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# Sustainable Water Supply in Ireland

Liam McCarton

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## **Sustainable Water Resources & Supply in Ireland.**

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## Table of Contents

	<b>Page No.</b>
1 Introduction to Sustainable Development.	3
2. Water Resources and Supply	4
2.1 Water Resources	4
2.2 Existing and Future Demand	5
3.Review of Legislation	9
3.1 European legislation in the Water Protection Sector.	9
3.1.1 Water Framework Directive.	9
3.1.2 Hazardous Substances.	14
3.1.2 Water Quality Objective oriented Directives	14
3.1.3 Emission-Control oriented	14
3.2 Summary of Key Inter-relationships between Legislation in the Water sector and other EC legislation in the Environmental Acquis.	14
4. Group Water Schemes.	16
4.1 Development of the Group Water Scheme sector.	16
4.2 National Federation of Group Water Schemes	17
4.3 Basis for a new strategy	18
4.4 Rural Water Programme	19
4.4.1 Partnership approach to implementation	20
4.4.2 Investing in the RWP	20
5. Water Resource Vulnerability	21
6 Resource Vulnerability – Radon in Drinking Water Supplies	22
7. Sustainable Solutions : Water Conservation Technologies.	33
8. Benefits & Costs of Water Conservation Measures in Ireland	51

### APPENDICES

1. Implementation of the Rural Water Programme to December 2002.
2. Water Demand Per Capita Consumption Model
3. Survey of Non Domestic Water Charges in Ireland 2003
4. Survey of domestic water and wastewater charges in UK regions
5. CAPEX Financial Justification Model
6. CAPDCF Financial Justification Model
7. Site Visits

## **1. Introduction to Sustainable Development.**

Sustainable water technology is concerned with the complete range of technologies, techniques, products and processes that will enable humankind to reduce the impact of water production and water consumption on the environment and to establish a more sustainable mode of development.

The concept of sustainable development has gained wide usage over the past 15 years in an attempt to balance development needs and environmental protection. The Brundtland Report of the World Commission on Environment and Development, Our Common Future (1987) identified sustainable development as a global objective, which involved economic, social and environmental values. It defined sustainable development as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'.

Sustainable development of water resources involves considerations of population growth, urbanisation, industrialisation, land use practices, climate change and water recycling. As these factors are constantly changing, both in themselves and with respect to each other, any consideration of sustainable water resource management must take a short term and a long term view. To facilitate discussion of sustainable water resource management the following structure will be adapted:

1. Quantification of Renewable resources.
2. Water Quality Protection.
3. Conservation by the producer/consumer (economy in use).
4. Product substitution/Recycling.
5. Integrated water management systems.

## 2. Water Resources and Supply

### 2.1 Water Resources

The river Shannon which drains most of the central lowlands, has the largest catchment (11,400 km<sup>2</sup>) and yields a long term mean flow at the estuary head of 190 m<sup>3</sup>/s (O'Sullivan). The Liffey and the Lee represent important rivers in that their impoundments supply two of the largest urban areas, Duhblin and Cork respectively.

There is an estimated 4,000 lakes in the country, most are less than 50 ha while only 18 have areas greater 1,000 ha.

These lakes and rivers are important resources and provide valuable supplies for drinking water as well as serving as centres for tourism, recreation and amenity use, and ecological sites of international importance.

These surface waters and their impoundments also supple 75% of drinking water abstracted in the State.

Groundwater supplies provide the other 25% of drinking water supplies (Ground Water protection scheme). In certain counties the proportion of groundwater supplying drinking water is much higher, for example, Roscommon 86%, Offaly 60%, Laois 54%, Kilkenny 52% and the North Cork region which uses 90% groundwater. In many areas not served by public or group water schemes, groundwater is usually the only source of supply and there are an estimated 100,000 wells and springs in use in the State. Table 1 below shows a summary of groundwater resources by Region.

**Table 1 Summary of Groundwater Resources by Region.**

<b>Water Resources Region</b>	<b>Area</b>	<b>Area of Aquifers</b>	<b>Estimated Abstractions</b>	<b>Estimated Surplus Resources</b>	
	Km <sup>2</sup>	Km <sup>2</sup>	Mm <sup>3</sup> /yr	Mm <sup>3</sup> /yr	Mm <sup>3</sup> /yr over region
Eastern	7622.5	1392	6.08	197.4	25.9
South eastern	12768	4240	20.7	763	59.6
Southern	11406	1474.5	25.15	603.6	52.9
Mid-western	7508	2942.5	8.43	492.1	65.5
Shannon	10520	3124.9	16.69	471.7	44.8
Western	9615.5	4446	6.23	643.3	67
North-western	946	1245.5	6.3	202.5	21.4
<b>Total</b>	<b>68,900</b>	<b>18,865.4</b>	<b>89.58</b>	<b>3,373.6</b>	<b>49.0 over country</b>

## 2.2 Existing and Future Demand

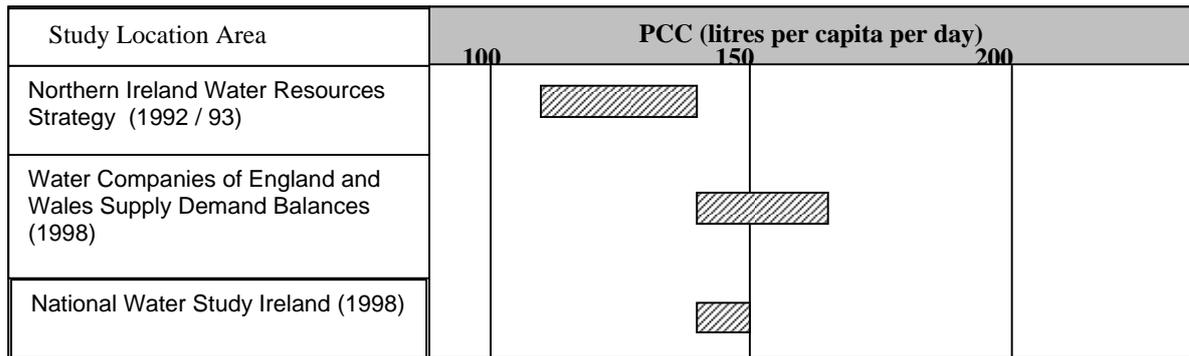
Water for domestic use is estimated to comprise 60% of the total demand for water in Ireland (Atkins). However, in the absence of metering and given unrestricted domestic demand, accurate statistics are not available. Therefore those working in the area of water supply and use have become reliant upon an estimated parameter, Per Capita Consumption (PCC), to estimate the existing demand and to project future demands in the sector. Table 2 below shows water consumption in Ireland

	<b>Total M3/day</b>	<b>Surface Water M3/day</b>	<b>Groundwater M3/day</b>
Public Water Supplies*	1,381,000	1,184,000	197,000
Rural Domestic	32,000	-----	32,000
Industry (Private Supplies)	179,000	79,000	100,000
Agriculture (Private Supplies)	249,000	-----	-----
Thermal Power (Fresh Water)	774,000	774,000	-----
	2,615,000	2,037,000	329,000

\* Includes some agricultural and Industrial use.

**Table 2 Water Consumption in Ireland**

The most recent and most comprehensive study of water in Ireland, The National Water Study, dealt with the PCC value by estimating it using two complimentary methods; the first by looking at previous studies and the second by reviewing the microcomponent analysis. In looking at previous studies it reviewed five studies carried out in parts of the Republic, one in the North of Ireland and also the Water Companies of England and Wales Supply Demand Balances. However the Irish studies were of questionable use as they were not representative studies of water consumption in Ireland. The North of Ireland study, while based on metered data, produced a PCC likely to be higher than that of the Republic, given the higher proportion of people living in urban areas. The study of water use in England and Wales was undertaken in 1998 using comprehensive studies. However its applicability to Ireland is limited, due to the issues of occupancy rates, less use of water for out of house activities and a lower uptake of white goods (e.g. washing machines and dishwashers). Figure 1 illustrates the results of these studies.



**Fig 1 PCC rates based on previous studies**

The particular issue of occupancy rates, with its implications for per capita share of water using activities associated with a property, also has an effect upon estimates for future demand. A falling occupancy rate is a product of the increased activity in the housing sector, with estimates that the state occupancy rate, estimated at 3.2 in 1996, will fall by 0.75% in the years to 2006, and by 0.6% in the twelve years to 2018.

Such figures and projections form an important part of calculating the PCC value. Microcomponent analysis comprises of taking the components that make up domestic demand (Table 3) and calculating the consumption rate for each microcomponent. This calculation is based on the uptake, the frequency of use, and the volume of water used per occasion. Both in house and out house uses are used to calculate the PCC.

#### ***In House Uses***

WC Flushing  
 Personal Washing  
 Clothes Washing  
 House Cleaning  
 Dish Washing  
 Waste Disposal Units  
 Cooking Water  
 Drinking water  
 Miscellaneous

#### ***Out of House Uses***

Car Washing  
 Lawn Watering  
 Plant Watering  
 Paddling Pool  
 Swimming Pool  
 Miscellaneous

**Table 3. Micro Components of Domestic Demand (Atkins, 2000).**

The Pcc estimated by the National Water Study was 131 l/h/day for Ireland in 1997. This was based upon an occupancy rate of 3.2 and white good uptake of 0.8

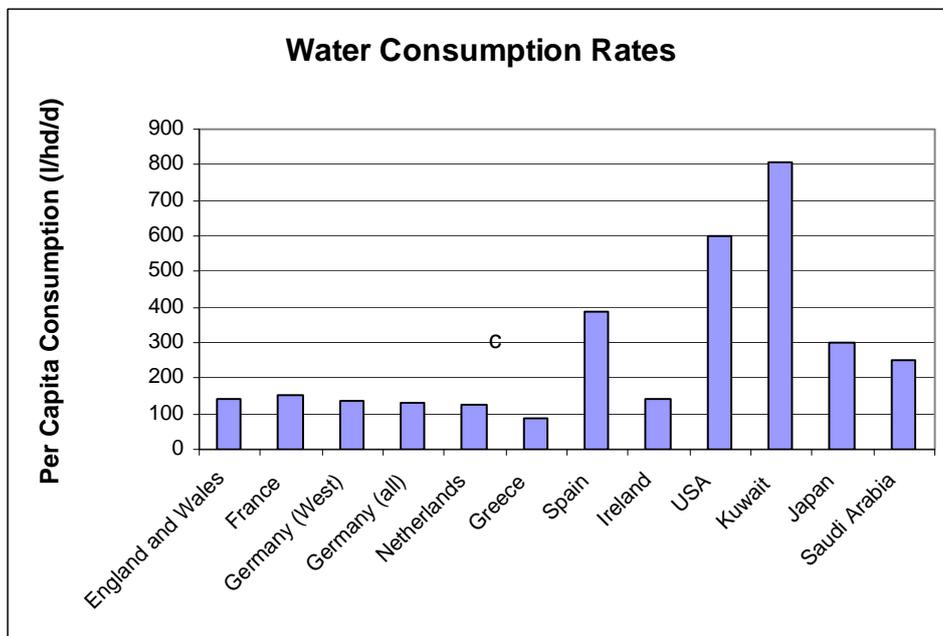
#### **European PCC rates**

Different reporting and water supply structures make any international comparison of per capita consumption rates difficult. Values for several countries established from a WRC study (International Comparison of the Demand for Water, 1998) are shown in Table 4.

Country	Per Capita Consumption ~ (PCC) (l/hd/day)
England and Wales	144
France	152
Germany (West)	139
Germany (all)	132
Netherlands	128

**Table 4 European Water Consumption**

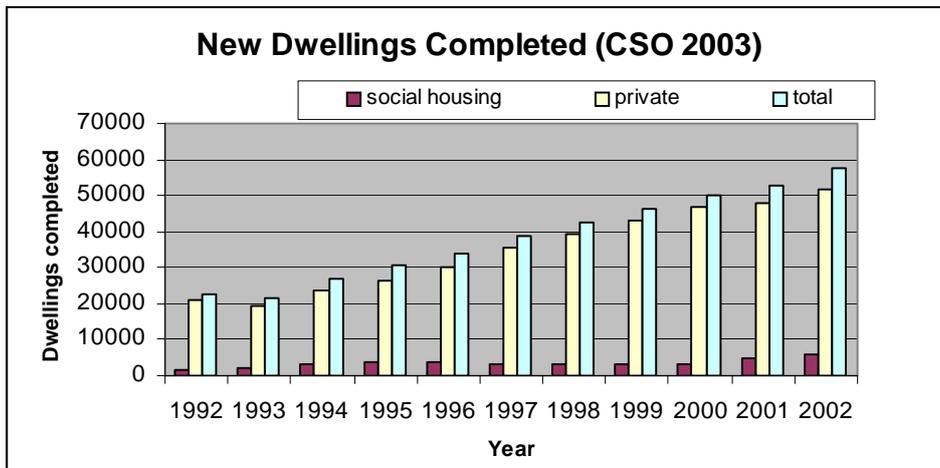
Figure 2 illustrates water consumption rates for various countries which were established in a study carried out by Memon & Butler, 2001.



