within the statutory limits, M+ is marginal above the statutory limit, U+ is unsatisfactory above the statutory limit

Discussion:

Logistical issues:

For the data included in this report the ratio of the number of water treatment plants to population varies from 1: 5,000 in the Midland Health Board to a maximum of 1: 93,000 in the Eastern Regional Health Authority. Major plants supplying large populations tend to have more sophisticated equipment as well as more personnel, most of whom are highly trained. The areas with multiple small plants supplying small populations are faced with greater logistical problems in maintaining fluoride levels within the statutory range. In a survey of knowledge levels of water treatment plant operators in the US, Lalumandier et al (2001) noted that operators at small water treatment plants reported significantly more variation caused by operator error. The US survey also identified mains water flow variations and feeder problems as the main causes of variation from optimal fluoride concentrations due to equipment failure.

The difficulties caused by scale in the provision of water are also noted in the National Water Study, (2000) which made suggestions about regionalisation of water management.

Identification of water supplies:

One of the difficulties experienced during the collation of the test results data was the identification of water supplies being fluoridated. In some cases the names changed over the period or were known locally by different names or the scheme was extended or discontinued. This points to the need for an unambiguous identifier which links the schemes to the Sanitary Authority and health board area responsible for water fluoridation.

Accuracy & Categorisation of results:

It should be noted that in this analysis of the Department of Health & Children's monthly tests all results were reported to 2 decimal places. The effect of this was that 1.10ppm was counted as *Marginal* and 1.11ppm as *Unsatisfactory*. This correction represented a slight variation from the original Department of Health & Children method of reporting.

Currently the Public Analyst Laboratories are implementing a new ISO 17025 Laboratory Accreditation Standard which will introduce an "*uncertainty of measurement*" value for all test results. The Public Analyst Laboratory in Cork is quoting an uncertainty of measurement value of ± 0.044 ppm. This means that any report from this laboratory up to 1.044 may in fact be within the upper statutory limit of 1.0ppm. This development highlights the issue of the accuracy of the testing equipment at plant level compared with the Public Analyst Laboratories equipment.

The Public Analyst Laboratories may be required under their ISO accreditation to be in a position to report results to three decimal places accompanied a figure for degree of uncertainty. Currently in most water treatment plants neither the expertise nor the test equipment is available at plant level to attain the same degree of accuracy. The reporting of test results should take these factors into account. It could be argued that the Department of Health & Children in reporting the results as *Satisfactory*, *Marginal* and *Unsatisfactory* is taking into account issues such as the accuracy of equipment at water treatment plant level and the uncertainty of measurement of existing tests.

Role of the Monthly Test:

The monthly test is not useful for the day-to-day management of water fluoridation levels. As stated in Circular 14/1977 Section 7 (d) *"the monthly distillation test is intended to be an independent check at regular intervals of the fluoride content of the water"*. In order to maintain close control over the fluoride levels the colorimetric and gravimetric results should be monitored at plant level daily and by the designated engineering and health board personnel on a monthly basis.

Control Range:

The US Public Health Service has recommended an Acceptable Control Range of 0.1 below and 0.5ppm above the optimal concentration. In some states of the US where the optimal concentration is 1.0ppm the Acceptable Control Range varies 0.9-1.6ppm in Iowa to 0.9-1.2ppm in Illinois. In Colorado where the optimal fluoride concentration is 0.9-1.1ppm, the Control Range is 0.7-1.3ppm (Lalumandier et al 2001).

The 1987 UK *"Code of Practice on Technical Aspects of Fluoridation of Water Supplies"* laid down the following operational criteria:

- ❑ *The mean fluoride content of the water leaving the works in a calendar month is maintained between 0.9 and 1.1ppm, calculated for those periods when the fluoridation plant is in operation;*
- ❑ *The fluoride content of the water leaving the works is maintained between 0.8 and 1.2ppm for at least 90% of the time when the fluoridation plant is in operation;*
- ❑ *The fluoride content of the water leaving the works shall not exceed 1.5ppm at any time*

Changing the Maximal Admissible Concentration:

The maximal admissible concentration (MAC) is defined in the Health Act 1960 as one part per million fluoride. The Statutory Instruments describe the range as 0.8 to 1.0 part per million fluoride. The report of the Forum of Fluoridation launched in September 2002 (Department of Health & Children 2002) made a recommendation that the range should be lowered to 0.6-0.8ppm fluoride with a target value of 0.7ppm fluoride. In view of this recommendation it would also be opportune to define a Control Range and operational criteria as in the UK or US guidelines rather than simply reduce the values of the range.

4.3 Results of the analysis of the Environmental Protection Agency data

Environmental Protection Agency (EPA) Annual Reports

The data from the EPA annual reports from 1995 to 2000 were also examined. The EPA receives the results of tests carried out under the requirements of the EU Drinking Water Quality regulations (Directive 80/778/EEC), which have been incorporated into Irish legislation under Statutory Instrument No 81/1988. All test results that are less than 1.00ppm are reported by the EPA as complying with the requirements of this legislation.

It is very difficult to make comparisons between the Department of Health data and the EPA data for the following reasons: (i) the EPA data is presented by local authority

(corporation, county council or urban district council) area without reference to the number or names of the water schemes (ii) the EPA only reports exceedances (>1.00ppm) (iii) the ranges of exceedances used in the EPA analysis differ from those of the Department of Health & Children (iv) in some years there was no data for particular local authorities. In spite of these difficulties it is still useful to examine the trends in the data.

Table 4.1 Numbers of water supplies, samples & Sanitary Authorities reporting results

Year	No of supplies	No of samples	No of Sanitary Authorities reporting results
1995	336	3608	50
1996	438	5361	43
1997	435	5431	43
1998	444	6674	42
1999	460	7082	40
2000	360	7445	42

Table 4.1 indicates the numbers of public water supplies, the numbers of samples and the numbers of sanitary authorities submitting reports of fluoride testing under the Drinking Water Quality Regulations for 1995-2000. These results refer to water supplies serving populations of more than 1,000 people. The variation in the numbers of Sanitary Authorities reporting results may be due to changes in the location of water treatment plants, though in some years it would appear that some Sanitary Authorities did not submit results.

Figure 4.10 Compliance with the Drinking Water Regulations maximum fluoride level (1.00ppm F) as reported by the Environmental Protection Agency 1995-2000

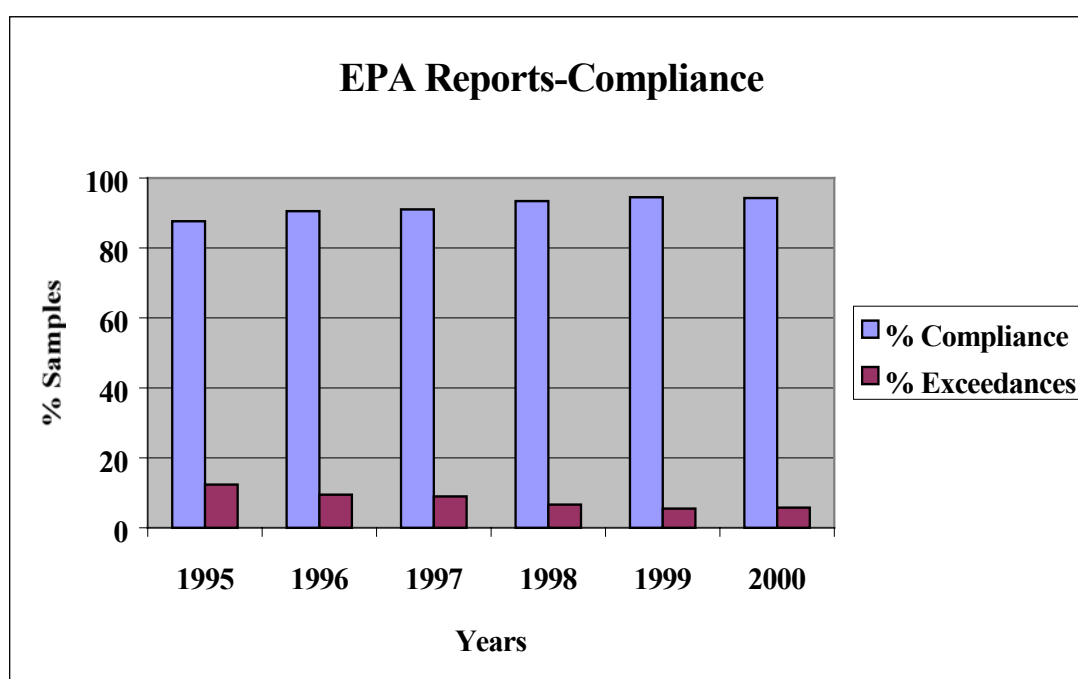
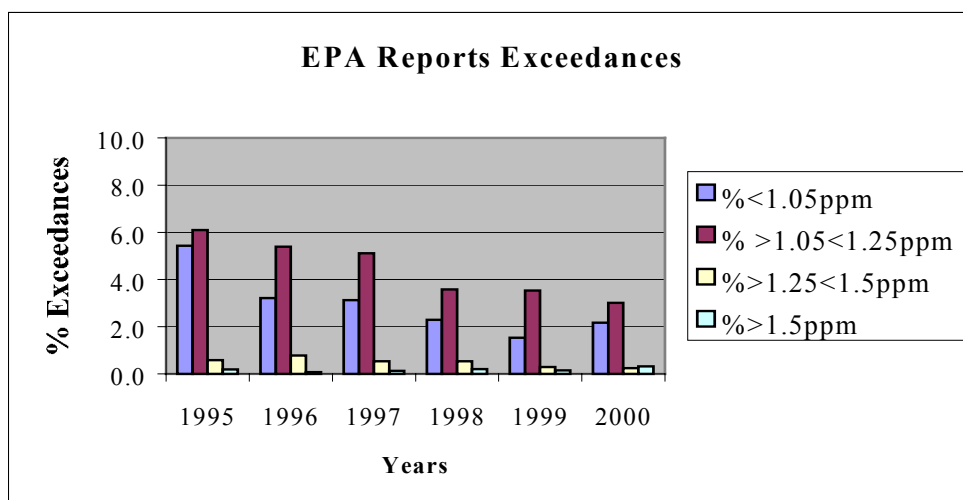


Figure 4.10 demonstrates the levels of compliance with the Drinking Water Regulations in respect of fluoride levels in public water supplies. Compliance with the Drinking Water Quality Regulations in respect of fluoride is defined as the level not exceeding 1.00ppm fluoride. Over the five years for which reports are available the levels of compliance range from 87.7% in 1995 to 94.5% in 1999.

Figure 4.11 gives the breakdown of the exceedances for 1995-2000, it is notable that the vast majority of the exceedances (>1.00ppm) are less than 1.25ppm and the percentage of exceedances is very low (12%) and decreases (5.5%) over the time period examined. Between 0.07% and 0.32% of the exceedances were greater than 1.5ppm fluoride.

Figure 4.11 Exceedances of the Drinking Water Regulations maximum fluoride level (>1.00ppm) as reported by Environmental Protection Agency 1995-2000



Discussion:

In the period in the period 1995-2000 the levels of compliance with the Drinking Water Regulations as reported by the EPA ranged from 87.7% to 94.5%. Exceedances dropped over the period and the majority of the values are in the lower ranges of exceedances. Given the move in the Public Analyst Laboratories to reporting the degree of uncertainty of results, it does not seem to make sense to report results up to and including the uncertainty of measurement value as exceedances or unsatisfactory. If the EPA results for these years are examined excluding the <1.05ppm group from the exceedances, the compliance levels would then range from 93.1% to 96.0%.

In commenting on the exceedances some of the EPA annual reports make reference to the background levels as a possible explanation for the exceedances. The National Water Study also makes this point although no reference is made to supporting data. This issue needs to be clarified by regular testing of the source water. It is known that where alum is used in pre-treatment then this may remove up to 30% of naturally occurring fluoride which would eliminate background fluoride as a cause for the exceedances (CDC 1986).

Recommendations:

- ❑ Each water treatment plant and distribution scheme should be given an alphanumeric identifier to each water treatment plant and scheme, which would relate the plant/scheme to the Sanitary/Local authority responsible. This recommendation was also made in the National Water Study (National Water Survey 2000) and has been implemented for the schemes examined in that survey
- ❑ Detailed maps of the water schemes are required to identify the extent of coverage of each scheme.
- ❑ There is a need to amend/update the Statutory Instruments to reflect changes in the names of some schemes.
- ❑ The format described in Department of Health Circular 14/1977 Appendix 1 which required the results of (i) the gravimetric-volumetric calculation, (ii) the daily test and (iii) the monthly test should be adopted. This would provide an insight into where discrepancies might exist between the three methods of measuring fluoride concentration in the water supply.
- ❑ The monthly test data should be recorded in a spreadsheet by the Principal Dental Surgeon or Principal Environmental Health Officer for electronic transmission to the Department of Health & Children quarterly. The Department already has such a file set up with macros to carry out simple calculations, which with slight modifications could be sent to each PDS and PEHO.
- ❑ The person taking the sample should as suggested in the Department of Health circular 14/1977 (Appendix 1) ensure *"by consulting with the waterworks staff, that the sample is not taken at a time when the fluoridation plant is being repaired, overhauled or is not otherwise functioning adequately"* (Appendix 1). This advice needs to be disseminated to the each Principal Environmental Health Officer and Principal Dental Surgeon so that those who actually take the samples are aware of it.
- ❑ There is a need to establish a system to alert the Principal Dental Surgeon and Principal Environmental Health Officer about (i) missing tests results, (ii) unsatisfactory results, (iii) a need for supplemental tests, (iv) when fluoridation plant is off line for repair, maintenance or is not functioning properly.
- ❑ The point at which the monthly sample is taken must be definitively representative of the supply in question.
- ❑ The monthly test data should be interpreted in the light of the accuracy of the test equipment being used at plant level.
- ❑ The reporting of variances from the limits given in the Statutory Instruments should take into account the uncertainty of measurement of the test used. Consideration should be given as to whether variances falling within the uncertainty of measurement should be reported as unsatisfactory and an agreed protocol should be used to standardise reporting.

- ❑ Given the narrow range of the statutory limits for water fluoridation, consideration should also be given to the introduction of a "*Control Range*" for test results. Targets for the proportion of results falling with the *Control Range* could be set and then used to monitor the performance of individual water treatment plants.
- ❑ All the relevant aspects the legislation and Departmental Circular letters should be brought together in a handbook or manual for easy reference. Copies of this manual should be available to all relevant health board and local authority personnel, such as engineers and plant staff.

5 Assessment of the operation of water fluoridation

Objective 2

- **To obtain input about the operation of water fluoridation from key health board personnel and the Public Analyst Laboratories.**

Introduction

The Principal Dental Surgeons (PDS) and the Principal Environmental Health Officers (PEHO) are the key health board personnel with responsibilities in respect of water fluoridation. Following a recent restructuring of the health board dental services, there is now a Principal Dental Surgeon with regional responsibility for water fluoridation. The Principal Environmental Health Officer has contact with the local authorities in relation to a variety of environmental health issues. Fluoridation Monitoring Committees have been set up in each health board administrative area to provide a forum for co-ordination between the key health service and local authority personnel. In order to obtain an estimate of how water fluoridation was operating from the health services perspective it was decided to obtain information from these two groups by questionnaire.

Materials and Methods

A postal questionnaire to all Principal Dental Surgeons (PDS) and Principal Environmental Health Officers (PEHO) was used to obtain information from the key health board personnel about the operation of water fluoridation in all the health boards (Appendix 2). Questions were asked about the operation of the Fluoridation Monitoring Committee (FMC), visits to water treatment plants, the monthly test results, codes of practice, quarterly/annual reports, funding and payment of accounts. The respondents were also asked to complete a list of the water supplies in their area with the approximate populations served by each.

A short questionnaire (Appendix 3) was also used to obtain information from the three Public Analyst Laboratories which carry out the testing for the health boards.

5.1 Fluoridation Monitoring Committees

Role and remit

The role and remit of the Fluoridation Monitoring Committee (FMC) was defined in a letter to the Chief Executive Officers (CEO) in each health board from the Department of Health dated 18th August 1992. (Appendix 5) The letter restates the overall responsibility of the health boards for fluoridation programmes under the Health (Fluoridation of Water Supplies) Act 1960. It also requests health board Chief Executive Officers to set up jointly with the local authorities concerned a Fluoridation Monitoring Committee for each community care area *"to ensure a full exchange of information and a high degree of co-ordination"*.

Composition

The letter from the Department of Health envisaged that the Committee would include the Director of Community Care and Principal Dental Surgeon and might also include the Supervising Environmental Health Officer (now the PEHO) and the Technical Services Officer. The suggestion was that the Committee should meet quarterly, to be

chaired by either the CEO or the Programme Manager Community Care. It also envisaged that the local authority would be represented by the County Engineer and other representatives considered appropriate. The composition and seniority of the representation on the committee gives a very clear indication of how the Department of Health viewed the importance of this committee.

The letter of 18th August 1992 also referred back to Circular 14/1977 dated 1st July 1997 (Appendix 1), which outlined for health boards and sanitary authorities their responsibilities in relation to fluoridation of public water supplies.