**Figure 2 Water Consumption Rates**

### Domestic Demand Forecast

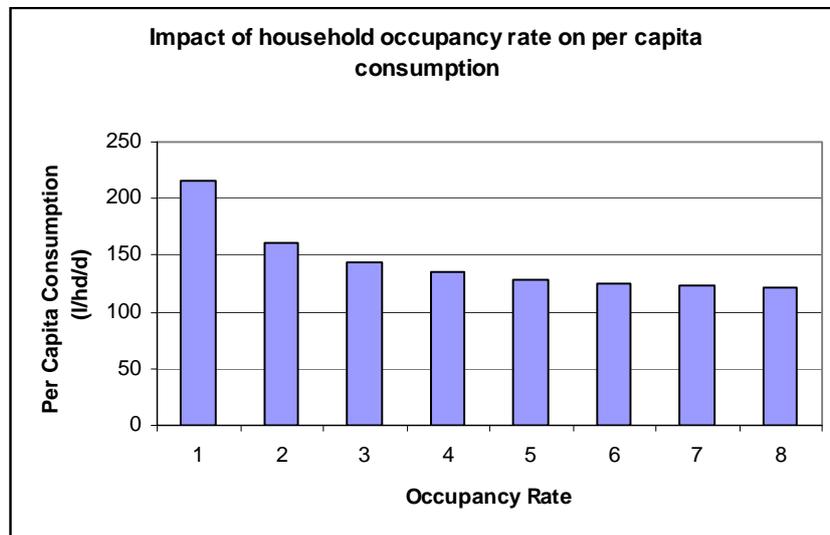
The aforementioned Water Study estimated the domestic demand for water use in 2018 using population forecast and pcc projections. Several factors will influence the forecast demand, including new house construction, occupancy rates and appliance uptake / usage. Dept. of the Environment and Local Government (DOELG) statistics indicate that the level of completions for 2002 totalled 52,000. Figure 3 illustrates Central Statistics Office (CSO) statistics for dwelling completions for the period 1992 – 2002.



**Figure 3 New Dwellings Completed 1992 – 2003**

**Occupancy Rate**

The particular issue of occupancy rates, with its implications for per capita share of water using activities associated with a property, also has an effect upon estimates for future demand. A falling occupancy rate is a product of the increased activity in the housing sector, with estimates that the state occupancy rate, estimated at 3.2 in 1996, will fall by 0.75% in the years to 2006, and by 0.6% in the twelve years to 2018. Fig 4 illustrates the impact of consumption rate versus household occupancy rate.



**Figure 4 Impact of Household Occupancy Rate on per capita consumption**

Projections for the Irish PCC in 2018 average at 153 l/h/d based on an occupancy rate of 2.72 and a white goods uptake of 0.8. This compares with a value for Northern Ireland (N.I. Water Resources Strategy) of 139.9 for 1997 and 168.2 for 2018. England and Wales demand was 149 l/h/d for 1997 and projected at 177 for 2018.

### 3. Review of Legislation.

#### 3.1 European legislation in the Water Protection Sector.

##### 3.1.1 Water Framework Directive.

Commission Proposals.

Adopted by the parliament and council of the union on 23 October 2000 and entered into force on publication in the official journal in December 2000. Member states have 3 years to transpose the directive into national legislation. The directive sets out a framework for management of water resources within the EU utilising a common approach, common objectives, principles and basic measures. Inland surface waters, transitional waters coastal waters and ground waters are considered. The river basin approach will raise public interest and awareness and promote discussion on the selection of the most cost effective options to achieve a particular environmental objective. The purpose of the directive is to establish a framework which:

- Protects and enhances the status of aquatic ecosystems (together with terrestrial ecosystems and wetlands directly depending on the aquatic systems);
- Promote sustainable water use based on a long term protection of available water resources;
- Aims at enhanced protection and improvement of the aquatic environment by progressive reduction of losses of priority substances and the phasing out of priority hazardous substances;
- Ensures the reduction of pollution to groundwater;

Contributes to mitigating the effects of floods and droughts.

Key aims of the Directive are:

- Incorporation of all water management requirements into a single system i.e. River Basin Districts. A river basin district is the area of land and sea, made up of one or more neighbouring river basins, together with their associated groundwaters and coastal waters. Groundwaters are to be assigned to the nearest or most appropriate River Basin District. Coastal waters extend one nautical beyond the territorial water baseline;
- Co-ordination of the objectives for which water is protected;
- Co-ordination of measures on particular problems and sectors;
- Increased public participation;
- Introduction of the concept of full cost recovery.

The main provisions of the Directive are summarised as follows::

##### **River Basin Management.**

Member states are required to administer and manage their aquatic environment on the basis of River Basin Districts and to identify and to designate appropriate competent authorities responsible for them. In Ireland, the individual river basins lying within out national territory have been identified.

Each member state is also required to produce a River Basin Management Plan (RBMP) for each river basin District lying entirely within their territory. These are to be published at the latest 9 years after adoption and every six years thereafter. Where river basins cross borders, Member States shall ensure co-ordination, with the aim of producing a single international RBMP.

The demands of the Framework Directive are also much greater than the Phosphorus Regulations. The phosphorus regulations apply only to rivers and lakes, whereas the EU Water Framework Directive applies to inland surface waters, transitional waters (estuaries), coastal waters and ground water. The phosphorus regulations allow a choice of improvements in terms of Biological Quality or MRP (ortho-P) levels and the requirements of the regulations must be met by 2007. The target of the Framework Directive is to achieve Good Quality Surface Water Status by 2015, both the biological Quality and Chemical Water Quality must be good. This is considerably more involved due to the combined chemical and biological requirements. The grading status adopted by the Directive is comparable with the EPA criteria.

### **Surface water environmental objectives.**

Member states are required to protect, enhance and restore all bodies of surface water with the aim of achieving good ecological potential and good surface water chemical status at the latest 15 years after adoption of the directive. This is subject to certain exemptions and extensions where all necessary improvements in the status of bodies of water cannot reasonably be achieved within the timescales.

### **Groundwater environmental objectives.**

Member states are required to protect, enhance and restore all bodies of groundwater with the aim of achieving good ecological potential and good surface water chemical status at the latest 15 years after adoption of the directive. This is subject to certain exemptions and extensions where all necessary improvements in the status of bodies of water cannot reasonably be achieved within the timescales.

### **Environmental Objectives for Protected Areas.**

achieve compliance with any standards and objectives relating to Protected Areas at the latest 15 years after adoption. This will be achieved through the phased implementation of a programme of measures including the UWWT directive, Nitrates Directive, IPPC Directive, Habitats Directives, Birds Directive, Bathing Water Directive.

### **Characterisation and Monitoring of River Basin Districts.**

Member states are required to provide for each RBD

- An analysis of its characteristics
- A review of human activity
- An economic analysis of water use

At least four years after adoption of the directive. They shall also establish programmes to monitor each RBD to establish an overview of surface water and groundwater, these to be operational six years after adoption of the Directive.

### **Drinking Water.**

Member states shall *identify* all waters used for abstraction for *human consumption of > 10 m<sup>3</sup>/day*, shall *monitor* all abstractions > 100 m<sup>3</sup>/day, shall comply with objectives and standards for such waters and ensure that after treatment they will meet Drinking Water

standards as laid down by Directive 80/778/EEC (amended by 98/83/EC) and shall ensure protection of bodies of water and establish safeguard zones if necessary.

### **Costs and Pricing.**

Member states shall take account of the principle of recovery of costs of water services, having regard to the economic analysis conducted and in accordance with the polluter pays Principle. They shall also ensure by 2010 that water pricing policies provide adequate incentives for users to use water resources efficiently and an adequate contribution of the different users to the recovery of the costs of water services.

### **Public Information.**

The directive strives to get citizens of the EU more involved in all water issues. Member states are required to encourage the active involvement of all interested parties in the implementation of the Directive, with particular reference to the production of RBMPs. Draft copies will be available for public consultation one year before adoption of the plan i.e. 8 years after adoption of the Directive for the initial RDMP.

The key implementation deadlines contained within the water framework directive are summarised in table xx

### **IMPLEMENTATION OF THE DIRECTIVE IN IRELAND**

On 22 December 2003 the directive will be transposed into Irish Law. Immediate tasks of the directive which are underway include the following:

- Delineation of River Basin Districts
- Identify "Competent Authorities"

A specific requirement of the directive is the establishment of river basin management (RBM) districts and the formulation of a RBM plan which will be adopted by the county councils. There are three operational river basin districts currently identified as follows:

- Shannon (IRBD)
- South Eastern
- Eastern

The following are proposed river basin districts:

- South Western
- Western
- North Western (IRBD)
- Nenagh – Bann (IRBD)
- North Eastern (NI)

:

**Table 5 KEY IMPLEMENTATION DEADLINES**

Deadline	Action Required
December,	
2000	• Directive enters into force.
2003	• Directive to be transposed into national law. • IRBDs and RBDs to be identified. • Competent authorities to be identified.
2004	• Characterisation of surface and groundwaters to be completed. • Impacts of human activity (industry, farming etc) to be identified. • Economic analysis of water use to be completed. • Location and boundaries of water bodies to be identified. • Reference conditions for water status to be defined. • Register of protected areas to be established.
2006	• Environmental monitoring to be established and operational to ensure comprehensive view of water quality in each RBD. • Work programme for production of River Basin Management Plans (RBMPs) for each RBD to be published.
2007	• Interim overview of the significant water management issues for each RBD to be published.
2008	• Draft RBMPs to be published for consultation.
2009	• RBMPs to be finalised and published. • Programmes of measures to be established in each RBD to meet environmental objectives.
2010	• Water pricing policies to be in place.
2012	• Programmes of measures to be fully operational. • Interim progress reports to be prepared on implementation of planned programmes of measures.
2015	• Main environmental objectives to be met. • RBMPs to be reviewed and updated every six years thereafter.

### Proposed International River Basin Districts and River Basin Districts

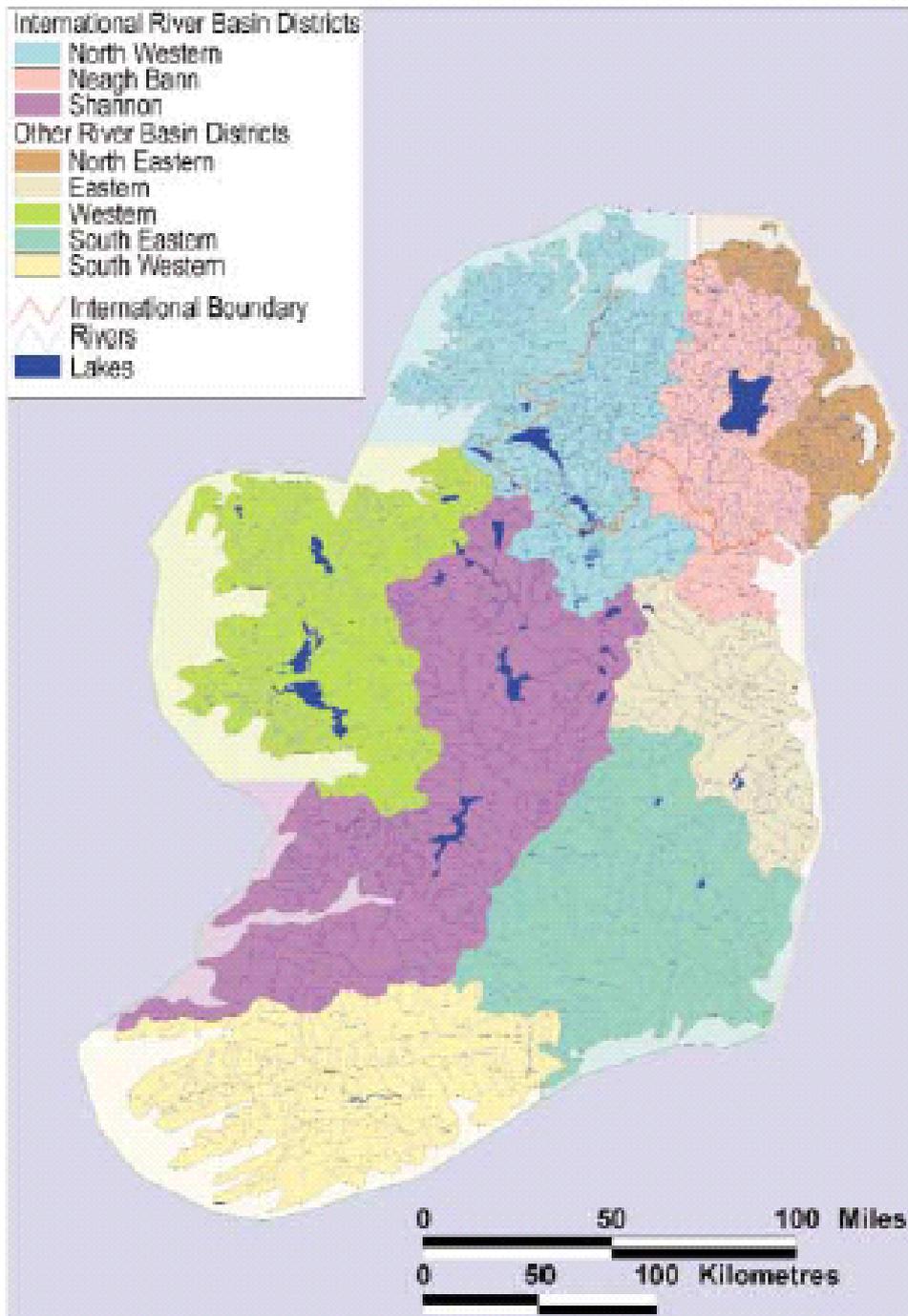


Fig 5 Proposed International River Basin Districts and River Basin Districts

### **3.1.2 Hazardous Substances.**

The parliament is required to adopt specific measures against pollution of water by individual pollutants or groups of pollutants presenting a significant risk to the environment. The commission has drawn up proposals setting out a list of priority substances selected amongst those which present a significant risk via the aquatic environment. By 2004, it is believed that the Commission will have a set of measures for phasing out priority substances and limiting the others by emission controls.