This letter was followed up by another dated 22nd September 1993, which enquired about progress on setting up the Fluoridation Monitoring Committees (Appendix 5). It also requested a response as to whether the FMC was operating to the satisfaction of the health board in improving liaison with the local authorities, improving test results and in monitoring the situation with regard to the current and future need for new/replacement plant. The last paragraph of this letter makes it quite clear that health boards should only consider refunding local authorities for services carried out to the satisfaction of the board.

5.2 Results from the questionnaires on the Fluoridation Monitoring Committees

Fifty questionnaires were distributed to all of the Principal Environmental Health Officers and Principal Dental Surgeons in the country, of which 46 were returned. Initial analysis showed very little difference between the Principal Dental Surgeons and the Principal Environmental Health Officers in the distribution of the responses. As the total number of responses possible was small the data was not stratified according to the position held by the respondent.

Outline of the responses to individual questions:

Effectiveness

Thirteen per cent (13%) of respondents claimed that the FMC was "*Not effective*", while 50% reported it to be "*Moderately effective*" and 33% to be "*Very effective*".

Frequency of visit to water treatment plants

When asked about the frequency of visits to water treatment plants, 13% claimed to visit "*Regularly*", 59% "*Occasionally*", 17% "*On request*", and 11% "*Not at all*".

Monthly test report

The monthly test report on water samples may be returned to either the Principal Environmental Health Officer, the Principal Dental Surgeon or the Senior Area Medical Officer. For this reason a question was asked about who received the monthly test report first. In 78% of cases the Principal Environmental Health Officer (PEHO) received the statutory report first, while the Principal Dental Surgeon (PDS) received the report first in only 13% of cases. It is surprising to note from the responses that in 33% of cases that PDS did not receive the report until at least 2 other people had seen it. However in 59% of cases the first two people to receive the report were either the Principal Environmental Health Officer or Principal Dental Surgeon.

Contact with the Local Authority in the event of an unsatisfactory report

In 78% of cases the PEHO is the person reported as contacting the local authority in the event of an unsatisfactory test result.

Timeliness of the report

Seventy per cent (70%) of respondents reported receiving the reports within a "useful time", 22% did not receive them within a useful time, and the remaining 8% either did not know or did not always receive these reports within a useful time.

Length of time to receive the report

When asked about how long it took to receive these reports, 74% claimed to receive them in a month. Thirteen per cent (13%) answered that they were received in 1-2 months and a further 13% replied that it took more than 2 months.

Code of practice

Forty six percent (46%) reported having a code of practice for water fluoridation plants, 35% said there was none and 20% did not know.

The submission of the quarterly report to the Department of Health & Children

In 61% of responses the PEHO was reported as submitting the quarterly reports to the Department of Health & Children and in 22% of responses the PDS submits the quarterly report.

Collation of an annual report for the Department of Health & Children

Only 57% of respondents reported that an annual report was submitted to the Department of Health & Children. Thirty per cent (30%) said no report was sent and 13% did not know.

Authorisation of payments

In 46% of responses the Principal Dental Surgeon is reported as authorising payments, the PEHO authorises in 18% of cases and 37% reported that "Others" authorised payments.

Option to withhold payment

Only 41% of respondents were aware that there is an option to withhold payment where results are unsatisfactory. The remainder either said that there was no option to withhold payments (44%) or they did not know or did not answer the question (15%).

Payments made to the local authorities in the year to which they refer

Fifty four per cent (54%) of respondents reported that the majority of payments to local authorities were made within the year to which they refer. However 31% either did not know or did not answer the question.

The process of identification of capital requirements

The FMC was identified by 54% of respondents as the means by which the capital requirements were identified. The PEHO or the PEHO in consultation with the local authority was identified by 20% as determining capital needs; however 11% of the sample believed that the capital needs were determined by others (i.e. not the FMC, the local authority or the PEHO). A further 15% did not know or did not answer the question.

Discussion

The Fluoridation Monitoring Committee has a key role in monitoring the local management of water fluoridation. From the results of this study it would appear that some aspects of its role are functioning well but there is room for improvement in others. It is disappointing that only 57% of respondents reported sending an annual report to the Department of Health & Children. In light of changes in structures and designated responsibilities within the health boards and local authorities the composition of the Fluoridation Monitoring Committee should be updated. The roles and responsibilities of the key health board personnel need to be clarified.

Recommendations on Fluoridation Monitoring Committees (FMC)

- ❑ Key performance indicators should be identified for use in monitoring of water fluoridation.
- ❑ Nationally agreed minimum protocols for a programme of assessment and visitation of water treatment plants would ensure a standardised approach by each Fluoridation Monitoring Committees.
- ❑ The differing roles and responsibilities of the Departments of Public Health, the Principal Dental Surgeon (including the PDS with regional responsibility for water fluoridation) and the Principal Environmental Health Officer in the health boards' areas need to be defined and circulated to health boards and local authorities.
- ❑ The key personnel both in the Sanitary Authority and the Health Board need to be identified by name and contact numbers so that personnel at all levels of the health boards and local authorities are aware of who is responsible for the various aspects of water fluoridation.
- ❑ The Fluoridation Monitoring Committee should send a written report back to the plant personnel with feedback on the outcome of any visit, giving recommendations and time scales for implementation.
- ❑ The Fluoridation Monitoring Committee should produce a standardised annual report covering areas such as audits of water treatment plants, analysis of test results, responses to variances and capital requirements. This report should be submitted by the health board to the Department of Health & Children and the relevant local authorities.
- ❑ The composition of the Fluoridation Monitoring Committee needs to be redefined in the light of changes in health board and local authority structures. A minimum number of meetings per year should be determined.
- ❑ Nationally agreed minimum recommendations on a programme of assessment and visitation to water treatment plants are required.

5.3 Information from the Public Analyst Laboratories

In order to determine how the monthly test were handled by the Public Analyst Laboratories (PAL) a questionnaire was devised and sent to the three laboratories handling the monthly fluoride tests in Dublin, Cork and Galway. The Dublin Public Analyst Laboratory provides testing for the Eastern Regional Health Authority boards, Midland Health Board and North Eastern Health Board regions. The Cork laboratory covers the Southern Health Board and the South Eastern Health Board, while the Galway laboratory covers the Western Health Board, the North Western Health Board and Mid Western Health Board.

The questionnaire (Appendix 3) included questions on a range of issues and the following is a summary of the findings:

Results:

Testing

All three laboratories reported a facility for unscheduled and rapid response sampling but none had a requirement for samples to be submitted on specific dates each month. The Cork laboratory typically tested 93 samples per month, Dublin 66 samples per month and Galway 92 samples per month.

Certification

The laboratories in Cork and Galway reported having their tests accredited to EN 45001 which has now been replaced by the ISO 17025 Laboratory Accreditation Standard. In Dublin while no accreditation was reported at that time, documented procedures are in place.

Equipment

All three laboratories reported using an ion specific probe (fluoride ion probe) to carry out these tests, the Galway laboratory also reported using the distillation test and that it was planning to change to ion chromatography.

Calibration

Each laboratory calibrates the test equipment daily with a series of fluoride standards some of which may be certified standards though these are not always available.

Test Results

Each laboratory reported results to the Principal Environmental Health Officer, by phone or fax in the event of an unsatisfactory result. The usual turnaround time for results was reported as 10 days for Cork, 2 weeks for Galway and 2-3 weeks for Dublin.

Discussion:

The distillation test was specified in the 1960 Health Act for the monthly test probably to ensure that the most accurate test available at that time was used. Since the 1960s there have been considerable advances in testing technology and the accuracy of such equipment. It is highly desirable that these more modern methods are used and it is advisable to avoid specification of a particular laboratory procedure in the legislation.

Seventy four per cent of the Principal Environmental Health Officers and Principal Dental Surgeons received the monthly test results within four weeks, while 13% received the result in one to two months and for a further 13% it took more than 2 months to receive the results. The turnaround time in the Public Analyst Laboratories ranged from 10 days to 3 weeks. This would indicate a need to improve the channels of communication between the Public Analyst Laboratories and the key health board personnel.

The ISO 17025 standard has a requirement that all testing reports should ideally contain a measure of the "*uncertainty of testing*". This will have implications for the reporting of test results and for the accuracy of test equipment at plant level. It would be very helpful if the monthly test sample were split and one portion kept for analysis locally. This would act as a check on the locally used test equipment. The logistics of this approach may cause some difficulties but it could be very beneficial in monitoring the accuracy of test equipment at plant level.

Recommendations:

- ❑ It would be more appropriate to specify in the legislation a requirement for the monthly test to meet current internationally recognised standards, rather than specify one particular test which may become outdated, as has occurred with the distillation test. The distillation test should be removed from the current legislation.
- ❑ While the Public Analyst Laboratory may have the capacity to report test results to three decimal places along with the figure for uncertainty of measurement. The effect of the uncertainty of measurement figure on the classification of the results as *Marginal, Satisfactory* or *Unsatisfactory* needs to be clarified.
- ❑ The Public Analyst Laboratories in conjunction with the health boards should give consideration to evaluating an alert system for reporting unsatisfactory test results with a view to re-testing the water supply.

6 Assessment of the water treatment plants

Objective 3

- To carry out an in-depth analysis of the operation of water fluoridation in a sample of water treatment plants in order to make recommendations on aspects of plant operation.

Principal Aim:

The principal aim of the plant visits was to assess the operation of selected water treatment plants under the headings listed below.

1. Source Water Testing
2. Dosing Equipment
3. Preventive Maintenance and Calibration
4. Testing and Test Equipment
5. Monitoring Visits
6. Personnel
7. Intake and Storage of Acid

Methods

A management consultant company (Promech Limited) was employed as a subcontractor in the evaluation because of its experience in accreditation (including ISO accreditation) of companies and organisations including some health board services. Two researchers visited fourteen water treatment plants located in six health boards and seven county council areas. The names of the plants visited are listed in Appendix 7. The plants were selected based on the size of population served and their geographic spread around the health boards. Although the sample was a convenience one, an effort was made to visit plants representative of different levels of technology.

The assessment was performed using a template questionnaire (Appendix 6). This was to ensure standardisation of approach. During the course of the site visit the engineer or the caretaker responsible for the plant was available to demonstrate various aspects of plant operation as well as answering questions under the various headings.

6.1 Source Water Testing

Aim:

The aim of this section was to:

Review the current practice in the plants with regard to testing of the fluoride levels in source water.

Requirements:

"A complete chemical analysis including fluorine content of a sample of untreated water from the supply proposed for fluoridation" is required prior to the Minister for Health and Children making Regulations under the Health Act 1960. There is no requirement in the legislation, the Regulations or the Departmental Circulars to carry out regular testing of source water for fluoride.

Findings:

Initial source water testing was usually carried out as required by the legislation prior to the commencement of water fluoridation. The ongoing testing of source water fluoride levels was infrequent or else it was not possible to determine when it was last carried out. Documented results were not available at any of the sites visited. In general source water analysis results were held by the administrative section of the Local/Sanitary Authority and were not available at plant level. In one plant the caretaker allowed for a known level of fluoride in the source water when calculating the dosing levels based on the results of previous test.

Discussion:

There appears to be a widely held belief that background levels of naturally occurring fluoride may be responsible for exceedances experienced in some areas. It is also possible that low background fluoride levels are subject to seasonal variation. In recent years EPA Annual Reports have made reference to the need for testing of source water for naturally occurring fluoride. The CDC Engineering and Administrative Recommendations for Water Fluoridation, 1995, recommend a minimum of annual source water testing by the state laboratory or one approved for such testing.

The CDC Manual for Engineers and Technicians provides a list of nine interfering substances, including colour and turbidity which may cause errors in fluoride measurement. When using the colorimetric method these must be removed or compensated for. Table 6.1 shows the full range of interfering substances and the concentrations (mg/l) required to cause error of plus or minus 0.1mg/l at 1.0mg/l fluoride.

Table 6.1 Interfering substances (mg/l) causing errors (± 0.1 ppm F) in fluoride measurement

Interfering Substances	Colorimetric	Electrode
Alkalinity (CaCO_3)	5,000(-)	7,000 (+)
Aluminium (Al)	0.1 (-)	3.0 (-)
Chloride (Cl)	7,000 (+)	20,000(-)
Iron (Fe)	10 (-)	200(-)
Hexametaphosphate ($[\text{NaPO}_3]$)	1.0 (+)	50,000
Phosphate (PO_4)	16 (+)	50,000
Sulphate (SO_4)	200(-)	50,000 (-)
Chlorine (Cl)	Must be completely Removed	5,000
Colour & Turbidity	Must be removed or compensated for	-

Testing of source water for fluoride levels is probably best carried out using an ion specific electrode so as to minimise the effects of interfering substances. The levels of interfering substances are likely to be fairly constant in ground water systems compared with surface water systems. The optimum times for testing would be mid winter and mid summer, so as to reflect the times when the water table is likely to be at its highest and lowest levels.

Recommendations:

- ❑ Testing of source water for fluoride levels should be performed at least every 12 months. For some sources it may be necessary initially to carry out such tests every 6 months to determine if there is seasonal variation.
- ❑ Source water test results should be recorded and available for review at the water treatment plant and should be included in the Fluoridation Monitoring Committee annual report on the water supply.
- ❑ The effect if any, of organic matter and the various interfering substances on fluoride measurement in individual water supplies needs to be determined.

6.2 Dosing Equipment

Aim:

The section of the assessment determined the types of dosing pumps, their make, model and year of installation. The areas assessed were the following:

Pumps

- Methods for measuring flow rate
- Procedures for altering the flow rate of the dosing meter
- Alarms for the system
- Availability and use of back up pumps

Day tanks and weighing scales

- Location
- Bunding
- Protective equipment

Requirements:

The Department of Local Government circular number L6/65 dated 31 May 1965 states *“Pump out-puts may be either proportional to varying flows or constant, and the pumps are to be provided with means of adjusting and controlling the rate of dosage in a positive and accurate manner. The installations to be capable, under unqualified guarantee of operating within an accuracy of $\pm 3\%$. The means whereby the rate of dosage is controlled to be so installed, constructed or protected so as the prevent interference by unauthorised persons.”*

Findings:

Pumps:

All plants had installed dosing pumps within the last seven years and as a result the equipment was of a high standard. The pumps were the flow proportional type. All plants had a system in operation for measuring water flow rate. None of the plants had a written procedure for the alteration of the fluoride dosing pumps, to a very large extent

adjustment were made based on small adjustments to the length (\pm 3-4mls) of the stroke of the pump and based on operator knowledge and experience. Operations manuals for the pumps were not always available on site. One supplier of pumps has a policy of leaving such manuals on site after installation. Two of the fourteen plants had an alarm monitor on the dosing system. The general practice was to rely on regular visual monitoring by operators or caretakers. Every plant visited had back up pumps installed. In general the operators/caretakers expressed satisfaction with the pumps saying that they experienced few problems with them.

Day tanks & weighing scales:

All plants had day tanks mounted on weighing scales. Few were bunded, though one was alarmed for spillage. Most of the weighing scales were beam/balance type, while digital type weighing scales were found in newer or refurbished plants. In almost all plants visited the weighing scales were not reported as having been calibrated recently.

Acid level in the day tank was indicated by an external eye level measure. In one instance the level was electronically monitored and alarmed to indicate the requirement to refill. In most instances there was no mechanism to prevent overflow and spillage of acid from the day tank. The design of the day tank room varied considerably. For safety reasons the day tank room should open to the exterior as opposed to opening internally to another part of the plant.

The level and type of personal emergency protective equipment varied widely. There was also a wide variation in availability of adequate ventilation/exhaust systems in the day tank room.

Discussion:

Pumps:

A visit to one supplier of pumps, (Bowen Water Technology) provided valuable additional information about some of the pumps in use in water treatment plants. The average life span is 5-10 years provided the recommended maintenance is carried out. This company recommended 1-3 services visits each year. It was company policy to leave one copy of the service documentation on site, send one to the relevant engineer and retain one for the company.

On-site maintenance consists of cleaning of drains and filters, regular checks of pumps as seals may leak, and good stock control to ensure that no air enters the lines. An on-call repair service with a 24-36 hour response time for breakdowns was available. The pumps are simple to replace and it is less cost effective to repair them. The company indicated a willingness to provide input into on site training of operators in the specific aspects of adjustment of the equipment supplied. The pump technology is changing with expensive (€38,000) self-adjusting pumps becoming available. Where there were different suppliers of pumps in the same water plant each company provided maintenance for their equipment.

The CDC Engineering & Administrative Recommendations for Water Fluoridation 1995 describes twenty general requirements under the Technical Requirements section.

Among the issues included (relating to dosing equipment) are (i) interlocking the system so that the fluoride feed system cannot flow unless water is being produced; (ii) location of the fluoride injection point; (iii) anti-siphon devices; (iv) location and accuracy of the fluoride pumps; (v) installation of a master meter on the main water service line; (vi) colour coding of the fluoride feed line and (vi) annual inspection of the fluoride feed equipment, controls, safety equipment and accessory equipment.

Day tanks & weighing scales:

The CDC Engineering & Administrative Recommendations for Water Fluoridation 1995 five recommendations specific to hydrofluosilicic acid systems. These relate to: (i) the use of a day tank; (ii) the location and monitoring of levels in the day tank; (iii) sealing and venting of the day tanks; (iv) containment for bulk tanks. It would be very useful if similar guidelines were available for the Local and Sanitary Authorities in Ireland.

The use of personal protective equipment is essential when handling fluoride chemicals. The CDC manual makes very specific recommendations on this subject as the equipment list varies according to the chemical being used.

Recommendations:

- ❑ The methods currently used to make alterations to the fluoride dosing equipment should be formalised into a standard operating procedure, specific to the locally installed equipment, for which manufacturers instructions manuals are available on site.
- ❑ The feasibility of providing alarms on pumps should be explored.
- ❑ Day tanks should be bunded to contain the maximum volume of the tank.
- ❑ Records of maintenance of the pumps and dosing equipment should be retained at the water treatment plant as well as the local authority office.
- ❑ The frequency of maintenance and calibration of weighing scales should be determined. Calibration records should be retained at the plant. The scales should be incrementally upgraded to digital format.
- ❑ The design of the room housing the day tank should take account of the particular issues related to containment, ventilation, access and egress. Consideration should also be given to the need for cut-out devices to avoid overflow.
- ❑ Daily records of the amounts of acid used and water treated should be recorded and retained in standard format either on paper or preferably electronically.
- ❑ A manual similar to the CDC Engineering & Administrative Recommendations for Water Fluoridation 1995 would prove very useful guidance for local authority and health board personnel involved with water fluoridation.

6.3 Preventive Maintenance & Calibration

Aims:

The aims of this aspect of the visit were to assess

- the maintenance and calibration of fluoridation equipment
- whether maintenance and calibration were performed internally by a staff member or by an external contractor
- the frequency of maintenance and calibration

Requirements:

The Department of Health Circular 14/1977, in section 8, (Appendix 1) provides guidance on the subject of maintenance both in terms of the spare parts to be kept in stock but also on maintenance contracts with the suppliers of equipment. There are no requirements in the Act or the Regulations or recommendations in the Departmental Circulars on calibration of equipment.

Findings on Maintenance:

Test Equipment:

The two largest plants had either fitters on site or a shared the services of fitters with other water treatment plants. For these plants the maintenance programme was based on the knowledge of the fitters and was not formalised or documented. Both plants identified this as an area for improvement.

Six plants had formal agreements with external contractors to provide preventive maintenance on either an annual or six monthly basis. However no records were available at the individual sites to demonstrate the work which had been performed. One contractor when contacted by the project team indicated that they would leave a service report with the operator/caretaker in future as well as forwarding a copy to the Senior Engineer in the Local Authority. At the remaining six plants it was not possible to determine the level of maintenance in operation whether formal or informal.

Findings on Calibration:

Test Equipment:

In two of the larger plants visited, calibration of the test equipment was undertaken on a periodic basis by the on site laboratory personnel. In one of the newer plants a photospectrometer was in use, for which the supplier issued a reference (control) sample on an annual basis. The plant then returns the results for the reference sample to the supplier, any deviations are rectified.

In one of the smaller plants operating under the auspices of a larger plant, the results obtained from the test equipment at the smaller plant are cross-referenced with the results obtained from the laboratory analysis at the larger plant. It was indicated that this was done on an occasional basis.

In the other ten plants, it was not possible to determine the level of calibration being carried out.

Flow meters:

In one of the larger plants the calibration of the flow meters was carried out by laboratory staff on a six monthly frequency. In a recently constructed plant, the contractors had installed a self-testing flow meter which can be assessed at defined frequencies.

In five other plants a service agreement was in place which incorporated the calibration of the flow meters. The frequency of calibration depended on the contract but tended to be either annual or on a six monthly basis. However records were not available at any of the locations to demonstrate that the calibration was undertaken or the results achieved.

Weighing Scales:

All plants had day tanks mounted on weighing scales. In general the weighing scales were of the beam type. Digital scales were found in the newer plants. It was not possible to determine the extent of the calibration of the weighing scales. There appeared to be a perception that this was not a critical issue as the dosing of the water was based on a flow proportional rate methodology.

Discussion:

Water fluoridation is a process that requires the addition of minute concentrations of fluoride within a very narrow range. Preventive maintenance and calibration of equipment are vital to ensuring the accuracy of the process. Most of the water treatment plants either had maintenance contracts in place or had rapid access to services to minimise the length of the breakdown.

Recommendations:

- ❑ The existing internal and external preventive maintenance and calibration programmes should be audited to measure their effectiveness and determine any further requirements.
- ❑ For each site the preventive maintenance programme should list the equipment, define the maintenance required for each item of equipment, the frequency of the maintenance and identify those responsible for such maintenance.
- ❑ Records of internal and external preventive maintenance and calibration should be retained at the plant as well as the local authority office.

6.4 Testing and Test Equipment

Aim:

To examine the testing of the treated water and the recording of results of both daily and periodic testing. The aspects assessed were the

- type of equipment used to test for fluoride
- frequency of testing
- actions taken on receipt of an unsatisfactory result
- notification process in operation.

Requirements:

The Regulations made by Statutory Instruments for each water supply require that daily colorimetric testing be carried out. The Regulations specify that a distillation test be carried out every 4 weeks by the Public Analyst Laboratories. *"This test is intended to be an independent check at regular intervals of the fluorine content of the water."* The details of this testing, as well as the response recommended are provided in the Department of Health Circular 14/1977. The Department of the Environment Circulars L9/62 requires that details of the amounts of water treated and fluoride used be kept to allow for the calculation of the concentration of fluoride in the treated water. This calculation acts as a cross-check on the colorimetric test.

Findings:

Spectrophotometer:

One water treatment plant was using a spectrophotometer to carry out fluoride ion analysis.

Selective Ion Probes:

Six of the larger plants were using selective ion probes and these tests were performed by laboratory technicians, who were either on-site or they were brought to a plant where laboratory was available. Some plants were using both specific ion probes and colorimeters.

Colorimetric:

Ten of the plants visited were using colorimetric test equipment. The test kits and models in use varied in age and model, however most were simple but accurate hand held models.

Gravimetric-Volumetric:

In seven of the sites visited, a calculation of the fluoride concentration in the water was made based on the water and acid usage within a 24-hour time period. By using a conversion factor the plant personnel calculate the fluoride level based on a gravimetric formula, which can be used to verify the colorimetric reading. Any known background fluoride level in the source supply should be taken into account in this calculation. The gravimetric-volumetric calculation is a valuable cross-check on the colorimetric testing process. The calculation uses either the weight or volume of acid used divided by the volume of water (litres or metres cubed) used, multiplied by a constant or multiplier.

Two different conversion formulae were noted during the visits to the plants, one used a scale of multipliers related to the concentration of the acid and the other used a single multiplier. The Second Schedule of the various Statutory Instruments, Article 6 (3) states *"that the acid shall contain 14% of fluosilicic acid by weight, subject to a tolerance of 0.5 per cent above or below that strength"*. If the multiplier for the 14% concentration is used for all calculations then the effect on the calculated concentration of fluoride is minimal. Even if the highest multiplier were used with the lowest acid concentration then the effect would be to give an error of + 0.08ppm. Given that the concentration of the acid in different batches may vary and that mixing occurs between batches within the storage tanks it is probably better to use a fixed multiplier (for the 14% concentration). Routine testing of the concentration of the acid in the day tank in all water treatment

plants would present considerable difficulties, but it could be monitored occasionally in the larger plants.

Recording of Results:

Twelve of the fourteen plants were noted as recording the daily test results. Two plants appeared not to record the results, but maintained that testing was done on a daily basis. A number of plants used a template sheet for recording results. These template sheets recorded colorimetric test results and, where calculated, the gravimetric results. Other plants used a diary to record test results for each day.

Reporting of Results:

In two plants a monthly report was not forwarded to the Local Authority/Sanitary Services engineering staff. Environmental Health Services of the health board tended to be notified only when results were unsatisfactory; in some areas the Principal Dental Surgeon was notified. In most cases minor exceedances were rectified by local corrective measures but the level of the response depended on the expertise available at plant level. In the Dublin area of Eastern Regional Health Authority the plant personnel notify the Environmental Health Services personnel when the fluoride treatment plant is not operational.

In the event of the levels of fluoride exceeding the statutory limits, most plants had a policy of contacting the Area Engineer and the relevant Health Board personnel to notify them of the cause of the exceedance and the remedial action taken or required. This is in line with the recommendations in the Department of Health circular 14/1977 (Appendix 1).

External Testing:

In compliance with the Health Act 1960, the Environmental Health Services of the health boards collect test samples from fluoridated water supplies on a monthly basis. These samples are analysed by the Public Analyst Laboratory Services and the results are notified to the Environmental Health Officer in the Health Board, who notifies the Local Authority of an unsatisfactory result. Quarterly and annual reports of these results are submitted to the Department of Health & Children by either the Principal Dental Surgeon or the Principal Environmental Health Officer.

External testing is also carried out by the Environmental Health Services of the various health boards to comply with the Drinking Water Quality Regulations. These results are notified to the Sanitary Authority which subsequently returns them to Environmental Protection Agency.

Discussion:

The testing of water samples at plant level is an area of critical importance in the water fluoridation process. Two of the critical issues which affect the outcomes are the type of equipment used and the test method.

Colorimetric testing:

In the past only colorimetric methods were available at water treatment plants for testing the minute fluoride concentrations in fluoridated water supplies. Currently fluoride levels are measured using colorimetric, ion specific and photospectrometric methods, though it would appear that the majority of plants are using colorimetric methods. The

colorimetric or SPADNS photometric method is based on a reaction in which a deep colour is formed between zirconium and an SPADNS (sodium 2-[parasulphophenylazo]-1,8-dihydroxy-3,6-naphthalene disulphonate) which is an azo dye. The colour ranges from deep red in the absence of fluoride to light red when the concentration is high. A photometer is essential to detect small differences in colour related to the range of concentrations experienced in water supplies, it is almost impossible to detect these by eye. The analysis is carried out by adding a measured volume of reagent to a measured volume of water, which is then placed in the cell within the instrument. There are three methods of preparing the sample for analysis. The open method involves the use of re-usable sample tubes which must be carefully washed and cleaned. A measured quantity of standard fluoride solution is used to standardise the equipment. This method is accurate to two decimal places but requires careful preparatory technique and there is a need for careful handling of the reagents from a safety viewpoint. It is also cheap, costing approximately €0.18 per test.

The second method uses pre-packed SPADNS spikes (2mls) which are vacuum packed. When the spike is broken in the test solution it sucks up a fixed volume of water into the reagent though some of the SPADNS is lost back down the spike. So this method avoids operator contact with the reagents, it is not as accurate as the open method and it costs approximately €0.40 per test.

The third method uses a pre-packed standard solution (HCT) to which precisely measured quantities of the test solution are added and then placed in the testing equipment. This is a one-glass cell technique which costs approximately €2 per test. One source of error with the open method and pre-packed spikes is that minor aberrations in the glassware may affect the result. Rotation of the cell may produce a quite different result for the same sample. Using the pre-packed vials to which the test solution is added means that the same error is included in each measurement.

Colorimeters range in price (€450-€1,200) and depending on the sophistication of the technology. Pocket colorimeters are cheap and accurate to two decimal places, though some older models only read in units of 0.1ppm. They must be zeroed correctly for each test, require standardisation once a week and are likely to be useful for only one parameter, in this case fluoride. Mid price testing equipment (€1,200) is accurate, multifunctional (different parameters which is useful in water treatment plants), can use any of the sample preparation methods, they can also store the test result data.

With all types of colorimetric equipment and methods used there are special precautions that must be taken with all SPADNS procedures:

- ❑ The temperature of both the water sample and the standard sample should be 20 degrees C (± 1 degree).
- ❑ The glassware must be clean, use of de-ionised water to remove interfering chemicals is vital. Glassware must also then be dried.
- ❑ Accurate measurement of the reagents is vital
- ❑ Chlorine must be eliminated
- ❑ When test equipment is being standardised, a test sample in the range being measured (1ppm) should be used.

- ❑ Many other ions found in water interfere with the testing for fluoride. These interfering ions (Table 6.1) may if present in sufficient concentrations affect the test results.

The CDC Engineering & Administrative Recommendations (CDC 1986) makes specific recommendations about the use of colorimetric and ion electrodes in different water sources. The alum used in the treatment of surface water sources may cause fluctuating interferences in the analysis. Where consistent interferences are present (iron, chloride, phosphate, sulphate or colour) the final test result may need to be adjusted for these. The possibility of fluctuating phosphate levels in surface water supplies related to agricultural activities or other effluent discharge may need to be investigated so as to determine the influence of such changes on interferences in fluoride testing.

The colorimetric test equipment has a specified range of tolerance for the measurements of any parameter including fluoride. The level of tolerance of the test equipment may need to be reviewed. The accuracy of the models in use needs to be verified for tolerance and repeatability. A minimum specification for colorimetric test equipment should be developed to address issues such as accuracy, ease of use and repeatability.

Photospectrometers

Photospectrometers are now available (€3,000+) which will carry out analysis on 130 parameters, are simple to use (some have touch screen technology), create a data log of tests and can use the various type of cells for holding the samples. There is a range of equipment available including desk top and portable models.

Ion specific probes

Ion specific probes have been used in the Public Analyst and other laboratories for analysis of various parameters including fluoride for some time. The probe or electrode contains a fluoride solution with a crystal on the tip which acts as an ionic conductor. The fluoride ions move down the concentration gradient which sets up a voltage potential which is proportional to the concentration of fluoride ions. They are technique sensitive and require standardisation and calibration. They are only sensitive to interfering substances at very high concentrations. There is now available in-line ion selective technology which carries out testing every 4 minutes and is equipped with a system shut down alarm.

Reporting of results

The key personnel in the Sanitary Authority and the Health Board need to be identified by name with their contact numbers so that personnel at all levels are aware of who is responsible for the various aspects of water fluoridation. The pathway for reporting test results in the health boards also needs to be clearly identified, with protocols for action in the event of non-compliance devised.

Recommendations:

- ❑ A minimum specification for fluoride ion test equipment in water treatment plants should be devised to take account of issues such as precision, accuracy, ease of use, functionality and cost.

- ❑ The methods currently used to test the fluoride levels at the water treatment plant should be formalised into a standard operating procedure, which is specific to the equipment being used and in accordance with the manufacturer's instructions.
- ❑ Consideration could be given to introducing a random or continuing method of verification of the test result obtained at plant level.
- ❑ A standard results recording sheet should be adopted to note daily, the quantity of acid used, the amount of water treated, the colorimetric/other test result, and the concentration of fluoride calculated using the gravimetric formula.
- ❑ Results should be recorded and made available electronically, where feasible. A copy of the results should be forwarded to the designated Sanitary Authority engineer monthly and then forwarded to the Environmental Health Services.

6.5 Monitoring Visits

Aims:

The aims of this section were to determine

- the awareness of monitoring visits to the plants
- whether these were visits by the Engineers, Principal Environmental Health Officers and/or the Principal Dental Surgeons
- the purpose and frequency of these visits
- if any reports or feedback were generated from the visits.

Requirements:

There are no requirements in the Act or the Regulations or recommendations in the Departmental Circulars on monitoring visits.

Findings

Engineers

For the three largest plants visited there was an engineer on site. For sites which had a caretaker who visited daily, the normal practice was for the overseer or foreman to visit each location on a weekly basis. Three plants indicated that the engineer visited on a monthly or regular basis. The remainder of the plants indicated that the engineer visited on an occasional basis or when a problem arose.

Principal Environmental Health Officers/ Environmental Health Officers

Two Community Care areas had a policy of twice yearly visits by the Environmental Health Officers. Five of the plants assessed indicated that the Environmental Health Officers would visit on receipt of unsatisfactory results. The balance (7) said that the Environmental Health Officers did not visit.

Principal Dental Surgeons

One Community Care area had a policy of annual visits by the Principal Dental Surgeons. Otherwise the Principal Dental Surgeons either visited the water treatment plants for familiarisation at some stage or they did not visit at all.

Any feedback received following the visits to the water treatment plants was informal. No written reports were issued to the plants visited.

Recommendations:

- ❑ Visits to the water treatment plants should be undertaken under the direction and organised by the Fluoridation Monitoring Committee (FMC). These visits should take place on at least on an annual basis.
- ❑ The Fluoridation Monitoring Committee should send a written report back to the plant personnel with feedback on the outcome of the visit, recommendations and time scales for implementation.

6.6 Personnel

Aim:

The aim was to assess how many personnel were on site and whether they were part or full time. The level of training received by the operators was also assessed.

Requirements:

There are no requirements in the Act or the Regulations or recommendations in the Departmental Circulars on personnel numbers or training.

Findings:

The two largest sites visited, one with approximately 25 staff and the other with 11, both had training programmes in place which they felt fully addressed the topics listed in the assessment. While they felt that their staff were adequately trained both recognised the importance of refresher training. In one of the smaller plants (with 3 personnel) there was a training programme and a strong awareness of the importance of well-trained staff.

For the remainder of the smaller sites, which were primarily managed by caretakers, the level of training received varied. Four areas had sent their caretakers on a training course, which is supported by FAS. These courses are held at regional training centres. The course is of eight days duration and on successful completion of the examination a City & Guilds certification is achieved.

Most operators or caretakers indicated that they felt they were adequately trained in equipment operation. This was particularly the case for the operators who were employed when the plant or new equipment was commissioned.