The water framework directive will repeal and replace several existing EU Directives in relation to individual aspects of water management namely:

#### **3.1.2 Water Quality Objective oriented Directives**

Water quality objective orientated directives are listed as follows:

- Bathing water Directive (76/160/EEC)
- New drinking water Directive (98/83/EC)
- Directive on Surface water for drinking water abstraction (75/440/eec as amended by Directives 79/869/eec and 91/692/eec)
- Freshwater Fish Directive (78/659/eec as amended by 91/692/eec)
- Shellfish water Directive (79/923/eec as amended by 91/692/eec).

#### **3.1.3 Emission-Control oriented**

Emission control oriented directives are listed as follows:

- Urban waste water treatment directive (91/271/eec as amended 98/15/ec and related decision 93/481/eec)
- Nitrates directive (91/676/eec)
- Ground water directive (80/68/eec as amended by 91/692/eec)
- Dangerous substances directive (76/464/eec)
- Directive on Discharges of Mercury from the chlo-alkali electrolysis industry (82/176/eec)
- Directive on Discharges by Cadmium (83/513/eec)
- Directive on Discharges of Mercury from other sources (84/156/eec)
- Directive on Discharges of Hexachlorocyclohexane (84/491/eec)
- Directive on Discharge of List 1 Substances (86/280/eec as amended by 88/347/eec and 90/415/eec)

## **3.2 Summary of Key Inter-relationships between Legislation in the Water sector and other EC legislation in the Environmental Acquis.**

### **Horizontal Sector.**

- Environmental Impact assessment Directive (85/337/eec)
- Access to Environmental Information Directive (90/313/eec)
- Reporting Directive (91/692/eec) and Water Questionnaires (92/446/eec and 95/337/eec).

**Waste Sector.**

Waste Framework Directive (75/442/eec and amending directives)  
Hazardous waste directive (91/689/eec as amended by 94/31/ec)  
Sewage Sludge Directive (86/278/eec)  
Titanium Dioxide directives (78/176/eec, 82/883/eec and 92/112/eec).

**Nature Protection Sector.**

Habitats Directive (92/43/eec)

**Industrial Pollution Control and Risk Management Sector.**

IPPC Directive (96/61/ec)  
Risks of Existing Substances Regulation(793/93) and related substances.  
Seveso II Directive (96/82/ec).

## **4. Group Water Schemes.**

### **4.1 Development of the Group Water Scheme sector.**

The lack of piped drinking water in rural areas was identified as a 'major unresolved issue' facing Ireland in the late 1950s. As part of a 1959 strategy aimed at addressing this shortcoming, it was envisaged that communities might establish 'group water schemes' in those localities where reliable sources were available. Early efforts in this direction were restricted, however, by lack of the necessary financial resources.

From the late 1960s, increasing numbers of group water schemes evolved under the grant system for the provision of water in individual houses. There were obvious advantages and economies in providing water to a number of homes from a common source, using the same reservoir, pumping equipment and pipelines, with applicants pooling their grants and providing voluntary labour. The benefits of this approach were quickly recognised by the Department of the Environment and every effort was made to encourage its widespread adoption. Group schemes flourished in the 1970s, often through the efforts of local co-operatives and farmers organisations.

Two types of structures emerged; private schemes, sourcing and distributing their own supplies of drinking water and part-private schemes, distributing publicly-sourced supplies. By the mid 1990s, the part-private sector was providing drinking water to almost 73,000 homes (approx. 240,000 people), while private schemes catered for 50,000 homes (approx. 165,000 people). Taken together, the sector accounted for water provision to 29 per cent of all rural households.

In December 1996, the then Environment Minister, Brendan Howlin, TD, devolved to local authorities the responsibility for administering capital grants in respect of group water schemes. The Minister also announced the abolition of service charges for domestic water supplies on public schemes operated by local authorities.

In view of the necessity to establish a framework for the upgrading and development of rural water supplies, it was decided that each county prepare a Rural Water Strategic Plan.

Through January 1997, group water schemes began a series of meetings and consultations to determine how the sector should respond to their exclusion from the measure announced by Minister Howlin in December 1996. Initial contacts culminated in a large and representative gathering in Knock, County Mayo. There, on Sunday, 2 February 1997, a National Federation of Group Water Schemes was established and a National Executive put in place.

In 1997, the primary objective for the leadership of the new organisation was to ensure that members of group water schemes, whether private or part-private, would be treated on a basis of equity vis-à-vis their fellow citizens on public schemes. A series of discussions with the new Minister, Noel Dempsey, TD, and his Department officials established the entitlement of group scheme members to subsidy payments. Moreover, the negotiating role of the Federation was acknowledged, as was the partnership basis that would inform any future strategy relating to the rural water sector.

## 4.2 National Federation of Group Water Schemes

The National Federation of Group Water Schemes (NFGWS) is the representative organisation for private and part-private group water schemes in Ireland. Founded in 1997, in response to the ending of water charges on public water schemes, the Federation was incorporated as a co-operative society in 1998.

The primary objective of the NFGWS, at its inception, was to secure equality of treatment, ensuring that those it represented received their full entitlement with regard to the financial supports already conceded to their fellow citizens in urban areas.

The aims of the organisation have broadened in light of mounting evidence of poor water quality, most notably within the group sector where treatment facilities are either inadequate or non-existent on the overwhelming majority of schemes.

Recognising the difficulties of compliance in certain areas with the requirements of EU directives and with national policy in relation to water quality, the Federation has forged a new partnership arrangement with government and with the local authorities. The Rural Water Programme, formulated in discussions between these partners and launched in 1998, laid out the common objectives to be pursued and the particular roles of each of the partners, including the NFGWS.

On foot of a detailed consultant's report, the Federation set about putting in place the internal structures required to effectively carry out its remit.

While continuing to represent the particular interests of group water schemes, individually and collectively, and while insisting on local discussion and agreement as core requirements throughout the process of change, the NFGWS will consolidate and strengthen its partnership role throughout the life of this plan, facilitating and encouraging a more professional approach within the GWS sector.

Amongst the first tasks, clarification is required as to the actual number of active GWS in existence, their size and extent of distribution. A base report in respect of these issues will provide a necessary focus for targeted actions in the years ahead.

The achievement of a water quality standard constitutes the paramount short to medium-term objective for the NFGWS. Of necessity, the most efficient and cost-effective means of realising this objective will be pursued and the Federation's efforts will be directed towards encouraging and enabling group water schemes to move resolutely in this direction.

The Design, Build and Operate (DBO) approach to the installation of treatment facilities on well over 500 privately-sourced GWS will be the main external priority of the Federation over the next few years. The 'bundling' of suitable schemes to avail of a single contract is now accepted by the National Rural Water Monitoring Committee, the DOELG and the Federation as the best way forward in terms of achieving economies of scale and of fast-tracking the provision of treatment facilities on the maximum number of schemes in the shortest possible timeframe.

In the longer term, the maintenance of a high quality standard will be the key issue facing the sector. It is crucial that structured education programmes are delivered which will equip group schemes for the years ahead. While the NFGWS will continue to play its part in furthering the operational training programmes provided through the Water

Services National Training Group, ongoing attention will also be paid to delivering (and, where necessary, updating) management training for group water schemes.

The active testing and promotion of source protection models and the creation of a wider community consciousness of the environmental issues at stake, will figure largely as a short, medium and long-term objective. NFGWS educational programmes will progressively target this area, particularly in the context of water treatment issues having been satisfactorily resolved. The Federation also envisages a role for the group water sector in framing policy/legislation with regard to source protection and in ensuring compliance with such policy/legislation, once agreed/enacted.

Promotion and implementation of the Quality Assurance Scheme will constitute a core element of the Federation's activities during the life of this plan. The formulation and delivery of effective performance management strategies is planned for the Group Water Schemes sector. The establishment (within the life of the plan) of a dedicated centre, to provide a co-ordinating, monitoring and certification centre for group water schemes will support these objectives.

Following on an objective assessment of the group water sector to be incorporated in our base report, the NFGWS will encourage and facilitate restructuring at every level of the private and part-private water services industry. Strategies agreed at county level - including those advocating amalgamation or take-over of non-viable GWS - will be actively pursued.

Progress in relation to the foregoing objectives and related actions will be measured on an ongoing basis, a full evaluation to be incorporated in annual reports throughout the life of the plan.

#### **4.3 Basis for a new strategy**

The need for a strategy that would address the rural water sector was underlined by environmental and legislative pressures that had evolved since the 1970s when most group schemes were in their infancy.

Lifestyle changes and the alteration of farming practices, in particular the intensification of agricultural production, had a profound impact on water quality and little had been done in the intervening period to address this issue. Investigations under the auspices of the Environmental Protection Agency (EPA) had identified water supplied by group schemes as particularly vulnerable to contamination, by virtue of the fact that the vast majority of schemes had insufficient or non-existent facilities to treat raw water. The consequent risks to public health provided a compelling incentive to deal with the issue of water treatment.

A secondary incentive was provided by EU directives and by various Statutory Instruments introduced at a national level, laying down specific parameters in relation to the quality of drinking water. Even as the NFGWS was meeting with government in 1997 to discuss the future of the sector, the EU Commission was in the process of refining its own position. Difficulties in relation to the previous Directive 80/778/EEC were

addressed in a new Directive 98/83/EU. This sought 'to protect human health from the adverse effect of any contamination of water intended for human consumption' by ensuring that it is 'wholesome and clean'. The directive defines as 'wholesome and clean' water that,

- is free from micro-organisms, parasites and other substances which, in numbers or concentrations, constitute a potential danger to human health.
- meets with requirements set out in the directive for microbiological and chemical parameters.

Beyond legislation addressing water quality, the legal framework covering the water services industry was, at best, disjointed. A raft of legislative enactments, amongst these the Local Government (Sanitary Services) Act 1878-1965, covered the wider water services industry, while various pieces of legislation directly affecting the private water sector had been introduced via primary legislation in other areas: the basis for group water schemes, for example, being legislated for in the Housing Act, 1958.

Given the determination on the part of government to meet its obligations under the EU Directive and the improving state of the economy, the political will and the resources necessary to pursue a new strategy were available. Moreover, the devolution of responsibility in the water sector to local authorities and the emergence of the NFGWS as the representative organisation for the private water sector, meant that structures were in place which had the potential, given goodwill on all sides, to facilitate agreement on a radical new approach that would address both the environmental and legislative issues that had arisen.

#### **4.4 Rural Water Programme**

In February 1998, Minister Noel Dempsey announced the launch of a Rural Water Programme (RWP), an initiative that arose directly out of discussions over several months between his Department and representatives of the NFGWS. The plan included a package of measures aimed at establishing a new framework for the upgrading and development of rural water supplies. Furthermore, it included the promise of substantially increased capital provision for the improvement of rural water supply systems, with resources being focused on the areas of greatest need. Several key objectives were included:

- To protect public health by ensuring compliance with the Drinking Water Directive.
- To pursue a planned approach to investment and ensure best practice in all aspects of the management and operation of rural water schemes.
- To give practical effect to the principle of partnership with the voluntary group scheme sector in the determination and implementation of policy on rural water supply through the local monitoring committees.
- To assist in the effective administration of the devolved rural water programme.
- To sustain the rural environment and promote economic development.