The areas that the operators indicated a desire for enhanced training in the following areas:

- Health & Safety in respect of water fluoridation
- Calibration of equipment for used for fluoridation
- Incident Management relating to water fluoridation

While qualified engineers were present in some plants, the smaller plants had in the main operators transferred from other sections of the Local Authorities. This further emphasises the need for a formal training programme and records of training received by individuals to be kept.

Since this evaluation was carried out a new one-day course has been designed which specifically addresses the training issues related to water fluoridation. This will be delivered in the regional training centres during 2002.

An important bonus for most locations was the very low level of staff turnover and the level of experience acquired by the operators over the years. Formal training courses and structures would address the issues, which will occur upon the retirement of the current operators.

Discussion:

Lalumandier et al (2001) identified training of water treatment plant operators as an important factor in the variations from optimal fluoride concentration. The Centre for Disease Control in the US provides training programmes for water fluoridation staff at various levels. The CDC recommends: (i) that water treatment plant operators receive a minimum of one day (six to eight hours) of training for fluoridation annually; (ii) all state fluoridation specialists should attend the CDC basic fluoridation training course at least once a year and the advanced workshop at least once every three years; (ii) trained state personnel should provide start-up training for all water plant operators for each new fluoridated water system.

Recommendations:

- The existing formal training programmes should be evaluated to determine if all aspects of water fluoridation (equipment operation, intake & storage of acid, water analysis, incident management) and all relevant personnel in both the Sanitary Authorities and Health Boards are adequately trained.

6.7 Intake/Storage of Acid

Aim:

The aims of this section were to assess the

- procedure for the intake of acid at each site visited
- available protective clothing
- location and bunding of the acid storage tank
- procedure for dealing with spillage
- stock control employed to monitor acid levels.

Requirements:

The Safety, Health and Welfare at Work Act 1989 requirements apply to Local/Sanitary authorities and water treatment plants and the requirements of this legislation are relevant to water treatment plants.

Findings:

Procedures for Intake of Acid

Nine plants had a procedure for intake/delivery of the acid. The two larger plants had trained the operators in the intake of acid and dealing with spillages. However in all other instances no formal procedures were evident and the predominant response from caretakers/operators was that the intake of the acid was the responsibility of the driver of the tanker. The location of the intake pipe varied from plant to plant, in some plants the driver or plant personnel had to climb over other installations to access the delivery point for the acid storage tank.

Procedures for dealing with spillages

Eleven plants had a formal procedure to deal with the spillage of acid, three had no formal procedure. There was a perception that if a spillage occurred that the plant personnel would contact the acid supplier. Safety Data Sheets and hazard warning signage were not universally evident and in some instances phone numbers of the previous acid supplier were still on display. Almost universally plant personnel cited the desire for training or additional training on the handling of the acid and dealing with emergencies.

Procedures with regard to delivery and spillage of acid were very much left to the acid supplier. It was seen as the acid supplier's responsibility to ensure that if there was a problem with the delivery of the acid or if a spillage occurred the supplier would be contacted.

Protective Clothing:

The protective clothing available to the operators varied greatly from site to site. Most sites had goggles and gloves available, others had masks and most of the newer or larger plants had installed showers.

Storage Tanks:

Of the plants visited, five were observed to have storage tanks which either had no bunding or were inadequately bunded. In most of the smaller plants the tank was locked into the main building which houses all the plant equipment.

All plants had day tanks mounted on weighing scales; however in only one instance was the day tank bunded. The bunded area also had a sensor to detect spillage. Also in most instances there was no method to prevent overfill and spillage when filling.

Stock Control:

The four largest plants visited had a telemetric/alarmed stock control system. Most of the smaller plants rely on the operators to monitor stock levels by means of a tank level indicator, which was a cat and mouse type or sight glass. Most operators monitored levels on a daily basis and indicated that running out of acid was an unlikely occurrence.

Recommendations:

- ❑ Current practices should be formalised into standard procedures in each plant for the intake of the acid, including regular integrity tests for cracks or corrosion in storage tanks ducting.
- ❑ The feasibility of introducing low-level access for delivery of acid should be explored in all water treatment plants. At the same time the possibility of installing a non-return intake valve designed to only accept the delivery hose from the acid bulk tanker should also be explored. It is also desirable that the intake pipe area, where feasible be bunded.
- ❑ Bunding or other containment measures sufficient to contain the full volume of the storage tank should be in place such as double skinned storage tanks. For the larger plants, the possibility of the bunded area being alarmed should be explored.
- ❑ The location and security aspects of storage tanks should be evaluated.
- ❑ The Safety Data Sheet for the acid should be available at all plants in an appropriate location together with the emergency phone number for the current acid supplier.
- ❑ Audits should be undertaken in each plant to determine the appropriateness of the currently available the personal protective clothing/equipment/materials in respect of hydrofluosilicic acid.

7 Assessment of the procedures used by the supplier of fluoride additive

Albatross Ltd of New Ross, Co. Wexford was the company under contract to supply hydrofluosilicic acid to all Sanitary Authorities in the country at the time of the evaluation. This company had received ISO 9000 accreditation for their supply and distribution procedures.

Requirements:

The Statutory Instrument provides the specification for the hydrofluosilicic acid. The Safety, Health and Welfare at Work Act 1989 requirements apply to this company as to any other.

Objectives:

The purpose of this visit was (i) to assess the controls or procedures in operation to deal with the storage, testing and processing of the acid and (ii) to assess the incident and emergency response procedures in place.

Acid Source & Intake:

Hydrofluosilicic acid is sourced from a company in Bilboa, Spain. It is not a by-product of any industrial process. Sulphuric acid is added to fluorspar (CaF_2) which produces hydrofluoric acid. Silica (SiO_2) is then added to the hydrofluoric acid to produce hydrofluosilicic acid (H_2SiF_6) also known as hexafluosilicic or fluosilicic acid.

Storage & Dilution:

The system of dilution of the acid is manual and is carried out in three dilution tanks. Diluted product is tested for concentration and specific gravity to ensure that it meets the final specification of 14% percentage acid and specific gravity of 1.1130. The percentage acid is analysed by titration and the specific gravity by weight. A sample from each batch is retained for future reference. The laboratory is not accredited but personnel have 30 years of cumulative experience in this laboratory.

Deliveries:

Each load is accompanied by a signed Certificate of Analysis, with a Consignment Number on each certificate. The certificate states the specific gravity of the batch and is traceable back to the original consignment of acid.

There is one driver and a back up driver, both have received Hazchem Training. The company operates with one large bulk tanker and one small tanker. Orders are received and deliveries are made on request. The company asserts that 90% of deliveries are on schedule. The tanker has regular spark tests to verify the integrity of the tank.

Incident Management

The company has no direct role in dealing with emergencies at the water treatment plants. If they are contacted about spillages the company has no response outlined but pointed out that this was not their responsibility. The company representative did state

that they would be willing to provide assistance with the training of plant personnel through the regional training programmes.

Recommendations:

The company awarded the contract to supply hydrofluosilicic acid should:

- ❑ Consider the need for a product recall procedure
- ❑ Circulate the Safety Data Sheet to all plants on an annual basis
- ❑ Be approached to advise on or provide input into hazard chemical training for Local Authority personnel in handling fluoride products.
- ❑ Indicate on the delivery docket the tolerance in sample analysis

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Department of Health & Children

Department of Environment & Local Government

The North Eastern, North Western, Southern, South Eastern South West Area, Western, Health Boards.

Local Authorities: Cavan County Council, Cork County Council, Dublin Corporation, Galway County Council, Kildare County Council, Kilkenny County Council, Sligo County Council, Waterford County Council,

Promech, Management Consultants, 20 Upper Merrion St, Dublin 2

Public Analyst Laboratories in Dublin, Cork and Galway

Appendix 1 - Department of Health Circular 14/1977

Department of Health
Hawkins House, Dublin 2

An Roinn Sláinte
Teach Haicin, Baile Átha Cliath 2

TEL. (01) 784322 EXTN.

TELEX. 4894

REF. 1st July 1977

Circular 14/1977

Fluoridation of Public Water Supplies

Chief Executive Officer

Each Health Board

A Chara,

1. I am directed by the Minister for Health to state that he has had under review the progress made in implementing the programme for the fluoridation of public piped water supplies in pursuance of the Health (Fluoridation of water Supplies) Act, 1960.

2. 135 water supplies have now been equipped for fluoridation, serving an over-all population of 1.76 million. 75, mostly small, supplies serving a total population of 123,950 remain to be equipped for the process.

3. Fluoridation of piped water supplies is one of the cheapest and most effective measures yet discovered in the field of preventive dentistry. Its importance in the dental care services provided by Health Boards cannot be too highly stressed. Constant monitoring to ensure that the fluorine content piped water supplies is maintained within the correct levels is an essential element of the services. To date this Department, by means of the monthly returns received from the Health Boards, has monitored the fluoride content of individual water supplies throughout the country. As water fluoridation is part of the general community care services the Minister considers that Health Boards might now assume responsibility for monitoring the fluoride content of fluoridated water supplies in their community areas as well as for ensuring, in consultation with the local authorities concerned, that other water supplies suitable for fluoridation are equipped as resources permit.

4. Directors of Community Care will have a general responsibility to the Programme Manager, Community Care, for the satisfactory operation of fluoridation in the Board's area. Within each community care area it would seem the responsibility for monitoring the general operation of the service should be assigned to the Senior Dental Surgeon, who should also keep under review the need for its extension to new water supplies.

5. It has been represented that on occasion the results of distillation tests either had not been reported to the Chief Medical Officer or Dental Surgeon or that the tests had not been carried out at all. These tests are prescribed in the Regulations made by the Minister under the 1960 Act and it is essential that they be carried-out on all fluoridated water supplies at the appropriate intervals (see paragraph 7 (d) of the attached memorandum).
6. As from 1st July 1977 monthly reports (apart from the report for June 1977) on the fluorine content of fluoridated water supplies should not be sent to this Department but a general report on the fluorine levels in such water supplies; based on distillation test results, should be sent to the Department after the close of each quarter (see paragraph 1(c) or attached memorandum).
7. The attached memorandum was prepared in co-operation with the Department of Local Government and copies have been sent by that Department to local authorities. It outlines for Health Boards and local authorities their respective responsibilities in relation to the fluoridation of public via water supplies.
8. This Circular supersedes this Department's Circulars Nos, 32/65 or 9th July 1965 and 18/69 of 9th June 1969.

The title Director of Community Care as used in this Circular and enclosure means Director of Community Care and Medical Officer of Health

J. O'ROURKE.

(Memorandum enclosed with Circular 14/77)

FLUORIDATION OF PUBLIC WATER SUPPLIES

Legal and administrative position:

1. The legal provision for the fluoridation of public water supplies is contained in the Health (Fluoridation of Water Supplies) Act, 1960. The Act gave health authorities general responsibilities for the fluoridation of water supplies specified in regulations made by the Minister in pursuance of the Act. On the establishment of the Health Boards this general responsibilities was transferred by Section 6 of the Health Act, 1970 to Health Boards from 1st April 1971.
2. Fluoridation is now part of the community services administered by Health Boards. For the effective administration of the community care services, each Health Board area is divided into a number of community areas. A list of Health Boards and their community areas is contained in Appendix A. A Director of Community Care has general responsibility for the community care services in each community area. However, the Department of Health envisages that responsibility for day to day monitoring of the fluorine content of fluoridation water supplies and generally for implementing the fluoridation programme will normally be assigned to the Chief or Senior Dental Surgeon.
3. In accordance with the regulations made by the Minister for Health, in consultant with the Minister for Local Government, local (sanitary) authorities will continue to bear direct responsibility for the installation, maintenance and operation of fluoridation plants as agents for the Health Boards. A list of (i) water supplies equipped for fluoridation and (ii) supplies not yet so equipped is contained in Appendix B.

Financial arrangements

4. As provided for in Section 4(1)(e) of the 1960 Act, expenditure, both operational and capital, incurred by a local authority on the fluoridation of its piped water supplies is recoupable in full to that authority by the relevant Health Board. Operational expenditure includes expenditure on the fluoride (fluorine compound) used, normally hydro-fluosilicic acid (H_2SiF_6), and expenditure on plant maintenance.

Capital expenditure on fluoridation includes the costs of-

- (a) fluoridation equipment and its installation;
 - (b) storage tanks for hydro-fluosilicic acid and their installation;
 - (c) any buildings provided to house equipment and storage tanks; and
 - (d) provision of special access facilities to these buildings.
5. The recoupment of operational and capital expenditure by a Health Board to a local authority may be arranged by mutual agreement between the two bodies. Expenditure by a Health Board in relation to fluoridation is recognised for Health Services Grant purposes, subject to overall budgetary limitations.

Addition of fluorine to water and monitoring fluorine concentration:

6. The Regulations made by the Minister for Health under the 1960 Act provide that the amount of fluorine which may be added to a water supply shall be such that the water, after the addition of fluorine, shall contain not more than 1 part of fluorine, or not less than 8/10ths of one part of fluorine, per million parts of water.

7. Every effort should be made, however, to maintain a constant level of fluorine in the water as close as possible to 1 ppm without interruption. To ensure that the correct concentration of fluorine is maintained in a fluoridated water supply the following procedures should be carefully observed:

(a) As required by the Regulations made under the Act, a daily colourimetric test should be carried out to determine the fluorine content of the water. This is normally done at the water-works by the water-works staff. The daily samples for this test should be taken below the injection point at the water-works and occasionally at other points in the distribution system arranged to cover the whole system in a period of time.

(b) The memoranda on fluoridation accompanying the Department of Local Government's Circulars L9/62 of 15th August 1962 and L6/65 of 31st May 1965 require records to be kept of the amounts of water treated and of the fluorine used for these records the average fluorine content of the water can be directly calculated by the water-works staff. (Copies of: the Circulars referred to are attached as Appendices C and D).

(c) If: the daily colourimetric tests show a significant variation from the predetermined dosing rate over a period of three consecutive days, or from the fluorine content calculated as at (b) above, the results should be rechecked and any necessary adjustments made in the rate of injection. A report summarising the dosing rates and results of the colourimetric tests each month as at parts (1) and (2) in the form of Appendix E should be forwarded by the water-works engineer to the Director of Community Care as soon as possible after the end of each month. The Director should then enter in part (3) of the report form the result of the distillation test made during the month (see paragraph (d)) and then send a copy of the complete report to the water-works engineer and to the Chief or Senior Dental Surgeon for the area concerned. In future, these monthly reports should not be sent to the Department of Health but general report, in the form of Appendix F, covering the fluorine levels in all fluoridated water supplies in the Health Board's Area should be sent by the Director of Community Care to that Department as early as possible after the end of each quarter, beginning with the quarter ending 30th September 1977. The director should also send a copy to the Chief or Senior Dental Surgeon for his information.

(d) The Regulations also require a distillation test to be carried out at fortnightly intervals during the first six months of fluoridation of a water supply and at intervals not exceeding four weeks thereafter. The distillation tests should be made by a Public Analyst and samples of water for the tests should be taken from different points in the distribution system. Unless required for other purposes unconnected with fluoridation, a complete chemical and analysis would not appear to be indicated in addition to the distillation test for fluorine content. The distillation test is intended to be an independent check at regular intervals on the fluorine content of the water. Hence the Director of Community Care should ensure that the distillation test is made at least once a month. The Health

Inspector, or other Health Board Officer, deputed to take the samples of water for the Public analyst should make sure, by consulting the waterworks staff that the sample is not taken at a time when the fluoridation plant is being repaired, overhauled or is not otherwise functioning adequately.

(e) A copy of the Public Analyst's report should be furnished immediately to the water-works engineer. If the result of a distillation test by the Public Analyst shows any significant variation from a level of 1 ppm, the water-works engineer should make any adjustment necessary in the rate of injection, having first reviewed results of the colourimetric tests and the calculated figures relating to the dates immediately prior to that to which the distillation test refers. If considered necessary, further distillation and colourimetric tests should be arranged.

(f) Should a fluoridation plant break down, immediate repairs should be put in hands so as to have it in commission again with the shortest possible interruption. If it is felt, in the event of a breakdown, that the necessary repairs cannot be satisfactorily carried out by the water-works staff, the suppliers of the plant should be notified at once and asked to carry out the requisite repairs without delay. If a serious breakdown should occur, for example, one likely to involve an interruption of 14 days or more, a report on the matter and on the remedial measures being taken should be furnished by the water-works engineer, without delay, to the Director of Community Care; also a copy of the report should be sent to the Chief or Senior Dental Surgeon of the area concerned.

Fluoridation plant maintenance

8. Sanitary authorities should, however, ensure that breakdowns of fluoridation plants are avoided as far as possible. An essential factor in the continuous and efficient operation of fluoridation plant is its proper maintenance. Each local authority, which provides fluoridated water, should, therefore, take the following steps, if it has not already done so, to maintain each fluoridation plant in good working order.

(a) A stock of minor spare parts required for routine replacements including oil seals, neck rings, gaskets, diaphragm and plunger should be kept on site. Major replacement parts should be ordered in good time to allow for delivery periods.

(b) It is recommended that every sanitary authority enter into an arrangement with the suppliers of each fluoridation plant to service the plant at least once a year. Where a number of fluoridation plants, supplied by the same firm, are located within a convenient distance of each other, the firm should be asked to quote a reduced charge for servicing. A local authority is entitled under the provisions of the Health. (Fluoridation of Water Supplies) Act, 1960 to obtain from the Health Board recoupment of the full cost of servicing fluoridation plant.

Fluoride supplies

9. Arrangements should be made by the local authority to maintain a tall times an adequate stock of fluoride, normally hydrofluosilicic acid, for use at tile water-works. Orders for delivery of acid, therefore, should be placed in good time with the suppliers, Messrs. Albatross Fertilisers Ltd., New Ross, Co. Wexford. The firm, with the approval of the Department of Health, has undertaken to supply to local authorities acid imported, on the basis of a six-year contract, from its associate firm in Holland; deliveries of this

acid to water-works began in February 1976. To ensure that the acid complies with the standard specification (see Appendix D) a sample of the acid should be taken at the injection point from time to time and sent to the Public Analyst for analysis.

10. Any breakdown in the arrangements for the supply of acid to water-works should be reported immediately to the Director of Community Care by the local authority concerned. The Director of community Care should in turn report the matter immediately to the Department of Health and inform the Chief or Senior Dental Surgeon.

Fluoridation of further water supplies

11. The fluoridation of water supplies, specified in Regulations made under the 1960 Act but not yet equipped for the process, should be pressed ahead as resources permit. New water supplies or enlarged existing small supplies which are not already covered by Regulations made under the 1960 Act, should be considered for fluoridation where the population to be served is approximately 1,000 or more. To enable the Minister for Health to make Regulations to provide for the fluoridation of such supplies, the local authority is requested to furnish through the Director of Community Care the following information to the Health Board for submission to the Department of Health:

- (a) the name of the water supply scheme, the population serviced and the area served (in general terms)
- (b) a report by the Public Analyst on a complete chemical analysis, including fluorine content, of a sample of untreated water from the supply proposed for fluoridation; and
- (c) an estimate of the capital cost of installing fluoridation plant for the water supply in question (so that the Health Board may make financial provision for the recoupment of such expenditure by the local authority).

12. The Health Board and the Department of Health should be informed immediately by the local authority of the date of commencement of fluoridation of a water supply.

Prepared by Department of Health in consultation with the Department of Local Government

July 1977

DEPARTMENT OF LOCAL GOVERNMENT

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DUBLIN 1

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L.9/62

APPENDIX C

15 Lunasa 1962

A Chara

I am directed by the Minister for Local Government to refer to the Health (Fluoridation of Water Supplies) Act, 1960 and to forward herewith, for you information and for guidance of the County Engineer and his staff, a copy of a specially prepared memorandum dealing with technical aspects of the procedure for the fluoridation of public water supplies. It is understood that a copy of a British Report entitled "The Conduct of the Fluoridation Studies in the United Kingdom and the Results Achieved after Five Years" has been circulated to you by the Department of Health (Circular M.102/79 dated 31.07.62). The Report includes information in regard to equipment used in the fluoridation of supplies, control of the level of fluorine in the water and personal precautions taken by waterworks staff.

Mise le meas

To each City and County Manager

DEPARTMENT OF LOCAL GOVERNMENT

Memorandum on the Fluoridation

of

Public Water Supplies

<u>SECTION 1</u>	Specification for Chemicals
<u>SECTION 2</u>	Specification for Equipment
<u>SECTION 3</u>	Point of Application
<u>SECTION 4</u>	Control and Testing
<u>SECTION 5</u>	Precautions in Handling and Storing Fluoride Chemicals

June 1962

SECTION 1

Specification for Chemicals

(1) Sodium Fluoride

The substance shall contain a minimum of 98 per cent sodium fluoride (NaF) by weight, providing 44.3 per cent available fluoride.

It shall not contain any toxic or harmful impurities when dissolved in water.

The content of insoluble materials shall not exceed 0.5 per cent.

The moisture content shall not exceed 0.5 per cent.

The substance shall have a crystalline form (20-40 mesh particle size) and shall be free from dust.

(2) Sodium Silicofluoride

The substance shall contain a minimum of 98 per cent sodium silicofluoride (Na₂SiF₆) by weight, providing 59 per cent available fluorine.

It shall not contain any toxic or harmful impurities when dissolved in water.

The content of insoluble materials shall not exceed 0.5 per cent.

The moisture content shall not exceed 0.5 per cent.

The substance shall be in the form of a powder and shall conform to the following sieve tests:

- (a) 100 per cent to pass through a 40 mesh sieve;
- (b) 95 per cent to pass through a 10 mesh sieve; and
- (c) not less than 5 per cent nor more than 35 per cent to pass through a 325 mesh sieve

Section 2

Specification for Chemical Feeders

The type of Fluorine feeder required will depend on the volume of water being put into supply. For small supplies, particularly those not under continuous supervision – 50m³ per day up to 2500m³ per day – solution feeders will be suitable. For larger supplies dry feeders will be required. It will be necessary to meter the volume of water being put into supply where fluoridation is practised.

Solution Feeders using Sodium Fluoride

- (i) To be constructed of corrosion resistant material.
- (ii) They must automatically dose a solution of sodium fluoride at a rate proportional to the flow of water, even over wide variations.
- (iii) They must be capable of functioning both with and without the use of external power such as electricity.
- (iv) They must be completely reliable
- (v) They must be able to operate without attention for periods of several days at a time.
- (vi) They must incorporate means for adjusting and controlling the rate of dosage in a positive and accurate manner.
- (vii) They must be able to apply the sodium fluoride solution either to an open body of water or into a main under any normal pressure.
- (viii) They must be fitted with safety devices to prevent the direct syphonage of fluoride solution if a negative pressure in the discharge lines arise.
- (ix) They must be capable of automatic starting and stopping

Dry Feeders using Sodium Fluoride or Sodium Silicofluoride

Volumetric Feeders

- (i) Accuracy of feed to be ± 3 per cent; rate of feed to be readily adjusted and controlled.
- (ii) Depending upon conditions at the waterworks, the feeder must be capable of being arranged (a) for gravity feed; (b) for injecting discharge; (c) for pumped discharge.
- (iii) If pumping rate of water is variable the feeder must be capable of being equipped to proportion the chemical feed to the flow.
- (iv) The feeder must be equipped with a built-in continuous solution chamber made of corrosion resistant material of such a capacity and flow of water that a solution

and not a slurry of the chemical is fed into the water supply. This chamber must be fitted with an agitator or other device to ensure solution of the solid fluoride chemical.

- (v) The feeder to be fitted with a hopper of sufficient size to hold a minimum of 136kg of chemical. Arching and caking of chemical in the hopper is to be prevented by mechanical agitation.
- (vi) The feeder to be provided with a built-in scale to weigh the hopper and feeding mechanism but not the solution tank.
- (vii) A recorder to show the loss of weight of chemical in the hopper is to be available if required.
- (viii) The feeder is to be entirely enclosed by a case fitted with doors or removable panels to give access to pipes and feeding mechanisms. This case shall prevent the escape of any fluoride dust in the works.
- (ix) Adequate safeguards must be incorporated to prevent flooding or free flowing of chemical into the solution chamber.

Gravimetric feeders

- (i) As for Volumetric Feeders (i) to (ix) above, except that
- (ii) the accuracy shall be 1 per cent
- (iii) the rate of feed shall be based on the loss of weight in the hopper by means of a motor-driven counterweight along a built-in scale. To be capable of being pre-set and to easily adjusted.
- (iv) To be fitted with a dust extractor to prevent the escape of dust during filling operation.

Types of Solution feeders

- (i) proportional control gravity solution dosers;
- (ii) water operated solution injection pump;
- (iii) electricity operated solution injection pump.

Type (a) and (b) to be used in such cases where electric power is not available and where the daily consumption of water does not exceed 50m³ per day. The minimum capacity of the solution tank is to be three days supply of sodium fluoride solution.

- Type (a) For capacity dosers to be used primarily to feed a uniform dose of sodium fluoride solution to the free discharge (through a pipe or channel) of a spring or similar source. The working principle to be that of the tilting bucket or similar device which over balances when filled with definite quantity of water and thereby actuates a positive dosing valve which should deliver a fixed amount of sodium fluoride solution from the solution tank. The water discharged from the tilting device to be intimately mixed with the chemical solution before leaving the apparatus.

- Type (b) Medium capacity doser to be used where the solution has to be injected under pressure and where the main flow is variable and so necessitates automatic proportioning. This is affected by a standard chemical injection pump whose rate of stroking is proportional to the flow to be treated and which is powered by a meter actuated by that flow.
- Type (c) High pressure doser. Electric powered. To be used where injection against high pressure is necessary and electric power is available. A chemical injection pump is also employed.

SECTION 3

Point of application

Mr. J. R. Collins, A.M.I.C.E., A.M.I.W.E., Borough Water Engineer and Manager, in Watford, where a Pilot fluoridation installation has been operating under the control of the British Ministers of Health and of Housing and Local Government, states in his paper "Fluoridation and the Waterworks Engineer". "There is little possibility of interference with fluoridation arising from other water treatment processes and recent investigations indicate that fluorides may be applied before coagulation or filtration without significant loss of the chemical".

Dr. E. Windle Taylor, N.A., M.D., D.P.H., Director of Water Examination, London Metropolitan Water Board in his report for the year 1957-59 included an account, with relevant data in both tabular and graphical form, of an investigation into the effect of purification procedures on the fluoride content of water. The tests were carried out to study the effects of

Storage

Storage and filtration

Storage and coagulation followed by filtration

Test (a) was extended over a period of 10 months

Test (b) during a period of 70 days

Test (c) during a period of 40 days

His conclusions stated in the following terms:

"It seems clear from these results that when sodium fluoride is added to each to produce concentrations of the order of 1 ppm, F, ordinary waterworks treatment has no effect on its content. There is therefore no disadvantage in applying the mineral early in the purification process if this procedure would be more practicable. Given means of accurately determining the flow of water at any point and modern dosing apparatus that is now available, the required dose can be maintained with sufficiently high degree of precision.

"The risk of infecting the purified water would also be avoided by applying the fluoride at a pre-filtration stage".

“It is, therefore, a practical possibility to apply fluoride to water for the prevention of dental caries at a waterworks intake, or in any case before filtration and to maintain the dose through the treatment plant without any significant loss of the material.

The significance of both of these observations, one from a practitioner and the other from a research worker, is that there is no restriction as to the point of application of the fluoride. The layout and disposition of filtration and chemical injection units in our existing treatment works may indicate the point of application and in any event the one chosen should have regard to the effectiveness of control and freedom from personal risk in the handling and storage of the chemicals.

Where the water to be treated is moderately hard, it is necessary in the case of solution dosing apparatus that the water used for solution purposes be soft, i.e. free from calcium or magnesium bicarbonates. The inclusion in the fluoridation plant of a domestic or institution type base-exchange water softener will provide the full requirements in this respect.

SECTION 4

Control and Testing

Control at the point of injection should be twofold:

1. Calculation of the amount fluoride added to the water. When the rate of addition in pounds (oz's) per unit volume is known, the concentration of fluoride ion parts per million can be calculated.
2. Chemical determination of the fluoride ion in the finished water.

After allowing for any natural fluoride, if such is present in the water these two figures should agree; if they do not an investigation should be made as the disagreement may mean that mixing is incomplete or that fluoride is being lost in the treatment plant.

Calculation of the concentration of fluoride ion

In order that the concentration of the fluoride ion can be calculated, an accurate measurement of the amount of water treated must be made and recorded. In addition the amount of fluoride used per unit time, or in the case of a variable injecting rate by solution feed, the volume of solution used should be determined. When dry feed fluoridators are used a permanent record of the rate of feed is provided, but with solution feeders such facilities are not available and in this case regular readings of the amount of solution of known strength used should be taken and noted. There are several attached to the inside of the solution tank that can be easily read by the operator, although for a deep tank, a float, cable, pulley and scale on the outside of the tank would be better. A sight glass will also show the solution level in the tank. The use of a meter on the make up supply to the sodium fluoride saturator or solution tank also provides a means of recording the amount of sodium fluoride solution used.

From these records the amount of fluoride and volume of water passing into supply are known and from these the concentration of the fluoride ion is calculated, using the

knowledge that the fluoridation of 5,000 m³ gallons of water to a level of 1 ppm F requires the addition of 11.23kg of sodium fluoride or 8.33kg of sodium silicofluoride.

Testing:

Testing in so far as it will be carried out at the treatment plant will consist in making a colourimetric test using a standard comparator similar to that used in testing for pE and residual chlorine. The test is based on the formation of a colour lake with a zirconium salt and alizarin and the measurement of intensity of colour formed. This colour develops without the presence of fluoride and fluoride, when present, has a preferential reaction with zirconium and so reduces proportionately the colour produced. The colour without fluoride is pink and increasing amounts of fluoride reduce this to yellow. Free chlorine interferes with the colour formation but can be removed prior to analysis by the addition of a few drops of sodium arsenate. The procedure to be followed in practice is:

- (i) Add a few drops of sodium arsenate to the sample for test in the standard test tube where chlorination is applied in the water treatment.
- (ii) Add appropriate amount of zirconium-alizarin reagent.
- (iii) Allow treated sample of stand for one hour before comparing colour reaction with standards for different concentration in ppm. During this reaction period the test tube containing the treated sample should stand in a constant temperature bath at 20°C.

SECTION 5

Precautions in handling and storing of Fluoride Chemicals

Any plant where fluoride in powdered form is handled should be housed in a self-contained chamber, but where a solution feeder is used there is no need to provide special housing for the injection plant, which can be safely accommodated with any other waterworks plant.

Dry feeding equipment should be dust-tight and when appreciable quantities of fluoride are fed, should be fitted with dust extractors for use during filling operations. There can be no hard and fast rules but at rates of 10lbs per hour and upward, extractors should be fitted. At lower rates a great deal depends on the care exercised by personnel but the provision of a dust-tight receptacle as part of the feeder to take a complete container of fluoride is advisable.

Whatever arrangement is provided it is recommended that operators be supplied with rubber gloves and respirators, the latter being of a simple type consisting merely of a suitable pad to cover the mouth and nostrils. The gloves should be washed after use.

If chemical is spilled on the floor it should not be brushed up but should be removed by mopping or hosing with water. The chemical itself should be stored in dry rooms and should be raised off the floor by wooden pallets. The location of the chemical store should be such that the distance to be filling hopper is as short as possible

**Department of Local Government
Custom House
Dublin 1**

**Roinn Rialtais Aitiuil
Teach an Chustaim
Baile Atha Cliath**

Appendix D

Circular No. L.6/65

31st May 1965

A Chara

I am directed by the Minister of Local Government to refer to the Health (Fluoridation of Water Supplies) Act, 1960 and to forward herewith a copy of a memorandum on the use of Hydrofluosilicic Acid which has been approved for the fluoridation of public water supplies. You are requested to submit to this Department, as early as possible, your detailed proposals and specification for fluoridation plants using either Sodium Fluoride, Sodium Silicofluoride or Hydrofluosilicic Acid.

A copy of the memorandum dealing with technical aspects of the procedure for the fluoridation of public water supplies which accompanied the Department's Circular Letter L.9/62 of 15 Lúnasa, 1962, is re-issued herewith for you information.

Mise le meas

ADDENDUM TO
MEMORANDUM ON THE FLUORIDATION
OF
PUBLIC WATER SUPPLIES

(Under Circ. L.9/62 15 Lúnasa 1962)

HYDROFLUOSILICIC ACID

Specification for acid

The acid to be used for the fluoridation of Public Water Supplies shall contain 14% by weight of fluosilicic acid (H_2SiF_6), subject to a tolerance of 0.5 per cent above or below that strength and shall contain not more than 0.012 per cent by weight “heavy metals” expressed as lead (Pb) and no other soluble mineral or other organic substance in quantities capable of a deleterious or injurious effect upon health.

Characteristics of the Acid to the above Specification

<u>Strength of acid</u>	<u>13.5%</u>	<u>14%</u>	<u>14.5%</u>
F ion concentration	10.67%	11.06%	11.45%
Specific gravity	1.115	1.119	1.124
Weight of 1 litre of acid	1.115kg	1.119kg	1.124kg
Weight of F ion in 1 litre of acid	119.9	124.9	129.9
Vol. Of acid required to treat 10 ⁶ litres	8.4 litres	8 litres	7.7 litres

Storage of Handling of Acid

Fluosilicic acid is a near colourless liquid. It attacks glass or glazed earthenware and must be stored in rubber or glass lined containers. Wooden containers properly constructed may also be used. It has a corrosive action on the skin and because of this it should be handled with care, spillage should be avoided and containers should the skin the part be affected should be thoroughly washed immediately.

Storage facilities should be provided at the site or sites of the water treatment plants. Central storage for the purposes of re-distribution to the various water supplies requiring the acid will no be permitted. In the case of certain water supplies with access difficulties, it may be necessary to relax the general restriction on central storage. Such cases should be made the subject of a special report by the local authority to the Department of Local Government.

A minimum of one month's supply is to be provided at each site and replacement orders must be dispatched on or before the date on which stocks fall to ten days requirement.

Water supplies of 4,000 m³ per day must provide a minimum storage of 6m³ in order to avail of tanker deliveries.