##### **4.4.1 Partnership approach to implementation**

In introducing the Rural Water Programme, the Minister stated that the task of improving the quality, reliability and efficiency of rural water supplies would have to be undertaken in a structured way, with local authorities, group schemes and other rural interests working together to achieve shared objectives and making best use of available

resources. He proposed underpinning the partnership approach by creating new and inclusive structures.

The lynchpin of the partnership arrangements outlined by the minister was the National Rural Water Monitoring Committee (NRWMC) established in May 1998. Acting under an independent chairperson, and with representation from the Department of the Environment and Local Government, the Department of Arts, Culture, Heritage and the Islands, the NFGWS, local authorities, farming and rural organisations, the key functions of the new committee were twofold:

- To advise the Minister on matters relating to rural water supply policy
- To monitor the implementation by local authorities of the devolved capital grant measures

Partnership was introduced at a local level also, with rural water monitoring committees being established in each county to formulate, agree and implement strategies, based on guidelines provided by the NRWMC. Newly-appointed County Council liaison officers were tasked with ensuring that these partnership arrangements worked effectively.

#### **4.4.2 Investing in the RWP**

The Department's commitment to seeing through implementation of the RWP has been confirmed by sustained and substantially increased spending over several years. Annual expenditure increased from IR£10.5 million (€13.3 million) in 1996 to €46 million in the current financial year, with a further IR£14 (€ 17.78) million allocated to small public schemes. Capital works on group schemes have attracted the lion's share of this funding, standing at €40 million in 2002. Emphasising the focus on water quality, capital investments in treatment works now enjoy one hundred per cent funding with respect to essential elements of treatment and the adoption of DBO method of procurement, while ancillary works receive eighty-five per cent support.

Financial incentives have also been extended to the operation and training of the group schemes themselves. Operational subsidies introduced under the RWP have been significantly increased, from Ir£75 per dwelling in 2000 to IR£80 a year later, but a significantly higher rate of increase (IR£155) has been granted to schemes which have installed treatment works. Expenses incurred by group schemes in terms of affiliation to the NFGWS, training, meetings and other activities may also be claimed from the relevant local authority.

## 5. Water Resource Vulnerability

### Hazards: the Sources of Contamination

The potential sources of groundwater contamination or hazards can be classified into two groups: point sources or diffuse, and these are listed in Table 6. A detailed discussion of these hazards is outside of the scope of this report.

**Table 6 Sources of Contamination**

Point Sources	Diffuse Sources
1. Farmyards a. Manure and slurry b. Soiled water c. Silage effluent	1. Organic wastes, landspread or deposited by grazing animals and birds.
2. Septic tank systems and other on-site wastewater treatment systems.	2. Inorganic fertilizers.
3. Spent sheep dip.	3. Spraying of pesticides
4. Landfill sites	4. Urban areas
5. Spillages and leakages (from industrial sites mainly)	5. Rainfall
6. Contaminated surface water	
7. Road drainage	

## 6 RESOURCE VULNERABILITY – Radon in Drinking Water Supplies

### Introduction.

Radon is a naturally occurring radioactive gas resulting from the decay of uranium in rocks and soils. Upon decay it forms radioactive heavy metals which combine with air dust molecules to produce radioactive aerosols, which remain suspended in the air. It is also readily soluble in and dissipated from water. The presence of radon in potable water supplies increases the risk of lung and stomach cancer, due to exposure to increased radon levels dissipated from the water. Studies have shown that exposure to airborne radon can cause lung cancer, with an estimated 20,000 deaths in the US each year and approximately 2,000 deaths in the UK and Wales attributed to radon exposure (Clapham, D. ).

An inert gas, Radon can move freely through porous media such as fractured rock and soil. Where the pore spaces are water saturated the radon can dissolve into the groundwater. The utilisation of this water in the home (i.e. in showers, washing machines or toilets) increases the inhalation risk from radon as it is easily released from the water. In the US 160 cancer deaths per annum are attributed to inhaling radon from potable water.

This paper presents the results of a literary survey examining the potential increased risk of radon exposure caused by groundwaters, quantifies the risks in Ireland and recommends further research aimed at reducing exposure to radon in water.

### Sources of Radon

Ionising radiation from naturally occurring sources contributes more than 87% of the radiation dose to the general population (excluding medical exposure) . Fig 6 presents the percentage of annual radioactivity body dose received from exposure to natural sources of radiation.

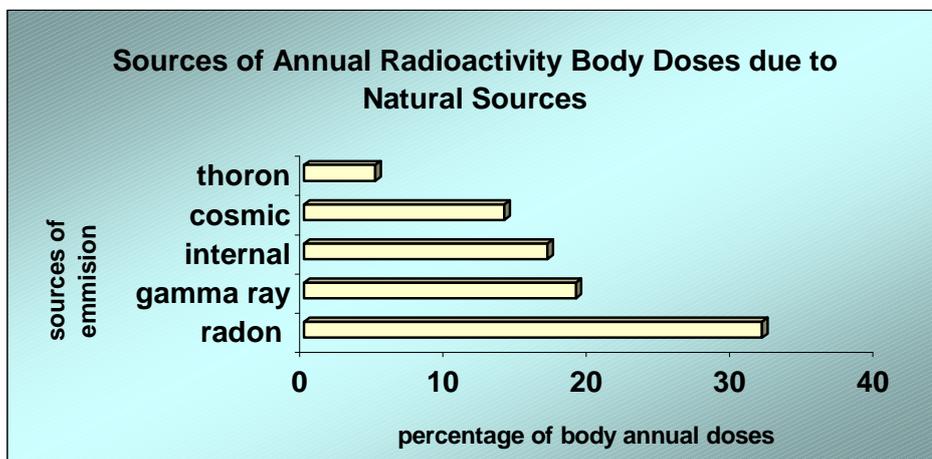


Fig 6. Sources of annual radioactivity body doses (Castle, 1988)

Isotopes in the uranium series,  $^{226}\text{Ra}$  (radium) and  $^{222}\text{Rn}$  (radon), are the principal contributors to natural radiation doses<sup>(2)</sup>. Radon is normally found at its highest concentration in granite bedrock areas. Problems can also occur in limestone areas due to faulting which allows water from deep aquifers to surface quickly. Water saturated soil with an average porosity of 20% and an average radium concentration of 20% can cause a radon concentration in the groundwater of the order of 50Bq/l.

### Measurement

Radon concentrations can be measured either in terms Becquerel of radon per cubic meter ( $\text{Bq/m}^3$ ) or Becquerel of radon per litre ( $\text{Bq/l}$ ). The becquerel (Bq) is a unit of radioactivity and corresponds to one radioactive disintegration per second. Alternative measurement systems for radon concentrations in water use picoCurie per litre. The conversion between the two systems is  $1 \text{ Bq/m}^3 = 0.027 \text{ pCi/L}$ . (NAS Report, 1999). Radiation exposure is measured by reference to an effective dose which is a measure of the total dose incurred over a lifetime following the intake of a radionuclide. It is expressed in sieverts (Sv).

Studies in the US and European countries have shown that while radon levels in surface waters tend to be low, concentrations in groundwater can be significant. Concentrations in groundwater have varied from 1 to 50  $\text{Bq/l}$  for rock aquifers in sedimentary rocks, to 10 to 300  $\text{Bq/l}$  for shallow wells in soil, to 100 to 50,000  $\text{Bq/l}$  in crystalline rocks.

### Risk of human exposure.

There are two principal sources of exposure to radon from water for humans, ingestion through water useage and inhalation of air. As Radon is released by the boiling process ingestion will mainly occur by direct consumption from tap water. 95 % of radon so ingested is excreted from the body, the remaining lodging in fatty tissue. Due to the short retention period (1.5hrs) of water in the body it is unlikely that any radioactive decay will have taken place before water is excreted. The consumption of 2 litres of water per day for 1 year contributes to the whole body effective radiation dose of 4 nSv per unit of radon concentration in water ( $\text{Bqm}^{-3}$ ) (HMSO 1995). The UK Radiological Protection Board (URPB) estimate that radon in drinking water represents 1% of the total risks from all sources of radon. However these studies are based primarily on water supplied from the mains. Studies in the US and Europe have shown that radon concentrations in private water supplies can be significantly higher. The average USA groundwater concentration of radon is in the range 11,000  $\text{Bq/l}$  to 33,000  $\text{Bq/l}$ , with some states exhibiting values in excess of  $3.7 \times 10^6 \text{ Bq/l}$ . Communities with private supplies from groundwater have been shown to be at approximately 200 times greater risk of exposure than people on mains supplies (Mose, 1996).

With respect to exposure by inhalation of air, epidemiological studies show a relationship between airborne radon and lung cancer, due to the decay of radon in air and the combination with air dust particles, producing radioactive aerosols. These present a risk when lodged in the lungs and stomach. The increase in indoor radon concentrations caused by water use depends on various factors such as water source, total consumption, volume of the house and ventilation rate. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) estimate that 1000 $\text{Bq/l}$  of radon in tap water will increase the indoor air radon concentration by 100  $\text{Bq.m}^3$ . Table 6 presents typical values for release of radon from household water useage.

Household Appliances	Value as a % of total dissolved radon
shower	66
dishwasher	95
toilet	30
taps	30 - 70

Table 7. Release of radon from household appliances (Clapham, 1996)

A study of waterborne pollution of indoor air carried out in Virginia, USA, tested 1500 homes for airborne radon levels and found that levels of radon in bathrooms were up to ten times higher than radon levels in livingrooms (Mose, 1996). The study concluded that radon levels in the water could significantly increase airborne radon levels above action levels in areas of the house where radon was emitted by water. This has implications for future UK and Irish radon studies which, have typically located measuring devices in living rooms and bedrooms and therefore there is no data to confirm this trend.

A report published in 1999 by the National Academy of Sciences (NAS) in the US confirms that there are drinking water related cancer deaths, primarily due to lung cancer. The report concludes that the estimated risk posed by radon from drinking water is small, relative to exposure to radon in indoor air, but larger than the risk from other regulated drinking water contaminants. Of the 14,000 stomach cancer deaths in the US in 1998, approximately 20 are attributed to ingesting radon from consuming radon saturated drinking waters. They suggest an age and gender averaged cancer death risk from a lifetime exposure to radon dissolved in drinking water at a concentration of 1 Bq/m<sup>3</sup> of the order of  $0.2 \times 10^{-8}$ . Of the 160,000 deaths from lung cancer in the US in 1998, approximately 19,000 could be attributed to exposure to indoor radon in homes with a further 160 attributed to inhaling radon from water.

Waterborne radon can also pose a potential health risk to workers who are exposed to excessive levels in their work place. A study carried out in Bavaria, Germany, examined radon concentrations in water supply facilities in order to assess the radon exposure levels to which the staff in these buildings were subjected. The results of the study indicated indoor radon gas concentrations of up to 300 kB/m<sup>3</sup>. (Trautmannsheimer, M. 2002). Radon levels of this magnitude could lead to radiation doses in excess of 20mSv per year. No such studies have been carried out to address radon levels in Irish Water Treatment facilities.

#### *Radiological Standards for Drinking Water*

There are three major types of decay product that carry off the surplus energy when a radioisotope decays, alpha particles, beta particles and gamma radiation. The World Health Organisation (WHO) strategy for assessing drinking water measures the presence of either of these particles in the water supply.

If either the gross alpha or gross beta activity levels exceed the reference levels the specific radionuclides should be identified and their individual activity concentrations measured. Fig 7 presents the procedures recommended by the WHO to be applied in the event standards are exceeded.

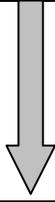
DETERMINE GROSS ALPHA AND GROSS BETA ACTIVITY		
<b>Gross Alpha &lt; 0.1 Bq/l and Gross Beta Activity &lt; 1 Bq/l</b>	<b>Gross Alpha &gt; 0.1 Bq/l and Gross Beta Activity &gt; 1 Bq/l</b>	
	Determine individual radionuclide concentrations and calculate total dose	
	Dose < 0.1 mSv	Dose > 0.1 mSv
		
<b>Water Suitable No further action</b>	<b>Water Suitable No further action</b>	<b>Consider and when justified take remedial action to reduce dose</b>

Fig 7. WHO procedure for assessing drinking water radioactivity levels (WHO 1993)

There are no WHO recommendations for radon concentrations in water. They recommend that the effects of the presence of radon in water should be evaluated at local level, taking into account other sources of radon in the human environment.

### USEPA

Drinking-water quality in the United States is regulated by the Environmental Protection Agency (EPA) under the Safe Drinking Water Act (SDWA). Since radon is acknowledged as a cancer-causing substance, the law directs EPA to set a maximum containment level (MCL) for radon to restrict the exposure of the public to the extent that is possible, that is, as close to zero as is feasible. The safe drinking water regulations only apply to community water systems > 25pe that use groundwater or mixed groundwater and surfacewater sources. It does not apply to surfacewater sources and private wells. Two different concentration levels are proposed as follows:

One standard will be the conventional MCL set at 300 pCi/L. (11,111 Bq/m<sup>3</sup>).. If a public water system meets this MCL, the company will have satisfied it's responsibilities under the SDWA.

The second standard is called the alternative maximum containment level (AMCL) set at 4,000 pCi/L (148,148 Bq/m<sup>3</sup>).. In this case the water company will be required to apply to the USEPA seeking approval to use the AMCL. To use the AMCL a multi-media mitigation programme is required to provide a variety of educational outreach programmes aimed at reducing the amount of radon gas that migrates directly into the home through the foundation. The aim of this programme is to reduce the airborne radon exposure to an amount equal or greater than the increased risk associated with a AMCL of 4,000 pCi/L instead of MCL = 300 pCi/L.

### EU Guidelines

There are no EU standards concerning radon concentrations in water supplies. There are recommendations issued on 20<sup>th</sup> Dec 2001 in relation to the protection of the public against exposure to radon in drinking water supplies<sup>(14)</sup>. The main recommendations are summarised as follows :

- An appropriate system be established for reducing exposure to radon in domestic potable water.

- Representative surveys be undertaken to determine the scale and nature of exposures due to radon in domestic potable water.
- Water in public schemes meet a limit of 100Bq/l, above which remedial action is needed.
- For an individual water supply (i.e private / group scheme) a reference limit of 1000 Bq/l should be set for consideration of remedial action
- Information made available to consumers on radon levels and removal technologies available.
- The exposure of workers to inhaled radon in establishments where significant amounts of radon may be released from water into indoor air, in particular in waterworks, spas and swimming pools, be controlled

Individual member states have assessed the effects of radon in the water supply and adopted levels. In 1997 the Swedish Institute of Radiological Protection estimated that that 5 – 15 deaths per year result from drinking water containing radon. Water containing radon levels in excess of 100kBq/m<sup>3</sup> requires treatment. The use of water containing more than 1 MBq/m<sup>3</sup> is forbidden. A further study revealed that there are 200,000 private wells, with more than 50% showing radon levels greater than 100kBq/m<sup>3</sup> and 5% with radon levels greater than 1 MBq/m<sup>3</sup>. Grants were allocated to these well owners to partly fund treatment options to reduce levels to an acceptable standard (Chruscielewski, W. 1999).

### Water Supply in Ireland

Groundwater is estimated to provide up to 25% of drinking water supplies in Ireland. Table 8 presents a summary of water consumption in Ireland, showing an estimated 13% of total usage originating from groundwater.

	<b>Total M<sup>3</sup>/day</b>	<b>Surface Water M<sup>3</sup>/day</b>	<b>Groundwater M<sup>3</sup>/day</b>
Public Water Supplies	1,381,000	1,184,000	197,000
Rural Domestic	32,000	-	32,000
Industry (private supplies)	179,000	79,000	100,000
Agriculture (private supplies)	249,000	-	-
Thermal power (fresh water)	774,000	774,000	-
<b>Total Water Usage (m<sup>3</sup>/day)</b>	<b>2,615,000</b>	<b>2,037,000</b>	<b>329,000</b>

Table 8. Water Consumption in Ireland (McCarthaigh, 1996)

### Group Water Schemes

Comprehensive data on the number and population of current group water schemes in counties in Ireland is difficult to accurately establish. Two principle sources were used in this study, the National Federation of Group Water Schemes Report for 2001 and an analysis of the returns to the respective Local Authorities. Both data sets are presented in table 9. The discrepancies can be partly explained by some schemes being taken over by Local Authorities since 2001, and also the amalgamation of smaller schemes.

IR£420M has been made available in the National Development Plan 2000 – 2006 for the upgrading and renewal of group water schemes. County Strategic Rural Water Plans have been completed in most counties with the aims of prioritising investment and implementing programmes to remedy deficiencies. These plans have been completed in partnerships between Local Authorities and Group Water Scheme Groups. Investment has been concentrated in these seven counties. New approaches using pilot Design Build Operate schemes are in place in several counties. The National Federation of Group Water Schemes is introducing a Quality Assurance Scheme for the group water sector with the aim of achieving certain minimum standards in terms of administration, management, operation and supply of water in full compliance with the amended 1999 Drinking Water Regulations. These regulations, however do not place any reference limits for radon in water supplies.

<b>NATIONAL FEDERATION OF GROUP WATER SCHEMES (2002)</b>				<b>WATER SUPPLY, IEI Conf. 2001 (G.O.SULLIVAN)</b>
<b>County</b>	<b>Number of . GWS</b>	<b>Population Served</b>	<b>% of County Population.</b>	<b>Number of GWS</b>
Carlow	23	3,000	7	41
Cavan.				100
Clare	44			<b>261</b>
Cork	300			<b>612</b>
Donegal.	350	6500	5	<b>548</b>
Dublin				39
Galway	662	51,600	39	<b>526</b>
Kerry	115	13,000	10	259
Kildare	11	2,600	2	134
Kilkenny	22			208
Laois	78			82
Leitrim	15	16,000	64	125
Limerick	300	25,000	15	313
Longford				159
Louth	18	8,295	9	104
Mayo	300	61,000	54.5	<b>449</b>
Meath	15	3,500	3	177
Monaghan	13	19,000	36.5	40
Offaly	17			70
Roscommon	185	7,300	14	<b>250</b>
Sligo	15	10,000	18	196
Tipperary North	267	12,000	18	237
Tipperary South				122
Waterford	4	1,600	17	115
Westmeath	2			126
Wexford	133	2,000	2	260
Wicklow				69
<b>Total</b>	<b>2,889</b>	<b>242,395</b>		<b>5,622</b>

**Table 9. Geographical Location of Group Water Schemes**

### National Radon Survey

The Radiological Protection Institute of Ireland (RPBII) carried out a national survey of radon in Irish dwellings between 1992 and 1999, published in Feb 2002 <sup>(15)</sup>. Radon was measured over a twelve month period in a random selection of houses in each 10 x 10km National Grid Square, a total of 11,319 dwellings, a sampling rate of 1 in 93 houses in the country. A national reference level of 200 Bq/m<sup>3</sup> has been set for long term exposure to radon in private dwellings above which remedial action should be considered. The RPBII estimate that a lifetime exposure to this reference level carries a risk of approximately 1 in 50 of contracting fatal lung cancer. This corresponds to twice the risk of death in a road accident <sup>(12)</sup>. The grid squares where the percentage of houses had indoor airborne radon levels in excess of this reference level were designated High Radon Areas. Table 9 summarises the results of the survey county by county.

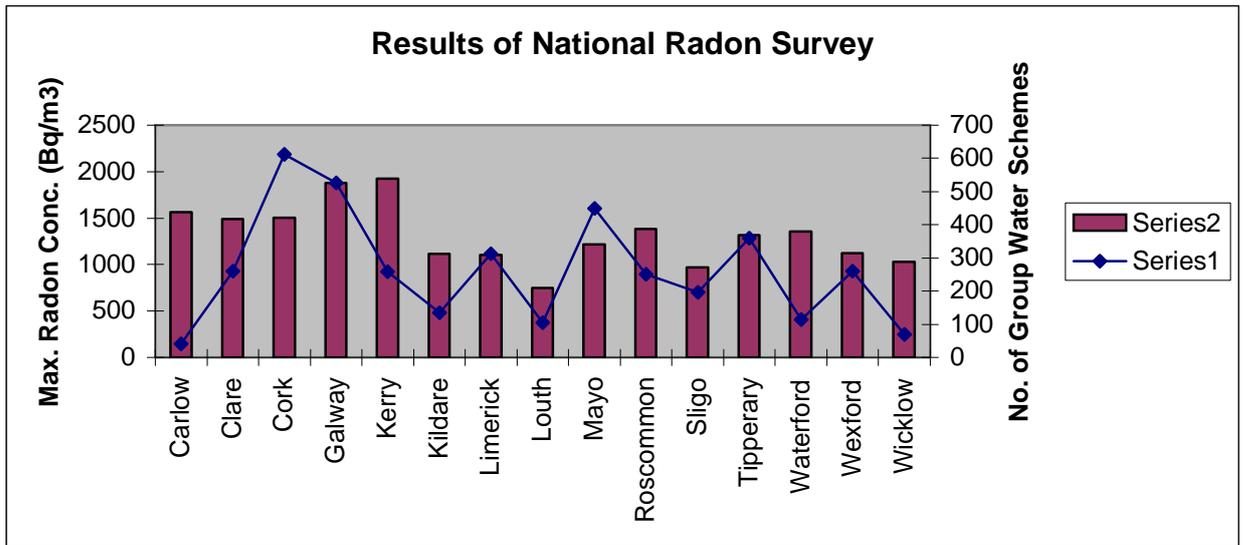
Radon measurements varied from concentrations of 10 to 1924 Bq/m<sup>3</sup>, with an average indoor radon concentration of 89 Bq/m<sup>3</sup>. Areas of the country, which have been classified as High Radon Areas based on the survey results include counties in the south east such as Carlow, Kilkenny, Waterford, Wexford, Wicklow and areas in the west such as Clare, Galway, Mayo and Sligo. The RPII use a conversion factor of 1 mSv radiation dose per 40 Bq/m<sup>3</sup> indoor radon concentration, assuming an occupancy of 7000 hrs per annum. Using this conversion factor an occupant in a dwelling with an indoor radon level in excess of 200Bq/m<sup>3</sup> can be predicted to receive a minimum radiation dose of 5 mSv per annum. The RPII's analysis of the 1996 census data indicate that between 280,000 and 320,000 people are currently receiving doses greater than 5 mSv per annum from exposure to naturally occurring indoor radon concentrations in Ireland. The International Commission on Radiological Protection (ICRP) estimate the risk for contracting a lifetime fatal cancer to be ***5 x 10<sup>-2</sup> per seivert.***

County	No. of Houses measured	No. Houses > 200 Bq/m <sup>3</sup> (%)	Mean Radon Conc. (Bq/m <sup>3</sup> )	Max Radon Conc. (Bq/m <sup>3</sup> )	Max Radiation Dose (mSv)
Carlow	194	15	123	1562	39
Cavan	180	3	67	780	20
Clare	742	9	88	1489	<b>37</b>
Cork	1211	6	76	1502	<b>38</b>
Donegal	487	4	69	512	13
Dublin	155	4	73	260	7
Galway	1213	15	112	1881	<b>47</b>
Kerry	932	6	70	1924	<b>48</b>
Kildare	480	6	90	1114	28
Kilkenny	181	9	100	717	18
Laois	334	5	83	565	14
Leitrim	145	5	60	433	11
Limerick	524	8	77	1102	28
Longford	132	6	75	450	11
Louth	124	11	112	751	19
Mayo	1184	13	100	1214	<b>30</b>
Meath	233	8	102	671	17
Monaghan	120	3	68	365	9
Offaly	286	2	68	495	12
Roscommon	235	7	91	1387	<b>35</b>
Sligo	270	20	145	969	<b>24</b>
Tipperary	852	7	79	1318	<b>33</b>
Waterford	162	12	119	1359	<b>34</b>
Westmeath	289	7	91	699	17
Wexford	469	12	99	1124	28
Wicklow	185	13	131	1032	26

**Table 10 Results of National Radon Survey,**

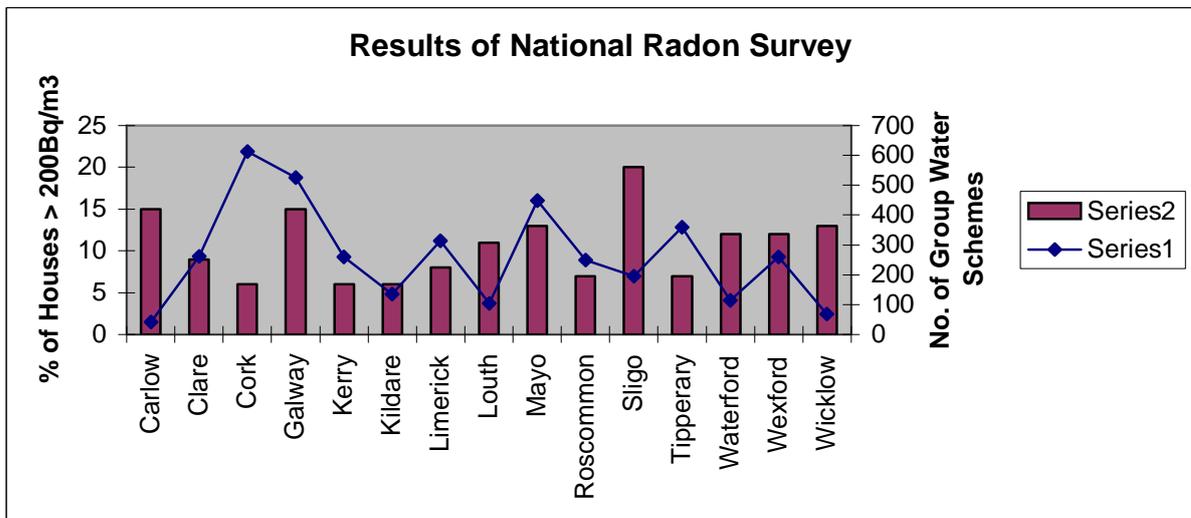
#### **Comparison of Group Water Scheme with NRPII results**

Fig 8 shows a graph of the maximum measured indoor radon concentration compared to the geographical distribution of group water schemes. Since the contribution of radon emitted from water useage in the home was not measured and since the level of radon in the water is unknown, no direct conclusions can be drawn. However, studies in European countries suggest that privately sources water supplies are at a far higher risk from radon than public supplies.