Injection Equipment

All components on the installation to be manufactured of such material so as to withstand a 20% solution of fluosilicic acid in water.

Pump out-puts may be either proportional to varying flows or constant and the pumps are to be provided with means of adjusting and controlling the rate of dosage in a positive and accurate manner.

The installations to be capable, under unqualified guarantee, of operating within an accuracy of $\pm 3\%$.

The means whereby the rate of dosage is controlled to be so installed, constructed or protected so as to prevent interference by unauthorised persons. Out put of pumps not to exceed 50% of maximum dose rate.

Pumps may be powered either by electricity or by water power. Pumps are not to be surcharged but must operate on a suction loft and the installation is to be fitted with an anti-syphonage device.

The whole installation must be able to operate, where circumstances may require, without attention for periods of several days at a time.

APPENDIX E

Health Board _____ Community Area _____

Report for month of _____. 19 on _____ Water Supply

Dosing rates as calculated from chemical usage.

Were highest for month at p.p.m. for days

Were lowest for month at p.p.m. for days

Average dosing rate was p.p.m.

Colorimetric Test Results

Were highest for month at p.p.m. on days

Were lowest for month at p.p.m. on days

Average daily fluorine content was p.p.m.

Engineer's comments on operation of fluoridation.

Signed Engineer Date

Distillation Test Results

Results of distillation tests gave p.p.m. on

..... p.p.m. on

..... p.p.m. on

(*insert date)

Director's comments on operation of fluoridation:

Signed
Director, Community Care

Date

APPENDIX F

Report on fluorine content of fluoridated water supplies

Health Board

Quarter ended _____ 19____

Community Area

Water Supply	Distillation Tests				
	Made during quarter	Satisfactory result	Unsatisfactory result	Average Result	Action taken if result unsatisfactory
	Number	Number	Number	P.P.M.	

Further comments, if any

Signed _____

Director of Community Care

Date _____

Notes: A distillation test should be carried out at least monthly on each water supply to determine its fluorine content. Satisfactory result means not less than 0.8 and not greater than 1.0 P.P.M. Unsatisfactory results means less than 0.8 or more than 1.00 P.P.M.

Appendix 2 - Questionnaire to Principal Dental Surgeons and Principal Environmental Health Officers

**SCHOOL OF DENTAL SCIENCE AND DUBLIN DENTAL HOSPITAL
DEPARTMENT OF PUBLIC & CHILD DENTAL HEALTH**



QUESTIONNAIRE ON WATER FLUORIDATION

Health Board Area _____ ☐ PDS ☐ PEHO (Please ✓one)

FLUORIDATION MONITORING COMMITTEE (FMC)

1. Is there a FMC operating in your area? YES ☐ NO ☐

2. If yes above how often does it meet?

3-monthly ☐ 6-monthly ☐ Annually ☐ Other _____

3. Who chairs the FMC?

PDS ☐ PEHO ☐ SAMO ☐ Engineer ☐ Other _____
(indicate grade)

4. In your opinion is the FMC effective?

Not effective ☐ Moderately effective ☐ Very effective ☐

5. Do you visit the fluoridated water treatment plants?

REGULARLY ☐ OCCASIONALLY ☐ ON REQUEST ☐

REPORTING OF TESTS

6. Who receives the monthly test reports first, second and third?

Please indicate by placing a number beside the relevant grade.

PEHO ☐ PDS ☐ SAMO ☐ OTHER ☐ DON'T KNOW ☐

7. If a result is unsatisfactory who contacts/advises the local authority?

PEHO ☐ PDS ☐ SAMO ☐ OTHER ☐ DON'T KNOW ☐
(indicate grade)

8. Do you receive the monthly test reports within a useful time period?

YES ☐ NO ☐ DON'T KNOW ☐

9. How long does it usually take for you to receive the monthly test results?

< 1 month ☐ 1-2 months ☐ >2 months ☐ Don't Know ☐

10. Are there any codes of practice/protocols in place in respect of water fluoridation in your area?

YES ☐ NO ☐ DON'T KNOW ☐

11. Who submits the quarterly reports to the Department of Health & Children?

PEHO ☐ PDS ☐ SAMO ☐ OTHER ☐ DON'T KNOW ☐

12. Is an annual report collated for the health board or Dept of Health & Children?

YES ☐ NO ☐ DON'T KNOW ☐

13. Are fluoride levels in groups water schemes sampled for fluoride?

YES ☐ NO ☐ DON'T KNOW ☐

14. If yes above, how frequently?

REGULARLY ☐ OCCASIONALLY ☐ ON REQUEST ☐

FUNDING OF WATER FLUORIDATION

15. Who authorises the payments for revenue items such as acid, maintenance of equipment?

PEHO ☐ PDS ☐ SAMO ☐ OTHER ☐ DON'T KNOW ☐

(indicate grade)

16. Is there an option to withhold revenue payments where test results are unsatisfactory?

YES ☐ NO ☐ DON'T KNOW ☐

17. Are all/most revenue payments due to the local authorities paid within the year to which they refer?

YES ☐ NO ☐ DON'T KNOW ☐

18. How are capital requirements identified?

19. What was the budget for water fluoridation in your area for the last 5 years?

BUDGET	1995	1996	1997	1998	1999
Revenue					
Capital					

In the space below please make comments about any general or particular issues you feel are relevant to the implementation of water fluoridation in your area or nationally. These comments DO NOT form part of the questionnaire and will be used as background information only.

Appendix 3 - Questionnaire to the Public Analyst Laboratories

LABORATORY QUESTIONNAIRE

Laboratory: _____ **Contact Name:** _____ **Tel:** _____

This questionnaire relates only to the monthly fluoride tests performed on water samples.

Health Boards which submit samples to the Laboratory:

Board	No. of Samples per Month	Name of Contact in Health Board	Sampling Program Yes/No

TESTING:

Are there specific dates in each month when samples must be submitted? YES ☐ NO ☐

Is there a facility for testing unscheduled samples? YES ☐ NO ☐

Can tests be performed as part of a Rapid Response? YES ☐ NO ☐

CERTIFICATION:

Are the tests accredited? YES ☐ NO ☐

If Yes, to what standard? _____

If No, do documented procedures exist? YES ☐ NO ☐

EQUIPMENT:

Type of Equipment Used in Testing: Ion Probe ☐ Fluoride Ion Probe ☐

Hach Meter ☐ Distillation Test ☐ Other: _____

What is the accuracy of the equipment used for the testing? _____

CALIBRATION OF TEST EQUIPMENT:

Briefly describe the process: (Methodology & Frequency)

RESULTS:

Who is notified of results*? PEHO ☐ PDS ☐ Public Health Doctor ☐ LA ☐ Other: ____

Briefly outline the procedure for notification of unsatisfactory results: _____

Method: Phone: ☐ Fax: ☐ Email: ☐ Post: ☐ Other: _____

Turnaround Times: (Specify Average:) _____

*** KEY: PERSONNEL TO WHOM REPORTS ARE SENT**

PEHO = Principal Environmental Health Officer, in the health board

PDS = Principal Dental Surgeon, in the health board

PH/SAMO = Public Health Doctor or Senior Area Medical Officer

LA = Local Authority staff (engineers or others)

Appendix 4 - Department of Health & Children monthly test results for all health board areas

Table 1: Test results by category in the Eastern Health Board - Dublin Area

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	74	84.1	9	10.2	5	5.7	8	8.3	88
1991	109	82.0	16	12.0	8	6.0	0	0.0	133
1992	69	63.3	18	16.8	18	16.8	1	1.2	107
1993	72	75.8	15	15.8	8	8.4	0	0.0	95
1994	40	90.9	2	4.6	2	4.6	4	4.8	44
1995	41	85.4	1	2.1	6	12.5	48	50.0	48
1996	5	83.3	0	0.0	1	16.7	90	93.8	6
1997	41	100	0	0.0	0	0.0	43	51.2	41
1998	35	92.1	2	5.3	1	2.6	0	0.0	38
1999	79	94.1	3	3.6	0	0.0	0	0.0	84
2000	59	70.2	3	3.6	6	7.1	16	22.2	84

Table 2: Marginal & Unsatisfactory test results in the Eastern Health Board - Dublin Area

Year	%U-	%M-	%M+	%U+
1990	4.6	2.3	8.0	1.2
1991	2.3	9.0	3.0	0.8
1992	10.3	7.5	9.6	6.5
1993	5.3	1.1	14.7	3.2
1994	4.6	0.0	4.6	0.0
1995	9.8	2.1	0.0	4.2
1996	16.7	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0
1998	2.6	5.3	0.0	0.0
1999	0.0	3.6	0.0	0.0
2000	7.2	1.2	2.4	0.0

Table 3: Test results by category in the Eastern Health Board - Kildare Area

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	NA	NA	NA	NA	NA	NA	NA	NA	NA
1991	18	75.0	4	16.6	2	8.3	0	0.0	24
1992	20	64.5	5	16.1	6	19.4	2	6.1	31
1993	23	61.1	7	19.4	6	19.4	0	0.0	36
1994	46	76.7	9	15.0	5	8.3	0	0.0	60
1995	50	82.0	5	8.2	4	6.6	2	3.2	61
1996	37	51.4	8	11.1	3	4.2	19	26.4	72
1997	51	71.8	10	14.1	10	14.1	13	15.5	71
1998	31	56.4	11	20.0	13	23.6	5	8.3	55
1999	31	66.0	4	8.5	12	25.5	1	2.1	47
2000	9	33.3	9	33.3	9	33.3	4	12.9	27

Table 4: Marginal & Unsatisfactory test results in the Eastern Health Board - Kildare Area

Year	%U-	%M-	%M+	%U+
1990	NA	NA	NA	NA
1991	0.0	0.0	16.7	8.3
1992	9.7	12.9	3.3	9.7
1993	8.3	2.8	16.7	8.3
1994	6.7	3.3	11.7	3.3
1995	1.6	3.3	4.9	4.9
1996	2.8	2.8	8.3	1.4
1997	9.9	2.8	11.3	4.3
1998	20.0	9.1	10.9	3.6
1999	23.4	6.4	2.2	2.2
2000	33.3	29.6	3.7	0.0

Table 5: Test results by category in the Eastern Health Board -Wicklow Area

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	NA	NA	NA	NA	NA	NA	NA	NA	NA
1991	30	41.7	15	20.8	27	37.5	0	0.0	72
1992	42	60.0	8	11.4	20	28.6	2	2.8	70
1993	33	46.5	14	19.7	24	33.8	1	1.4	71
1994	58	81.7	5	7.1	8	11.3	1	1.4	71
1995	55	70.5	11	14.1	6	7.7	0	0.0	78
1996	35	68.6	9	17.6	7	13.7	21	29.2	51
1997	43	79.6	10	18.5	1	1.9	18	25.0	54
1998	54	76.1	10	14.1	7	9.9	1	1.4	71
1999	35	64.8	7	13.0	12	22.2	18	25.0	54
2000	46	66.7	13	18.8	10	14.5	3	4.2	69

Table 6: Marginal & Unsatisfactory test results in the Eastern Health Board -Wicklow Area

Year	%U-	%M-	%M+	%U+
1990	NA	NA	NA	NA
1991	27.8	13.9	6.9	9.7
1992	22.9	11.4	0.0	5.7
1993	19.7	5.6	9.9	14.1
1994	7.1	2.8	4.2	4.2
1995	3.9	6.4	11.5	2.6
1996	11.8	13.7	3.9	2.0
1997	1.9	13.0	5.6	0.0
1998	9.9	8.5	5.6	0.0
1999	22.2	9.3	3.7	0.0
2000	7.3	12.0	7.3	7.3

Table 7: Test results by category in the Midland Health Board - Laois Offaly

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	52	41.6	32	25.6	41	32.8	8	6.1	125
1991	61	44.9	20	14.7	55	40.4	26	16.7	136
1992	115	65.7	31	17.7	30	17.1	7	3.9	175
1993	92	56.4	40	24.5	31	19.0	5	3.0	163
1994	79	48.5	48	29.4	36	22.1	24	12.5	163
1995	134	61.8	38	17.5	45	20.7	11	4.8	217
1996	93	63.3	31	21.1	23	15.6	81	35.5	147
1997	32	52.5	12	19.7	17	27.9	227	78.8	61
1998	97	63.0	34	22.1	23	14.9	134	46.5	154
1999	92	45.5	65	32.2	45	22.3	86	29.9	202
2000	176	56.1	85	27.1	53	16.9	10	3.1	314

Table 8: Marginal & Unsatisfactory test results in the Midland Health Board - Laois Offaly

Year	%U-	%M-	%M+	%U+
1990	28.0	16.0	8.8	4.8
1991	28.7	7.4	7.4	0.7
1992	12.6	7.4	9.7	4.6
1993	11.7	4.9	19.6	7.4
1994	13.5	4.3	25.2	8.6
1995	15.7	2.3	13.8	10.6
1996	10.9	7.5	12.2	6.8
1997	19.7	4.9	13.1	9.8
1998	11.0	3.2	18.8	3.9
1999	9.9	15.3	16.8	12.4
2000	11.8	15.3	11.8	5.1

Table 9: Test results by category in the Midland Health Board - Longford Westmeath

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	88	56.4	33	21.2	29	18.6	0	0.0	156
1991	101	64.3	24	15.3	31	19.8	0	0.0	157
1992	100	64.1	37	23.7	19	12.2	0	0.0	156
1993	59	37.8	61	39.1	36	23.1	0	0.0	156
1994	96	61.9	27	17.4	32	20.7	1	0.6	155
1995	87	55.8	19	12.2	51	32.8	0	0.0	156
1996	76	51.7	33	22.5	38	25.9	9	5.8	147
1997	74	52.5	32	22.7	35	24.8	15	9.6	141
1998	87	55.8	24	15.4	45	28.9	0	0.0	156
1999	74	47.5	19	12.2	63	40.4	0	0.0	156
2000	63	41.7	23	15.2	65	43.1	5	3.2	151

Table 10: Marginal & Unsatisfactory test results in the Midland Health Board - Longford Westmeath

Year	%U-	%M-	%M+	%U+
1990	5.8	5.1	16.0	12.8
1991	17.8	5.7	9.6	1.9
1992	7.1	6.4	17.3	5.1
1993	8.4	9.0	30.1	14.7
1994	11.00	6.5	11.00	9.7
1995	28.9	9.0	3.2	3.2
1996	20.4	10.2	12.9	4.8
1997	22.7	10.6	12.8	1.4
1998	28.3	9.0	6.4	0.6
1999	34.6	11.5	2.6	3.9
2000	42.4	14.6	0.7	0.7

Table 11: Test results by category in the Mid Western Health Board - Clare

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	59	49.6	28	23.5	28	23.5	119	0.8	119
1991	47	56.6	27	32.5	9	10.8	83	1.2	83
1992	64	65.3	28	28.6	6	6.2	98	19.2	98
1993	67	67.0	21	21.0	12	12.0	100	9.3	100
1994	84	72.4	21	18.1	11	9.5	116	3.3	116
1995	71	60.2	33	28.0	14	11.9	118	1.7	118
1996	37	67.3	10	18.2	7	12.7	55	60.4	55
1997	53	69.5	17	22.4	8	10.5	76	15.7	76
1998	83	79.1	9	8.6	13	12.4	105	2.8	105
1999	69	69.0	16	16.0	15	15.0	100	7.4	100
2000	69	62.2	31	27.9	11	9.9	111	7.5	111

Table 12: Marginal & Unsatisfactory test results in the Mid Western Health Board - Clare

Year	%U-	%M-	%M+	%U+
1990	18.5	21.9	5.0	5.0
1991	9.6	27.7	4.8	1.2
1992	3.1	13.3	15.3	3.1
1993	7.0	12.0	9.0	5.0
1994	4.3	13.8	4.3	5.2
1995	7.6	21.2	6.8	4.2
1996	10.9	12.7	5.5	1.8
1997	6.6	15.8	6.6	4.0
1998	12.4	2.9	5.7	1.0
1999	14.0	7.0	9.0	1.0
2000	8.1	13.5	14.4	1.8

Table 13: Test results by category in the Mid Western Health Board - Limerick

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	58	53.7	28	25.9	22	20.4	0	0.0	108
1991	62	57.4	23	21.3	23	21.3	0	0.0	108
1992	63	58.3	34	31.5	11	10.2	0	0.0	108
1993	62	57.4	25	23.2	17	15.7	0	0.0	108
1994	63	60.0	27	25.7	15	14.3	3	2.8	105
1995	44	57.1	26	33.8	7	9.1	31	28.7	77
1996	43	68.3	14	22.3	6	9.5	45	41.7	63
1997	67	73.6	18	19.8	6	6.6	29	24.2	91
1998	79	67.5	27	23.1	11	9.4	15	11.4	117
1999	48	60.8	21	26.6	10	12.7	53	40.2	79
2000	69	62.2	31	27.9	11	9.9	21	15.9	111

Table 14: Marginal & Unsatisfactory test results in the Mid Western Health Board - Limerick