**Fig 8 Comparison of Radon Concentration and No. of group water schemes**

Fig 9 shows a graph comparing the areas where greater than 10% of the houses had levels in excess of 200 Bq/m<sup>3</sup>. Sligo had the highest proportion with 20% of the of the houses measured exhibiting levels in excess of the action limit of 200 Bq/m<sup>3</sup>.



**Fig 9**

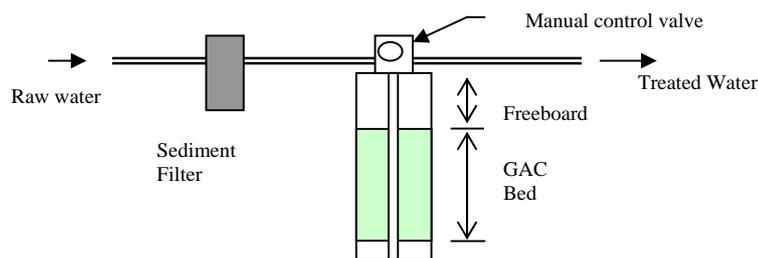
**Treatment Options**

Reduction of radon exposure in dwellings can be achieved principally by reducing airborne radon exposure. Every new house, in accordance with the Building Regulations, is required to incorporate at the time of construction radon preventative measures. The degree of protection is dependant upon the geographical location of the dwelling and the radon exposure rating. Reduction of radon in water supplies is not currently required as there are no radon exposure ratings. However, if the water supply

is drawn from a groundwater source, particularly if the underlying rock is granite (igneous) there is likely to be some level of radon present and some degree of treatment to remove the radon should be considered.

There are two main treatment options for the removal of radon from water supplies, aeration and granular activated carbon.

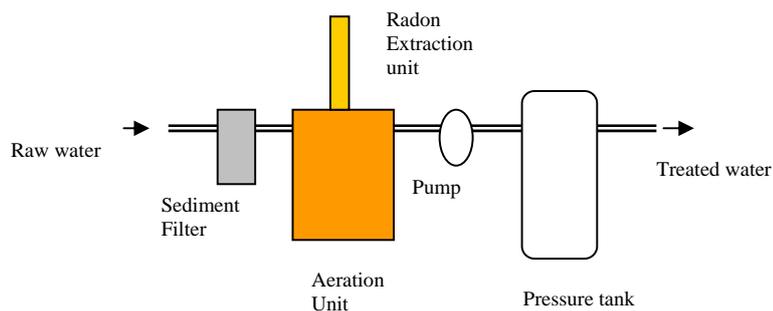
Granular Activated Carbon (GAC) units may be used at the point of entry on small supplies. The unit can be installed on the water line entering the house from the well following the pressure tank (fig 11). A study carried out by the USEPA found that GAC systems



**Fig 10 Typical GAC system**

removal efficiency varied between 79 and 99%, with efficiencies improving if the units were preceded by ion exchange to remove iron which can impede radon adsorption by lining the surface of the GAC. Unlike a normal filtration unit backwashing is detrimental to the radon removal performance of a GAC since a large amount of gas may be released during the process. Disposal of the carbon material may require specialist hazardous waste facilities.

Aeration of the well water is another treatment option, to release and vent the dissolved radon before the water is used in the house. Removal efficiency varies according to the technology but average removal rates of 99% for packed tower aeration units are reported. Home aeration units (fig 11) have been installed in some US states. However experience with these units is limited to date.



**Fig 11 typical aeration system**

Such systems will require an additional pump to boost the low radon water from the aerator back up to the operating pressure and a fan or compressor to provide the stripping air. The radon is then vented through an air vent located above the roof in order to ensure radon gas does not reenter the house.

### **Conclusions**

Radon is the largest contributor to the annual radioactivity body doses due to natural sources. This has been understood and investigated in Ireland and levels have been set and remedial action suggested to reduce levels of exposure within households where the level of radon in the atmosphere is higher than the recommended dose. However, the presence of Radon in potable water and the contribution of water borne and dispersed radon has not been included in these studies.

International studies have shown an increased radon level in homes where ground water is the chief source of potable water. There are no EU guidelines on the levels of radon concentrations in potable water though there are recommendations for protection of the public.

Concerns about the level of radon in potable water in Ireland centre on the fact that **25%** of the potable water is groundwater. Radon levels can be higher in groundwater supplies as they are subject to less agitation and originate from lower strata, with a greater possibility of contact with radon containing rock strata. No data exists for radon levels in private water supplies in Ireland, however studies in the US have found radon levels in private wells to be ten times higher than local mains water. The fact that High Radon Areas identified in the RPBII study coincide with areas where group water schemes predominate requires further investigation and study. Future studies should focus on levels of radon in group water schemes in high radon areas, together with undertaking the monitoring of levels of radon in all parts of the house, not just the living room, and particularly areas where householders are exposed to running water.

## **7. Sustainable Solutions Water Conservation Technologies.**

### **1. Introduction**

Given the increasing incidence of serious flooding in Europe in recent years it might seem odd to be addressing the problem of water conservation. However, recent economic prosperity has led to an increased per capita use of water for domestic and industrial use. The traditional approach to meeting increased demand is to augment supply. However, mobilising new resources involves ever higher costs. Allied to this is the concept of sustainability, which can be defined as *'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'*. An important consideration of itself, sustainability forms a major part of the new EU water strategy outlined in the Water Framework Directive 2000, which member states have 3 years to transpose into national legislation. Therefore, the concept of water conservation and water saving technologies are set to play a major role in our lives. Increasing the rate of water efficiency requires a multi-dimensional approach that can be achieved by adopting alternative technologies. The application of these technologies is further facilitated by the growth in urbanization and the scale of change in demand patterns.

### **2. Sustainability**

A quarter of all European water consumption is in urban areas (households, public buildings and commercial establishments). The urban population has traditionally received its water via a mains network and disposed of wastewater via a piped sewerage system. A number of problems have been linked to centralised supply and disposal systems. These include resources not located in areas of high demand and increased surface water runoff volumes due to urbanisation. An alternative and more long term sustainable option is to manage water demand in parallel with the development of sustainable water supplies to meet increased total water demand. Water efficiency can be increased by reducing the amount of water required for every day use. Fixture and appliance retrofitting, aligned with providing an alternative water supply (rainwater) and reducing water demand through using greywater (used water that does not contain faecal material) can contribute significantly to the sustainability of water resources.

#### **2.1 Water Demand**

The demand for water in Ireland is increasing, not only in relation to population growth, but also with regard to changing socio-economic patterns. Rising lifestyle standards are reflected in an increased level of ownership of appliances, a shift in household size to one-person households, and expanded municipal supply networks. The demand of an increasing industrial sector must also be taken into account. Agricultural use of water is another important water use, which has not been well catalogued and researched. Table 11 presents data on water consumption in Ireland in 1996.

	Total (M <sup>3</sup> /day)	Surface Water (M <sup>3</sup> /day)	Groundwater (M <sup>3</sup> /day)
<b>Public Water Supplies</b>	<b>1,381,000</b>	<b>1,184,000</b>	<b>197,000</b>
<b>Rural Domestic</b>	<b>32,000</b>	-	<b>32,000</b>
<b>Industry (Private Supplies)</b>	<b>179,000</b>	<b>79,000</b>	<b>100,000</b>
<b>Agriculture (private supplies)</b>	<b>249,000</b>	-	-
<b>Thermal Power (Fresh water)</b>	<b>774,000</b>	<b>774,000</b>	-
<b>Total Water Usage</b>	<b>2,615,000</b>	<b>2,037,000</b>	<b>329,000</b>

Table 11. Water Consumption in Ireland 1996 (McCarthaigh, 1996).

The pace of economic development will increase the demand on water supply infrastructure over the next 10 years. The average per capita water consumption (PCC) for Ireland in 1997 varied between 130 l/h/d to 139 l/h/d (NWS, 1999). Projections for the year 2018 indicate a PCC of between 146 and 158 l/h/d. Fig 13 illustrates the main uses of water in a domestic situation, where toilet flushing, showering/bathing and clothes washing account for almost 80% (IPTS, 1999).

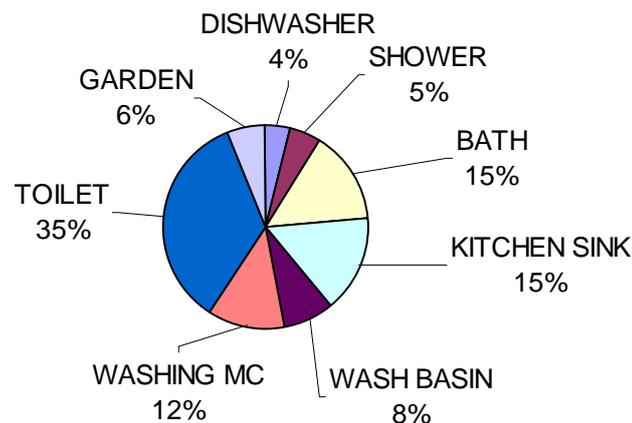


Fig 12. Typical breakdown of household water use

## 2.2 Economics

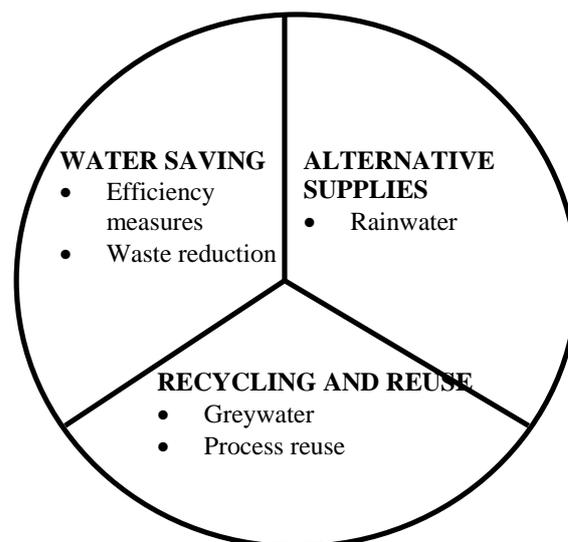
Economics is an important issue in sustainability. Water services in Ireland are mainly delivered by local authorities to both domestic and non-domestic sectors. Current government policy requires that local authorities should apply charges to the non-domestic sector that reflect the costs (both capital and operational) of provision of water and wastewater services. These charges are to be applied on the basis of a unit charge in respect of metered water supply. Local authorities are required to achieve universal metering of water supplied to the non-domestic sector by 2006. This is in accordance with the Water Framework Directive 2000 which states that *'Member states shall ensure that by 2010 water pricing policies provide adequate incentives for users to use water resources more efficiently and an adequate contribution of the different users to the*

*recovery of the cost of water services'* It is likely that once the true cost of provision of water to the consumer is applied that the water conservation/efficiency features of consumer goods will be a priority selling point. This will raise public awareness of water related environmental issues and encourage users to value water as an important resource.

*These developments will result in technologies that increase water efficiency and reduce mains water useage becoming economically attractive to both domestic and non-domestic users. Increasing water use efficiency will contribute to the sustainability of water supply and also reduce economic costs to the supplier and end user.*

### 3. Water Efficiency and Reuse Technologies

Fig 14 illustrates the three main strategy options to balance demand and supply in a building. The amount of water required to carry out a given task can be reduced through good housekeeping practices and the use of water efficient fittings/appliances. Alternative supplies such as rainwater can be utilised, and greywater can be recycled for reuse in the building.



**Fig 13 Options to balance supply and demand in a building**

Water technology options range from small scale measures at the demand side, information technologies at network level, to large scale interventions at the source side i.e. using recycled water and/or salted water. Table 12 presents a review of these domestic water technologies.

Water End Users			Water Suppliers		
			Network		Source
Indoor water saving fixtures and appliances	Outdoor water saving devices	Rainwater and Greywater reuse	Distribution network leakage detection and optimisation technology	Pressure management technology	Water desalination recycling plants, Dual piping

**Table 12. Examples of domestic water technologies (Suzenet et al., 2002)**

Statistics from the water supply sector indicate that unaccounted for water levels are in the region of 47% nationally due to a combination of leakage and insufficient management information and metering. This paper will not examine network inefficiencies but will focus on the technologies applying to the water end users. Technologies at the end-use address indoor and outdoor water usage. These can be grouped together as:

1. **Water Efficiency measures**
2. **Rainwater Harvesting**
3. **Greywater reuse.**

### 3.1 Water Efficiency Measures

It is possible to significantly reduce the water demand in a building without affecting the comfort of the occupants. Measures for water efficiency here include fixture and appliance retrofitting and installation of dual flush toilets and low flow showerheads (retro-fitting refers to adapting or replacing an existing fixture or appliance to increase water use efficiency).

Studies in European countries have shown that replacing existing fixtures/appliances with low flush toilets, economy washing machines and flow limiting showerheads and faucets can result in an overall reduction in water demand of over 30 % (Tables 12). Low-flow plumbing fixtures and retrofitting programmes are permanent, one time conservation measures that can be implemented with little or no additional cost over the lifetime of the fixtures. Savings can also be made if water is subject to supply charges. The pay back time to end-users is often less than two years for low flow fixtures. For the more expensive measures such as replacing toilets, payback times may be of the magnitude of ten years (Burrill,1997).

<b>Toilets</b>	<ul style="list-style-type: none"> <li>• Low flush toilets typically use 6 litres of water per flush, as against 7½ and 9 litres in older models. Some newer models use 2 litres for urine and 4 litres for solids.</li> <li>• Waterless urinals are a successful alternative in public locations.</li> <li>• Installing automatic controls on flushing cisterns for urinals can reduce the water consumed by 78%.</li> <li>• Internal overflows.</li> </ul>
<b>Showers, baths and basins.</b>	<ul style="list-style-type: none"> <li>• Low flow shower heads.</li> </ul>
<b>Taps.</b>	<ul style="list-style-type: none"> <li>• Hands free tap.</li> <li>• Spray, low flow taps and aerators. These can achieve a flow reduction from 0.2 litres/second to 0.04 litres/second resulting in a saving of 0.16 litres/second or 80%.</li> </ul>
<b>White goods.</b>	<ul style="list-style-type: none"> <li>• Eco-labelling. Newer washing machines will soon use 20 litres per wash cycle compared with the normal 80 – 100 litres</li> </ul>
<b>Gardens</b>	There are many uncertainties in the scale of outdoor water use, due to limited available information. Studies in Germany, France and the UK indicate that the major outdoor use for water is gardening. The increase in outdoor water demand has seen a growth in retail sales of watering products of approximately 20% per annum in the 1990s (IPTs, 1999).

**Table 13 Water Efficiency and Conservation Measures.**

<b>Appliances/ Fixtures</b>	<b>Water use</b>	<b>% reduction.</b>
Toilets	Litres/use	
Conventional	9	
Low-flow	6	33
Showerheads	Litres/min	
Conventional	14	
Low-flow	10	29
Faucets	Litres/min	
Conventional	12	
Low-flow	10	17
Flow-limiting	4	67
Washing machines	Litres/use	
Conventional	80	
Efficient	60	25
Economy	40	50

**Table 14. Examples of potential savings in the EU (IPTs,1999, Boymanns,2001).**

Typically washing machines and toilets account for 47% of domestic water consumption. **Using low flow 2/4 litre toilets and water efficient appliances (50 litres / use washing machines) savings of up to 11,500 litres of water a year for each person are possible. This represents 24% of daily household use.**

The Building Research Establishment Ltd. (BRE) have carried out studies to quantify the water consumption reductions achievable using efficiency technologies. Houses were selected and water efficient appliances and fixtures were fitted. Water consumption from these houses indicated a PCC rate of 97 l/h/d. This compares with the average UK PCC of 149 l/h/d (Legget et al., 2001)

#### **4. Water reuse technologies.**

- **RAINWATER HARVESTING**
  
- **GREYWATER RECYCLING**

##### **4.1 Rainwater Harvesting**

The application of an appropriate rainwater harvesting technology can supply a significant amount of water for household needs such as washing machines, toilet flushing and watering the garden. The critical factor in any rainwater harvesting system is the quality of the water. Harvested rainwater may be used to replace mains utilisation in the following applications: flushing toilets, washing machines, household cleaning, garden and other watering purposes. To obtain a high quality requires filtering the rainwater entering the collection system, storing it so that the quality does not deteriorate and finally delivering it to the site of utilisation without quality reduction (Moodie et al., 2000).

Table 14 presents an overview of the basic principles involved in rainwater harvesting:

- Use of rainwater only from suitable roof surfaces.
- No connections from other paved areas such as balconies, terraces or yard surfaces. This is due to the risk of pollutants.
- Design of the rainwater system to meet building standards, guaranteeing the drainage of the building, ventilation of the drainage system, preventing deposits of dirt and water etc.
- Fine filtering of the water before it enters the storage area (Fig. 3).
- Fine filtering of the water as it leaves the storage tank.
- Secure any storage tanks against leakage or the entry of foreign matter.
- Pipe work as short and as straight as possible.
- Use of non-corrosive materials and high quality, durable components.
- All light excluded from storage tanks and temperature not to exceed 18°C.
- Strict separation of potable water and harvest rainwater. Complete identification of all components in the harvesting system as “not for drinking purposes” (non-potable”).

**Table 15. Basic principles of Rainwater Harvesting.**

Fig 14. shows a section through a typical underground filter. This type of filter can capture up to 90% of rainwater for reuse while allowing detritus to overflow to surface drainage systems.



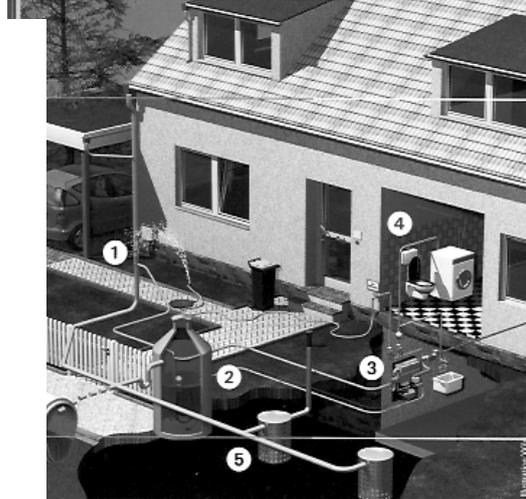
**Fig. 14. A rainwater harvesting filter.**

A large number of systems are now available, mainly from Germany where over 600,000 rainwater harvesting systems have been installed.

#### **4.1.1 Rainwater Harvesting - Domestic System**

Fig 15 shows a typical domestic rainwater system where rainwater is collected from the roof and processed through a vortex filter similar to that shown in Fig 15. The filtered water passes through to a storage tank. A submersible pump delivers water on demand via a floating suction filter to wc, washing machine and garden tap. A float

switch provides mains water back-up via a air gap tundish. Alternate systems pump water directly from the storage tank to a header tank in the attic.

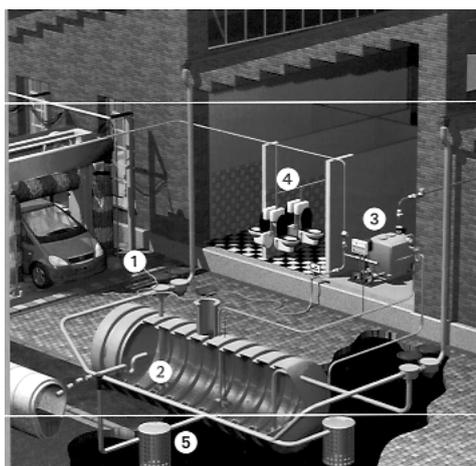


1. Filter System
2. Cistern / Storage module
3. Mains water backup valve
4. Users
5. Seepage System

**Fig 15 Typical domestic rainwater harvesting system (Konig, 2001)**

#### 4.1.2 Rainwater Harvesting - Commercial System

As shown in table 6 where a large roof catchment is available the potential yield from rainwater can be significant. Therefore rainwater reuse in commercial establishments can provide an alternative water source for appliance use and/or production facilities. Commercial systems (Fig 16) tend to be larger versions of domestic systems previously described. Stormwater attenuation may also be designed into the system as well as a reserve supply for fire fighting for large industrial buildings. Additional filtration in the form of fine sediment filtration and ultraviolet sterilisation can be included where large storage times are necessary.



1. Filter System
2. Cistern / Storage module
3. Mains water backup valve
4. Users
5. Seepage System

**Fig 16. Office building / industry rainwater harvesting system (Konig, 2001)**

#### 4.2 Potential Water Saving

The potential yield from rainwater is a function of the roof size, roof type and filter efficiency. Table 16 shows the relationship between roof size and annual rainfall.

Plan Roof Area (m <sup>2</sup> )	50	75	100	150	300	500	1000
Annual Rainfall (mm)	750	25	38	51	76	152	506
	900	30	46	61	91	182	608
	1000	34	51	68	101	203	675
	1200	41	61	81	122	243	810
	1400	47	71	95	142	284	945

Table 16. Potential annual yield of rainwater (m<sup>3</sup>) for a range of roof sizes.

##### 4.2.1 Potential Domestic Water Saving

As illustrated previously water for toilet flushing, and washing machine use can account for up to 47% of total domestic demand. Table 17 illustrates the potential water savings from a rainwater harvesting system in a typical domestic situation. These results are based on an average PCC of 131 l/h/d, an average household occupancy rate of 4 persons and a roof size of 50m<sup>2</sup>. The rainwater yield could provide 35% of the annual water demand for toilet flushing and washing machine use, resulting in a total reduction in the annual domestic water demand of 7,600 litres per person. If water efficient measures are installed in advance of a rainwater harvesting system the rainwater yield could potentially provide 95% of the toilet and washing machine demand. These figures illustrate the potential savings that could accrue from efficiency measures and/or rainwater harvesting systems.

	Annual Water Demand (litres)	W.C and W.M. demand (litres)	Annual Rainwater yield (litres)	Reduced annual water demand (litres)	% reduction
<b>Scenario One:</b> Water efficient w.c's and washing machines(WM) installed	191,260	33,400	-	157,860	17 %
<b>Scenario Two</b> Rainwater Harvesting	191,260	88,000	30,375	160,855	16 %
<b>Scenario Three</b> Combined water efficiency measures & rainwater harvesting	157,860	33,400	30,375	127,485	19 %

Table 17. Potential water savings

Table 18 presents a comparison of the potential water demand reductions in terms of per capita consumption figures achievable from the use of water efficient appliance / fittings, rainwater harvesting and a combination of the two.

	<b>PCC (2002) (l/hd/d)</b>	<b>Reduction in mains water (l/hd/d)</b>	<b>Reduced PCC (l/hd/d)</b>
<b>Scenario One</b> Water efficient w.c's and washing machines installed	131	31.5	99.5
<b>Scenario Two</b> Rainwater Harvesting	131	21	110
<b>Scenario Three</b> Combined water efficiency measures & rainwater harvesting	131	52	79

**Table 18. Comparison of PCC reductions using various scenarios**

Water savings from water efficiency measures could reduce the PCC from a current figure of 131 l/h/d to approximately 99.5 l/h/d. Similarly utilising rainwater harvesting systems could reduce the PCC to 110 l/h/d. A combination of the two could yield a PCC of 79 l/h/d. The potential to significantly reduce the PCC has been shown in the aforementioned BRE study where water efficient houses showed an approximate reduction of 35% on the average consumption rate.

This reduction in demand by utilising efficiency measures, in parallel with rainwater harvesting where appropriate, could provide significant additional capacity and has the potential to meet the predicted increase in water demand without increasing total supply, with consequential cost savings to local authorities.