Year	%U-	%M-	%M+	%U+
1990	16.7	11.1	14.8	3.7
1991	20.4	13.0	8.3	0.9
1992	8.3	17.6	13.9	2.8
1993	12.0	14.8	8.3	3.7
1994	10.5	18.1	7.6	3.8
1995	3.9	15.6	18.2	5.2
1996	3.2	7.9	14.3	6.4
1997	1.1	9.9	11.0	5.5
1998	3.5	12.0	12.0	5.2
1999	3.8	15.2	12.7	7.6
2000	5.4	4.5	15.3	6.3

Table 15: Test results by category in the Mid Western Health Board - North Tipperary

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	40	47.1	10	11.8	35	41.2	23	21.3	85
1991	30	36.1	13	15.7	40	48.2	13	13.5	83
1992	42	47.2	5	5.6	44	49.4	7	7.3	89
1993	39	43.3	15	16.7	36	40.0	6	6.3	90
1994	52	52.5	15	15.2	32	32.3	9	8.3	99
1995	39	59.1	10	15.2	17	25.8	42	38.9	66
1996	8	57.1	4	28.6	2	14.3	82	85.4	14
1997	18	52.9	6	17.7	10	29.4	62	64.6	34
1998	47	71.2	17	25.8	8	12.2	30	31.3	66
1999	35	54.7	18	28.1	15	23.4	44	40.7	64
2000	35	56.5	10	16.1	18	29.0	70	53.0	62

Table 16: Marginal & Unsatisfactory test results in the Mid Western Health Board - North Tipperary

Year	%U-	%M-	%M+	%U+
1990	41.18	8.24	3.53	0.00
1991	44.58	10.84	4.82	2.41
1992	49.44	0.00	5.62	0.00
1993	40.00	12.22	3.33	0.00
1994	30.30	6.06	3.03	0.00
1995	27.27	9.09	6.06	0.00
1996	14.29	28.57	0.00	0.00
1997	26.47	17.65	0.00	2.94
1998	12.12	16.67	9.09	0.00
1999	21.88	20.31	7.81	1.56
2000	29.03	11.29	4.84	0.00

Table 17: Test results by category in the North Eastern Health Board - Cavan-Monaghan

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	82	63.1	31	23.8	17	13.1	2	1.5	130
1991	68	64.8	25	23.8	12	11.4	27	20.5	105
1992	72	56.3	31	24.2	25	19.5	4	3.0	128
1993	65	50.0	31	23.8	34	26.2	2	1.5	130
1994	46	38.3	30	25.0	44	36.7	12	9.1	120
1995	26	19.7	26	19.7	39	29.5	0	0.0	132
1996	91	68.9	34	25.8	7	5.3	0	0.0	132
1997	78	59.1	32	24.2	22	16.7	0	0.0	132
1998	81	61.4	39	29.5	12	9.1	0	0.0	132
1999	81	61.4	35	26.5	16	12.1	0	0.0	132
2000	78	61.4	32	25.2	17	13.4	5	3.8	127

Table 18: Marginal & Unsatisfactory test results in the North Eastern Health Board - Cavan-Monaghan

Year	%U-	%M-	%M+	%U+
1990	10.8	9.2	14.6	2.3
1991	8.6	14.3	9.5	2.9
1992	14.8	14.8	9.4	4.7
1993	8.5	3.1	20.8	17.7
1994	11.7	5.0	20.0	25.0
1995	12.9	3.8	15.9	16.7
1996	3.0	12.9	12.9	2.3
1997	9.1	12.9	11.4	7.6
1998	6.1	17.4	9.8	5.3
1999	6.8	16.7	9.8	5.3
2000	10.2	16.5	8.7	3.1

Table 19: Test results by category in the North Eastern Health Board - Louth

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	51	75.0	14	20.6	3	4.4	4	5.6	68
1991	35	50.7	14	19.7	21	29.6	4	5.6	70
1992	73	69.1	11	20.2	3	10.6	9	2.1	87
1993	65	69.1	19	20.2	10	10.6	2	2.1	94
1994	91	94.8	4	4.2	1	1.0	0	0.0	96
1995	85	86.3	11	10.8	3	2.9	7	5.6	99
1996	66	70.7	20	21.7	7	7.6	3	4.2	93
1997	71	77.2	15	17.4	6	5.4	4	4.2	92
1998	51	53.1	27	28.1	18	18.8	0	0.0	96
1999	53	57.0	23	24.7	17	18.3	3	3.1	93
2000	57	64.8	25	28.4	6	6.8	8	8.3	88

Table 20: Marginal & Unsatisfactory test results in the North Eastern Health Board - Louth

Year	%U-	%M-	%M+	%U+
1990	2.9	4.4	16.2	1.5
1991	28.6	15.7	4.3	1.4
1992	3.4	8.0	4.6	0.0
1993	5.3	1.1	19.1	5.3
1994	0.0	2.1	2.1	1.0
1995	2.0	5.1	6.1	1.0
1996	6.5	5.4	16.1	1.1
1997	0.0	2.2	14.1	6.5
1998	13.5	18.8	5.2	2.1
1999	16.1	19.4	5.4	2.2
2000	5.7	23.9	4.5	1.1

Table 21: Test results by category in the North Eastern Health Board - Meath

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	31	54.4	18	31.6	8	14.0	15	20.8	57
1991	43	66.2	6	9.2	16	24.6	7	9.7	65
1992	54	78.3	7	10.1	8	11.6	3	4.2	69
1993	44	61.1	17	23.6	11	15.3	0	0.0	72
1994	51	68.9	16	21.6	7	9.5	10	12.8	74
1995	39	61.9	12	19.0	13	19.0	9	12.5	64
1996	10	62.5	5	31.3	1	6.3	68	94.4	16
1997	40	65.6	14	23.0	7	11.5	21	25.0	61
1998	59	58.4	25	24.8	17	16.8	7	6.5	101
1999	65	71.4	13	14.3	13	14.3	17	15.7	91
2000	43	46.2	29	31.2	21	22.6	15	13.9	93

Table 22: Marginal & Unsatisfactory test results in the North Eastern Health Board - Meath

Year	%U-	%M-	%M+	%U+
1990	10.5	10.5	21.1	3.5
1991	23.1	7.7	1.5	1.5
1992	2.9	4.3	5.8	8.7
1993	2.8	0.0	23.6	12.5
1994	8.1	9.5	12.2	1.4
1995	14.1	7.8	10.9	6.3
1996	6.3	31.3	0.0	0.0
1997	9.8	8.2	14.8	1.6
1998	12.9	9.9	4.0	1.0
1999	13.2	9.9	4.4	1.1
2000	18.3	26.9	4.3	4.3

Table 23: Test results by category in the North Western Health Board - Donegal

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	36	30.5	29	24.6	51	44.9	23	17.4	118
1991	52	45.8	21	20.0	41	34.2	43	22.9	115
1992	62	48.4	30	22.7	36	28.9	12	9.1	128
1993	62	44.3	27	19.3	50	36.4	21	12.8	139
1994	45	31.9	24	17.7	74	5.0	15	9.6	142
1995	49	52.7	21	20.4	23	26.9	63	40.4	93
1996	50	54.8	21	22.6	22	22.6	63	40.4	93
1997	33	46.5	9	12.7	29	40.8	73	50.7	71
1998	72	51.4	23	16.4	45	32.1	20	11.1	140
1999	90	60.2	32	20.3	30	19.5	28	34.4	152
2000	100	67.1	22	14.8	27	18.1	31	17.2	149

Table 24: Marginal & Unsatisfactory test results in the North Western Health Board - Donegal

Year	%U-	%M-	%M+	%U+
1990	30.5	5.9	18.6	12.7
1991	27.0	6.1	12.2	9.6
1992	15.6	12.5	10.9	12.5
1993	27.3	8.6	10.8	8.6
1994	47.9	12.0	4.9	3.5
1995	17.2	15.1	7.5	7.5
1996	16.1	15.1	7.5	7.5
1997	31.0	12.7	0.0	9.9
1998	28.6	12.9	3.6	3.6
1999	13.2	15.1	5.9	6.6
2000	14.8	10.7	4.0	3.4

Table 25: Test results by category in the North Western Health Board - Sligo-Leitrim

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	18	25.0	12	18.1	32	58.3	10	13.9	62
1991	29	50.0	16	26.7	15	23.3	12	16.7	60
1992	34	50.7	20	29.9	13	19.4	5	6.9	67
1993	59	74.7	17	21.5	3	3.8	5	6.0	79
1994	46	54.8	18	21.4	20	23.8	0	0.0	84
1995	41	48.8	13	16.7	30	34.5	0	0.0	84
1996	50	68.5	12	16.4	11	15.1	11	13.1	73
1997	40	52.9	21	31.4	9	15.7	14	39.3	70
1998	54	62.1	16	18.4	17	19.5	9	9.4	87
1999	37	52.9	12	14.3	21	32.9	26	27.1	70
2000	37	47.4	16	20.5	25	32.1	6	7.1	78

Table 26: Marginal & Unsatisfactory test results in the North Western Health Board - Sligo-Leitrim

Year	%U-	%M-	%M+	%U+
1990	45.2	12.9	6.5	6.5
1991	20.0	16.7	10.0	5.0
1992	11.9	13.4	16.4	7.5
1993	1.3	11.4	10.1	2.5
1994	22.6	10.7	10.7	1.2
1995	33.3	10.7	4.8	2.4
1996	13.7	8.2	8.2	1.4
1997	11.4	20.0	10.0	1.4
1998	16.1	6.9	11.5	3.4
1999	22.9	10.0	7.1	7.1
2000	30.8	17.9	2.6	1.3

Table 27: Test results by category in the South Eastern Health Board - Carlow-Kilkenny

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	113	68.5	23	13.9	29	17.6	15	8.3	165
1991	110	60.8	31	17.1	40	22.1	6	3.2	181
1992	116	71.6	28	17.3	18	11.1	30	15.6	162
1993	77	72.0	12	11.2	18	16.8	85	38.5	107
1994	114	57.9	49	24.9	34	17.3	18	7.9	197
1995	151	67.1	41	18.2	45	20.0	3	1.3	225
1996	116	55.8	46	22.1	46	22.1	20	8.8	208
1997	124	56.4	57	25.9	39	17.7	8	3.5	220
1998	138	62.2	46	20.7	38	17.1	6	2.6	222
1999	129	56.6	56	24.6	43	18.9	0	0.0	228
2000	164	72.9	39	17.3	22	9.8	3	1.3	225

Table 28: Marginal & Unsatisfactory test results in the South Eastern Health Board - Carlow-Kilkenny

Year	%U-	%M-	%M+	%U+
1990	16.4	7.9	6.1	1.2
1991	15.5	6.6	10.5	6.6
1992	10.5	9.9	7.4	0.6
1993	8.4	4.7	6.5	8.4
1994	10.2	4.6	20.3	7.1
1995	7.1	3.1	15.1	8.4
1996	8.2	1.4	20.7	13.9
1997	5.5	3.6	22.3	12.3
1998	11.7	7.7	13.1	5.4
1999	17.5	11.0	13.6	1.3
2000	7.6	8.9	8.4	2.2

Table 29: Test results by category in the South Eastern Health Board - Tipperary South

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	85	64.9	19	14.5	27	20.6	13	9.0	131
1991	82	66.1	13	10.5	29	23.4	8	6.1	124
1992	102	75.6	12	8.1	22	16.3	8	6.3	136
1993	97	78.9	16	13.0	10	8.1	21	14.6	123
1994	93	72.1	15	11.6	21	16.3	15	10.4	129
1995	97	67.4	15	22.2	32	2.1	9	6.3	144
1996	98	68.5	17	11.9	27	18.9	1	0.7	143
1997	47	65.3	11	15.3	14	19.4	72	50.0	72
1998	87	61.3	14	9.9	40	28.2	36	20.0	142
1999	74	52.9	24	17.1	36	25.7	46	25.6	140
2000	71	42.5	24	14.4	72	43.1	37	18.1	167

Table 30: Marginal & Unsatisfactory test results in the South Eastern Health Board - Tipperary South

Year	%U-	%M-	%M+	%U+
1990	19.1	10.7	3.8	1.5
1991	21.0	8.1	2.4	2.4
1992	10.3	6.6	2.2	5.9
1993	7.3	6.5	6.5	0.8
1994	11.6	4.7	7.0	4.7
1995	20.1	6.3	4.2	2.1
1996	13.3	8.4	3.5	5.6
1997	16.7	9.7	5.6	2.8
1998	26.8	6.3	3.5	1.4
1999	22.1	12.1	5.0	3.6
2000	34.1	9.0	5.4	9.0

Table 31: Test results by category in the South Eastern Health Board - Waterford

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	59	88.1	4	6.0	4	6.0	29	30.2	67
1991	84	87.5	8	8.3	4	4.2	0	0.0	96
1992	79	82.3	9	9.4	8	8.3	0	0.0	96
1993	76	89.3	6	8.3	2	2.4	12	12.5	84
1994	87	92.2	4	4.4	2	3.3	3	6.3	93
1995	78	84.2	8	8.4	9	7.4	1	1.0	95
1996	65	78.3	10	12.0	8	9.6	13	13.5	83
1997	115	89.8	10	7.0	3	3.1	17	12.3	128
1998	165	87.3	14	7.4	10	5.3	3	1.6	189
1999	168	90.8	12	6.5	5	2.7	6	3.1	185
2000	148	85.1	14	8.0	12	6.9	18	9.4	174

Table 32: Marginal & Unsatisfactory test results in the South Eastern Health Board - Waterford

Year	%U-	%M-	%M+	%U+
1990	3.0	3.0	3.0	3.0
1991	2.1	0.0	8.3	2.1
1992	5.2	1.0	8.3	3.1
1993	0.0	1.2	6.0	2.4
1994	2.2	0.0	4.3	0.0
1995	6.3	0.0	8.4	3.2
1996	0.0	0.0	12.0	9.6
1997	1.6	3.1	4.7	0.8
1998	2.6	3.7	3.7	2.6
1999	2.2	2.7	3.8	0.5
2000	6.9	6.3	1.7	0.0

Table 33: Test results by category in the South Eastern Health Board - Wexford

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	75	81.5	12	13.0	3	3.3	8	8.3	90
1991	68	74.7	8	8.8	14	15.4	7	7.3	91
1992	66	79.5	8	9.6	9	10.8	7	8.3	81
1993	64	75.3	11	17.6	6	7.1	44	33.3	81
1994	84	70.8	13	10.8	22	18.3	16	9.8	119
1995	91	78.0	7	7.6	22	14.4	7	5.8	120
1996	56	58.9	20	20.0	19	21.1	25	20.8	95
1997	71	69.6	21	20.6	10	9.8	18	15.0	102
1998	98	82.4	14	11.8	7	5.9	2	1.7	119
1999	97	75.2	17	13.2	15	11.6	3	2.3	129
2000	108	87.8	8	6.5	7	5.7	9	6.8	123

Table 34: Marginal & Unsatisfactory test results in the South Eastern Health Board - Wexford

Year	%U-	%M-	%M+	%U+
1990	3.3	3.3	10.0	0.0
1991	13.2	5.5	4.4	2.2
1992	8.6	4.9	4.9	0.0
1993	3.7	2.5	11.1	3.7
1994	10.9	4.2	6.7	7.6
1995	13.3	2.5	3.3	5.0
1996	4.2	1.1	20.0	15.8
1997	5.9	1.0	19.6	3.9
1998	4.2	5.0	6.7	1.7
1999	9.3	7.8	5.4	2.3
2000	4.9	4.9	1.6	0.8

Table 35: Test results by category in the Southern Health Board - Cork North

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	98	75.4	16	12.3	14	10.8	7	5.3	130
1991	112	84.2	12	9.0	9	6.8	2	1.5	133
1992	98	77.8	14	11.1	14	11.1	6	4.5	126
1993	109	87.8	6	8.1	5	4.1	12	6.8	120
1994	106	83.5	11	8.7	10	7.9	5	3.8	127
1995	95	76.4	16	13.8	9	7.3	12	9.1	120
1996	66	75.0	8	9.1	14	15.9	44	33.3	88
1997	118	86.9	11	7.7	7	5.4	44	27.8	136
1998	155	91.1	11	2.4	3	6.5	11	6.1	169
1999	157	89.1	11	3.9	3	7.0	9	28.3	171
2000	138	84.7	11	6.7	14	8.6	17	9.4	163

Table 36: Marginal & Unsatisfactory test results in the Southern Health Board - Cork North

Year	%U-	%M-	%M+	%U+
1990	10.0	5.4	6.9	0.8
1991	5.3	3.8	4.5	1.5
1992	7.9	5.6	5.6	3.2
1993	4.2	4.2	0.8	0.0
1994	7.1	6.3	2.4	0.8
1995	7.5	3.3	10.0	0.0
1996	13.6	3.4	5.7	2.3
1997	3.7	3.7	4.4	1.5
1998	1.8	2.4	4.1	0.0
1999	1.2	2.9	3.5	0.6
2000	7.4	4.3	2.5	1.2

Table 37: Test results by category in the Southern Health Board - West Cork

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	49	57.6	15	17.7	20	24.7	1	1.2	84
1991	55	61.6	16	18.6	17	19.8	1	1.2	88
1992	61	71.8	15	17.6	9	10.6	0	0.0	85
1993	71	83.5	10	11.8	4	4.7	0	0.0	85
1994	69	82.1	11	13.1	4	4.8	0	0.0	84
1995	72	85.7	5	6.0	7	8.3	0	0.0	84
1996	68	82.9	9	1.2	5	15.9	2	2.4	82
1997	72	87.8	9	7.3	1	4.9	2	2.4	82
1998	68	81.9	13	8.4	2	9.6	1	1.2	83
1999	69	85.2	11	11.1	3	3.7	3	3.6	81
2000	77	91.7	2	2.4	5	6.0	0	0.0	84

Table 38: Marginal & Unsatisfactory test results in the Southern Health Board - West Cork

Year	%U-	%M-	%M+	%U+
1990	19.0	7.1	10.7	4.8
1991	14.8	10.2	8.0	4.5
1992	5.9	10.6	7.1	4.7
1993	3.5	4.7	7.1	1.2
1994	1.2	1.2	11.9	3.6
1995	6.0	0.0	6.0	2.4
1996	2.4	1.2	9.8	3.7
1997	1.2	7.3	3.7	0.0
1998	2.4	8.4	7.2	0.0
1999	3.7	8.6	2.5	0.0
2000	6.0	1.2	1.2	0.0

Table 39: Test results by category in the Southern Health Board - Kerry

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	80	57.1	18	12.9	42	30.0	5	3.5	140
1991	57	38.3	26	16.9	69	44.8	18	12.5	152
1992	127	15.0	30	16.1	33	17.1	0	0.0	193
1993	102	79.7	13	10.2	13	10.2	4	3.0	128
1994	94	72.3	22	16.9	14	10.8	2	1.5	130
1995	104	79.2	12	9.2	16	11.5	0	1.5	132
1996	NA	NA	NA	NA	NA	NA	NA	NA	NA
1997	54	73.3	13	17.3	7	9.3	46	37.5	74
1998	82	61.2	29	3.7	33	35.1	10	6.9	134
1999	106	84.1	7	3.2	13	12.7	18	12.5	126
2000	95	72.5	21	14.5	15	13.0	13	9.0	131

Table 40: Marginal & Unsatisfactory test results in the Southern Health Board - Kerry

Year	%U-	%M-	%M+	%U+
1990	16.4	4.3	8.6	13.6
1991	18.4	5.9	11.2	27.0
1992	10.4	8.8	6.7	6.7
1993	6.3	3.9	6.3	3.9
1994	7.7	3.8	13.1	3.1
1995	9.8	3.8	5.3	2.3
1996	NA	NA	NA	NA
1997	5.4	5.4	12.2	4.1
1998	9.0	3.7	17.9	8.2
1999	6.3	0.0	5.6	4.0
2000	9.2	9.9	6.1	2.3

Table 41: Test results by category in the Southern Health Board - North Lee

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	66	55.0	38	31.7	16	13.3	0	0.0	120
1991	101	84.2	10	8.3	9	7.5	0	0.0	120
1992	93	86.1	8	7.4	7	6.5	0	0.0	108
1993	86	79.6	14	13.0	8	7.4	0	0.0	108
1994	108	90.0	4	3.3	8	6.7	0	0.0	120
1995	107	89.2	11	9.2	2	1.7	0	0.0	120
1996	81	79.4	9	4.9	12	15.7	18	15.0	102
1997	89	90.8	4	3.1	6	6.1	22	18.3	99
1998	105	81.3	7	3.1	4	15.6	4	75.0	116
1999	111	92.5	5	1.7	4	5.8	0	0.0	120
2000	98	82.4	5	4.2	16	13.4	1	0.8	119

Table 42: Marginal & Unsatisfactory test results in the Southern Health Board - North Lee

Year	%U-	%M-	%M+	%U+
1990	11.7	18.3	13.3	1.7
1991	4.2	5.8	2.5	3.3
1992	6.5	5.6	1.9	0.0
1993	2.8	2.8	10.2	4.6
1994	4.2	0.0	3.3	2.5
1995	0.0	2.5	6.7	1.7
1996	7.8	4.9	3.9	3.9
1997	4.0	2.0	2.0	2.0
1998	0.9	0.9	5.2	2.6
1999	3.3	1.7	2.5	0.0
2000	10.1	3.4	0.8	3.4

Table 43: Test results by category in the Southern Health Board - South Lee

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	NA	NA	NA	NA	NA	NA	NA	NA	NA
1991	21	42.9	1	2.0	18	36.7	9	25.0	29
1992	26	86.7	1	3.3	3	10.0	6	16.7	30
1993	36	100.0	0	0.0	0	0.0	0	0.0	36
1994	32	86.5	4	10.8	1	2.7	0	0.0	37
1995	28	82.9	5	14.3	2	2.9	1	2.8	35
1996	17	63.0	6	22.2	5	14.8	9	25.0	28
1997	23	74.2	7	22.6	1	3.2	5	13.9	31
1998	30	85.7	4	0.0	1	14.3	1	2.8	35
1999	34	94.4	1	2.8	1	2.8	0	0.0	36
2000	33	94.3	1	2.9	1	2.9	1	2.8	35

Table 44: Marginal & Unsatisfactory test results in the Southern Health Board - South Lee

Year	%U-	%M-	%M+	%U+
1990	NA	NA	NA	NA
1991	24.1	3.4	0.0	0.0
1992	10.0	0.0	3.3	0.0
1993	0.0	0.0	0.0	0.0
1994	0.0	0.0	10.8	2.7
1995	0.0	0.0	14.3	5.7
1996	7.1	0.0	21.4	10.7
1997	0.0	3.2	19.4	3.2
1998	0.0	0.0	11.4	2.9
1999	2.8	2.8	0.0	0.0
2000	2.9	2.9	0.0	0.0

Table 45: Test results by category in the Western Health Board - Galway

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	64	51.6	36	31.0	22	17.5	0	14.4	122
1991	102	55.8	50	34.7	13	9.5	17	11.8	127
1992	81	52.2	45	28.3	31	19.5	3	2.1	157
1993	86	53.1	38	25.3	35	21.6	3	2.1	159
1994	83	44.5	39	16.5	37	16.5	0	9.6	158
1995	91	59.4	31	22.4	27	18.2	20	12.8	149
1996	70	76.1	16	17.4	6	6.5	64	41.0	92
1997	74	61.5	26	20.5	23	18.0	33	21.8	123
1998	101	61.6	45	27.4	18	11.0	16	8.9	164
1999	92	68.1	30	20.7	13	11.1	45	25.0	135
2000	158	87.8	16	8.9	6	3.3	0	0.0	180

Table 46: Marginal & Unsatisfactory test results in the Western Health Board - Galway

Year	%U-	%M-	%M+	%U+
1990	10.7	11.5	18.0	7.4
1991	9.4	27.6	11.8	0.8
1992	6.4	12.1	16.6	13.4
1993	13.8	6.9	17.0	8.2
1994	14.6	7.0	17.1	8.9
1995	12.1	13.4	7.4	6.0
1996	3.3	6.5	10.9	3.3
1997	13.0	10.6	10.6	5.7
1998	6.7	18.9	8.5	4.3
1999	6.7	17.8	4.4	3.0
2000	3.3	6.7	2.2	0.0

Table 47: Test results by category in the Western Health Board - Mayo

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	44	37.3	28	23.4	46	39.0	14	10.6	118
1991	75	63.0	22	18.5	22	18.5	13	9.8	119
1992	67	57.3	29	24.8	21	17.9	11	9.2	117
1993	78	59.5	25	19.1	28	21.4	1	0.8	131
1994	88	68.2	27	20.9	14	10.9	3	2.3	129
1995	79	62.2	26	20.5	22	17.3	5	3.8	127
1996	79	60.3	36	27.5	16	12.2	1	0.8	131
1997	70	60.3	29	25.0	17	14.7	16	12.1	116
1998	66	57.4	34	29.6	15	13.0	5	4.1	115
1999	60	53.1	29	25.7	24	21.2	19	14.4	113
2000	65	55.1	34	28.8	19	16.1	14	10.6	118

Table 48: Marginal & Unsatisfactory test results in the Western Health Board - Mayo

Year	%U-	%M-	%M+	%U+
1990	22.9	5.1	18.6	16.1
1991	14.3	11.8	6.7	5.0
1992	11.1	12.8	11.1	6.8
1993	14.5	14.5	4.6	6.9
1994	4.7	11.6	9.3	6.2
1995	10.2	7.9	11.8	7.9
1996	7.6	15.3	13.7	3.1
1997	7.8	13.8	11.2	6.9
1998	8.7	18.3	13.0	4.3
1999	8.8	16.8	9.7	11.5
2000	11.9	25.4	3.4	4.2

Table 49: Test results by category in the Western Health Board - Roscommon

Year	Satisfactory		Marginal		Unsatisfactory		Missing		Total
	No	%	No	%	No	%	No	%	
1990	32	43.8	20	27.4	21	28.8	23	24.0	73
1991	72	59.9	25	19.0	29	21.1	1	0.9	126
1992	44	46.4	31	32.0	21	21.6	0	0.0	97
1993	46	35.9	32	25.0	31	24.2	4	3.7	109
1994	48	39.0	50	40.7	25	20.3	20	18.5	123
1995	43	40.2	36	33.6	24	26.2	7	6.5	102
1996	22	53.7	7	19.5	9	26.8	70	64.8	38
1997	38	67.8	9	18.6	4	13.6	57	52.8	51
1998	71	57.4	19	29.6	7	13.0	17	12.9	97
1999	51	46.8	26	22.9	32	60.6	47	30.1	109
2000	55	50.9	31	28.7	22	20.4	84	43.8	108

Table 50: Marginal & Unsatisfactory test results in the Western Health Board - Roscommon

Year	%U-	%M-	%M+	%U+
1990	24.7	17.8	9.6	4.1
1991	23.0	17.5	2.4	0.0
1992	19.6	21.6	11.3	2.1
1993	27.5	20.2	9.2	0.9
1994	13.8	22.8	17.9	6.5
1995	17.6	9.8	25.5	5.9
1996	21.1	7.9	10.5	2.6
1997	7.8	15.7	2.0	0.0
1998	5.2	12.4	7.2	2.1
1999	23.9	17.4	6.4	5.5
2000	16.7	17.6	11.1	3.7

Appendix 5 - Department of Health letters on Fluoridation Monitoring Committees

Department of Health
Hawkins House, Dublin 2

An Roinn Sláinte
Teach Haicin, Baile Átha Cliath 2

18 August 1992
Chief Executive Officer
Each Health Board

Fluoridation Monitoring Committees

Dear Chief Executive Officer,

As you know the satisfactory implementation of the national fluoridation programme requires a high level of co-ordination between health boards and local authorities.

The Department's circular of 14/1977 and the memorandum enclosed therewith outlined for health boards and sanitary authorities their responsibilities in relation to the fluoridation of public water supplies and it appears that there is currently a good understanding between health boards and local authorities of their responsibilities.

However, it would appear that the exchange of information and co-ordination between the boards and the local authorities is sometimes unsatisfactory, with the result that the best possible use of the available resources under the fluoridation programme may not always be made and the most satisfactory results may not always be achieved.

Having regard to the overall responsibility of health boards for fluoridation programme under the health (Fluoridation of Water Supplies) Act, 1960, I am now to request you to be good enough to establish jointly with the local authorities concerned a Fluoridation Monitoring Committee in respect of each community care area to ensure a full exchange of information and a high degree of co-ordination under local programme. A specific task of the Committee would be to review test results and ensure that remedial follow-up action is taken where necessary.

It is envisaged that health board representation on the Committee would include the Director of Community Care and the Principal Dental Surgeon and might also include, as appropriate, the Supervising Environmental Health Officer and the Technical Services Officer. The Committee might meet on a quarterly basis under the chairmanship of the Chief Executive Officer or the Programme Manager Community Care.

It is envisaged that the local authority representation on the Committee would include the County Engineer and would also include such other representatives, as the local authority considered appropriate.

Please be good enough to report, in due course, progress on the setting up of Fluoridation Monitoring Committee in your area.

This letter has been prepared in co-operation with the Department of the Environment who will also be contacting local authorities in the matter.

Yours sincerely

M. Lyons
Principal Community Health

Department of Health
Hawkins House, Dublin 2

An Roinn Sláinte
Teach Haicin, Baile Átha Cliath 2

22 September 1993
Chief Executive Officer
Each Health Board

RE: Fluoridation

Dear Chief Executive Officer,

Further to our previous correspondence please be good enough to advise this Department of the present position regarding the setting up of Fluoridation Monitoring Committee in your boards community care areas and whether they are operating to the satisfaction of the board in improving liaison arrangements with local authorities, in improving day to day operation of the fluoridation programme, in improving test results and in monitoring the situation with regard to the current and future need for new/replacement plant.

It is noted from the monthly test results submitted to this Department that in the case of a few public water supplies the local authorities in question do not appear to be performing their agency services for the boards in an adequate manner by maintaining fluoridation levels within the statutory limits on a regular basis. Health boards are entitled to an adequate level of agency service from local authorities and should consider refunding local authorities only for such services as are carried out to the satisfaction of the board.

Yours sincerely,

M Lyons
Principal Officer
Community Health Division

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Appendix 6 - Questionnaire to Assess Water Treatment Plants

WATER TREATMENT PLANT ASSESSMENT

Plant: _____ Date of Visit: _____ Visited By: _____

1. PLANT DETAILS

Year of commencement _____	Approximate population served _____
Map of distribution network	Yes <input type="checkbox"/> No <input type="checkbox"/>
Detail of group water schemes	Linked /To be linked
Names _____ _____	Population _____ _____

2. PRE SUPPLY TESTING

Is the source water supply tested?	Yes <input type="checkbox"/> No <input type="checkbox"/>
Results available _____	
Frequency of testing _____	
Method of testing _____	
By whom _____	

3. EQUIPMENT

Type of external pump _____	
Year of installation _____	Supplier: _____
Type of dosing pump _____	
Year of installation _____	Supplier: _____
Are there operations manuals available? _____	
Is there a method for measuring flow rate? _____	
Is there a written procedure for altering the flow meter? _____	
Is the system alarmed? _____	Is there a back-up pump? _____

4. PREVENTIVE MAINTENANCE

Is there a documented preventive maintenance programme? _____
Internal or external or both? _____
Are there records available? _____
Performed by: _____
Is the preventive maintenance programme adequate? _____

5. TESTING

Is the fluoride level in the treated water tested?	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>
Results available _____	How long retained? _____			
Method Used: Hach	<input type="checkbox"/>	Fluoride Ion Probe	<input type="checkbox"/>	Colourimetric test <input type="checkbox"/>
Frequency? _____	By whom _____			
Is the equipment used for other tests _____				
Is there a guide / chart for alteration of the flow meter? _____				
Action taken on foot of a unsatisfactory result _____				

Notification procedure as a result of an unsatisfactory result _____				

6. CALIBRATION

Is the test equipment calibrated? _____ Internal or external or both: _____
By whom: _____ Frequency: _____
Method: _____
Is the flow meter calibrated? _____ Internal or external _____
By whom _____ Frequency: _____
Method _____

7. MONITORING VISITS

Are there inspection visits? _____			
By Whom:	Engineer <input type="checkbox"/>	Frequency _____	Purpose _____
	P/EHO <input type="checkbox"/>	Frequency _____	Purpose _____
	PDS <input type="checkbox"/>	Frequency _____	Purpose _____
Are reports issued? _____ Is there a standard layout /format for reports? _____			
Any feedback from visits? _____ What type of feedback? _____			

8. PERSONNEL

How many personnel work on site? _____			
Titles: _____			
Full Time	<input type="checkbox"/>	Part Time	<input type="checkbox"/>
Has training been given in the following areas:			
Equipment Operation	Yes <input type="checkbox"/>	No <input type="checkbox"/>	
Testing of Supply	Yes <input type="checkbox"/>	No <input type="checkbox"/>	
Calibration	Yes <input type="checkbox"/>	No <input type="checkbox"/>	
Incident Management	Yes <input type="checkbox"/>	No <input type="checkbox"/>	
Health & Safety	Yes <input type="checkbox"/>	No <input type="checkbox"/>	
Handling & Storage of acid	Yes <input type="checkbox"/>	No <input type="checkbox"/>	
Any weaknesses identified in the training given: _____			

9. INTAKE / STORAGE OF ACID

Is there a procedure available for intake of acid?	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>
Is there suitable protective clothing/equipment available?	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>
Is the tank bunded?	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>
Appropriately located?	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>
Is the tank locked?	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>
Is there a procedure available to deal with spillages of acid?	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>

10. DOCUMENTATION

List the procedures and records in place.

Appendix 7 - Water treatment plants visited

Name of water treatment plant

Baileboro, Co.Cavan	6 th October 2000
Leixlip, Co. Kildare	28 th November 2000
Kilmeaden, Co.Waterford	30 th November 2000
Portlaw, Co.Waterford	30 th November 2000
Monasterevin, Co. Kildare	4 th December 2001
Castlecomer, Co. Kilkenny	11 th January 2001
Johnstown/ Urlingford, Co. Kilkenny	11 th January 2001
Tuam, Co. Galway	21 st March 2001
Lough Talt	8 th June 2001
North Sligo	8 th June 2001
Lough Easkey	8 th June 2001
Ballinatona/ Kanturk	5 th October 2001
Conna	5 th October 2001
Mallow	5 th October 2001