#### **4.2.2 Potential Commercial Water Savings**

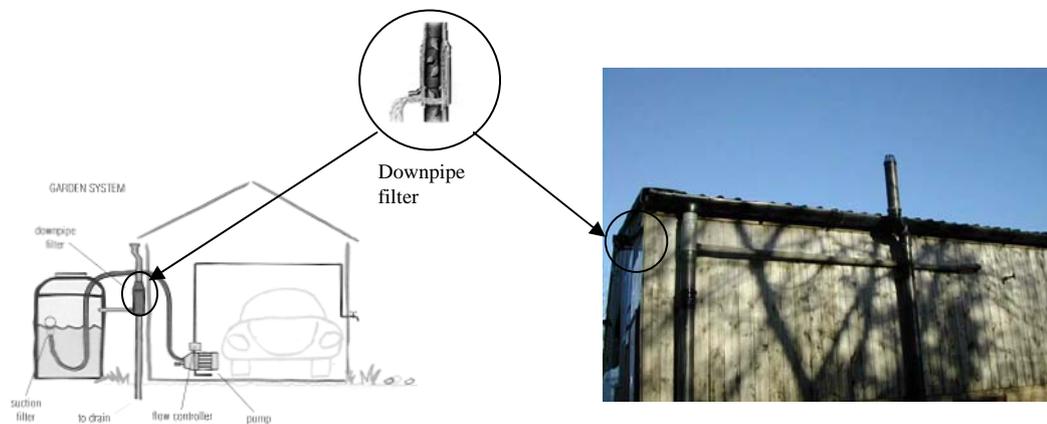
Industry in Ireland in the past 10 years has recognised the need for minimizing water use as the cost of both potable water supplies and wastewater disposal has increased. Most major 'wet' industries have adopted in-house water conservation policies and programmes. Low-tech solutions such as water efficient toilets and rainwater harvesting have a significant potential to reduce a companies annual water demand. Since rainwater yield is proportional to roof size (Table 16) office buildings, factories, hotels, etc. with larger roof areas, offer the potential to supply 100% of their toilet flushing demand from rainwater supply. Table 18 illustrates the potential mains water savings resulting from installing water efficient conveniences and rainwater harvesting in an office building with 50 persons and a roof plan area of 1000m<sup>2</sup>. Water savings of up to 195,000 litres per year could be achieved by installing low flush toilets. Rainwater harvesting has the potential to supply 100% of the demand for toilet flushing. The excess water could be stored and used in the manufacturing process thereby further reducing the demand for mains water with additional annual cost savings to the company.

Demand Type	Annual Water Demand (litres)	Rainwater Yield (litres)
Toilet		
• Conventional 9 l / use	351,000	573,750
• Low flow 4 l/use	156,000	

**Table 19. Potential water savings for commercial buildings.**

#### 4.2.3 Potential Water Saving for Farm Buildings

Agriculture has a significant water demand for both irrigation and general washings. The introduction of water rates for non-domestic users means water costs could become a significant part of the annual running costs of a farm. Rainwater harvesting has a significant potential to provide an alternative supply at relatively low capital and running costs. Fig.17. illustrates a rainwater harvesting facility for garden or agricultural use.



**Fig. 17. Rainwater harvesting system for Agricultural / Garden use (Rainharvesting Systems, 2002)**

An average Irish farm building with roof dimensions 14.4m x 13m at a pitch of 22° and an average annual rainfall of 900mm, has a ***potential rainwater yield of 113,603 litres per year***. This could be reused for irrigation, farm washings, and could be treated to provide potable water for livestock.

### 4.3 Economics

European studies show that rainwater systems have been proven to be economically viable where water consumption is above average and where there is sufficient rainfall to meet demand (Legett, 2002). Research undertaken by BRE in the UK found greywater systems to be uneconomic where mains water was readily available. Thus the capital and annual running costs are greater than the value of the water saved. Payback periods for the greywater systems assessed were likely to be in excess of the life expectancy of the system components.

#### Domestic Rainwater Harvesting Systems

It has been shown that rainwater when used for toilet and washing machine use has the potential to provide up to 16% of the annual domestic water demand. Small single household systems are the least economic particularly in the Irish context where potable water costs are not met by the consumer however this may change with the adoption of the Water Framework Directive.

#### Economies of scale

A shared system for an estate or housing association is more viable than single one off systems. Taking a typical 10 house estate with roof areas of 50m<sup>2</sup> the capital costs of a rainwater system could be reduced to less than €1,000 per household. If mains water is charged at a rate of €1 per m<sup>3</sup> the annual cost saving to the consumer would be of the order of €31 per annum. This would provide a simple payback period of 16 years. Maintenance and running costs would be minimal.

#### Commercial Buildings

Rainwater systems installed in larger establishments (roof area >500m<sup>2</sup>) can be economically viable. Assuming capital costs of €5,000 and taking non-domestic water charges of €1.40 per m<sup>3</sup> Fig. 18 illustrates the payback period of less than 7 years. Since the rainwater yield is in excess of the toilet demand additional savings could accrue if the water was reused as part of the manufacturing process.

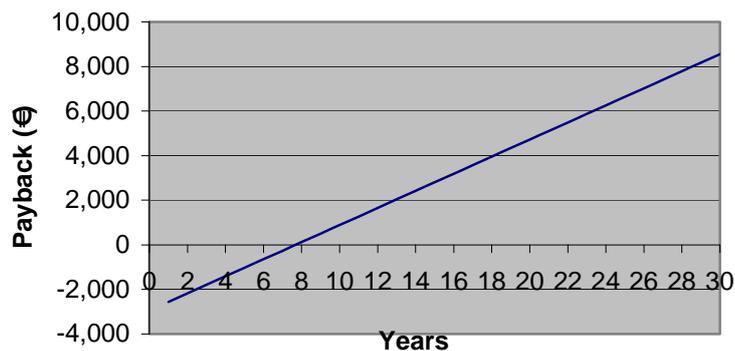


Fig. 18. Rainwater Harvesting Cost Analysis  
Commercial Premises

### **Potential Cost Saving to Water Suppliers**

Any analysis of water efficient measures or rainwater harvesting systems is to a certain extent dependent on the individual site location and function. Common to all applications is the cost saving which is likely to accrue to the water supplier, which in Ireland is typically the Local Authority. Table 17 illustrated the potential reduction in mains water usage (PCC), which could accrue from installing water efficient fittings and appliances and rainwater harvesting systems, either separately or in combination. Costs for production and supply of water vary from region to region. Department of the Environment and Local Government average figures for the production of water is typically of the order of 30 cent / m<sup>3</sup> and for the production and supply to the consumer is 80 cent / m<sup>3</sup>. It is evident that significant savings could accrue to the supplier by installing such systems in domestic and industrial buildings. It can be shown that introducing water efficient WC's could result in a production cost saving of the order of €3.45 per person per year. Introducing rainwater harvesting systems could result in production cost savings of the order of €2.28 per person per year. Taking this in the context of a municipal water treatment facility supplying potable water to 128,000 population equivalent, and assuming that 40% of the costs quoted are fixed, production cost savings of the order of up to 250,000 per annum are possible. Experiences in Germany suggest that similar cost savings have accrued to water suppliers following the introduction of such measures. New York city is currently in the process of distributing free to households, water efficient toilets, illustrating the cost effectiveness for a water producer of such a policy.

All water reuse technologies can be economically viable provided they are designed with reasonable payback periods in mind. In England and Wales the costs of rainwater harvesting systems can range from £20 to £3000 (Mustow et al, 1997). Cost savings are around £20 - £50/ per person/year (Smerdon et al, 1997). The costs of grey water systems are £750 - £1000, the cheaper price being possible if the system is installed during construction. The cost reduction with the water saving devices is £25 in Britain and £43 in Germany per household per year, based on 33% saving in drinking water. This is based on 1998 prices (Burkhard et al., 2000). With a metered system such as Germany the payback period for grey water systems is estimated at 8 years against 35 to 49 years in England and Wales. This is due to unmetered systems and low water prices.

### **Rainwater Quality Issues**

The quality of water intended for human consumption in Ireland is governed by rigorous legislation which covers a total of 53 bacteriological, chemical and physical parameters. There is no such legislation which governs the use of water for non-potable uses such as toilet flushing, a principal use for rainwater. In order to develop a market for such reuse technologies in Ireland, standards and / or guidance for use of water in the homes for purposes other than drinking will be necessary. Research on rainwater quality in Germany, which has an estimated 600,000 rainwater recycling systems installed in the last 15 years, suggest that suitably collected and treated rainwater poses no risk to human health (Sayers, 1999). When reporting contamination of a faecal nature German Authorities use the EU Bathing Water Directive as a comparison. The highest potential risk to public health appears to be associated with an illegal cross connection of the recycled water into a municipal water distribution system. Thus the appropriate technical inspection of the rainwater utilisation system and the installation of safety devices to prevent backflow are essential. Accurate labelling of the two systems is also important.

Water quality problems associated with the use of rainwater systems can be minimised through the use of best practice design guidance and the use of filtration and disinfection technologies where appropriate.

The restricted use of cistern water ( i.e. toilet flushing, clothes washing and gardening) contributes little to the possible exposure of a user to pathogens in the water. The likelihood of cistern water being misused as either drinking water or water for personal hygiene is small but not to be ignored. Hence the need for labelling.

Through correct planning and building of a system the possible microbiological contamination can be minimised and the risk of misuse of the water ruled out. Treatment of the water in order to attain drinking water standards is not required (Lucke, 1999).

If the rain water is used in Kindergartens, hospitals or nursing homes regular inspection by a qualified person is recommended. The critical points for harvesting systems with regard to hygiene are known and can easily be monitored visually. Microbiological sampling as part of the monitoring program contributes little additional information and is expensive (Lucke, 1999).

#### 4.3. Greywater Recycling

Greywater systems filter and recycle the water from bathroom sinks, showers and washing machines for use in flushing toilets and or irrigating landscape. The quality of the greywater is a function of the contaminants added during use of the water. Greywater can be characterised as rich in nutrients, high in contaminants and an ideal medium for bacteriological growth and microbial activity. That accruing from kitchen sinks and dishwashers is more contaminated than greywater from washing machines, baths showers and hand basins. As a result most packaged greywater systems do not utilise kitchen sink or dishwasher waste. Theoretically it is possible to treat this waste but the cost of filtration and treatment against the extra volume of water produced is not viable.

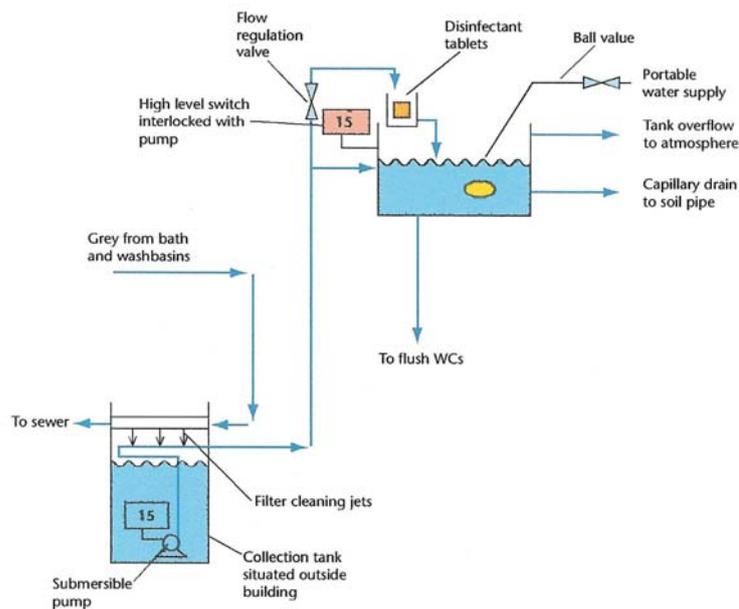
##### *Treatment System*

Greywater systems consist of a filtration unit, a storage tank with overflow to sewer, a pump, a disinfection (chemical dosing) header tank with both overflow and mains top up facilities and connecting pipework. The filtration and storage units collect water from wash basins, bath and shower (Fig. 19).

SOURCE	TREATMENT AND STORAGE	REUSE
WASHBASINS BATH SHOWER	FILTRATION STORAGE PUMP DISINFECTION HEADERTANK	WC FLUSHING

Fig 19. Flow diagram for a typical Greywater Recycling system.

Systems differ in how they arrange the components and the technologies used for filtration and disinfection. Fig 20 illustrates a typical proprietary system. Sensors can be installed that switch the system off if the foul sewer backs up, and the connection to the mains water supply means that the system can be automatically supplemented when grey-water flow is low or demand is relatively high (Leggett and Shaffer, 2002).



Well Butt Greywater reuse

**Fig 20. Well Butt Greywater Reuse System (Environment Agency,2001).**

### Reuse Options

Greywater can be considered as reuse or recycling of used water. Reuse of greywater, where it has not undergone treatment must be immediate as its quality deteriorates significantly within a few hours. Recycling means the grey-water has undergone treatment, and most systems filter and disinfect as they recycle.

The most common use of grey-water is for toilet flushing. This is a function of the water quality and the potential risks of using untreated greywater, and the close but coincidental match between the demand for toilet flushing water and greywater arising in domestic situations (Leggett and Shaffer, 2002). Packaged greywater systems provide a close match between the greywater arising and the demand for treated water for flushing, as both are related to occupancy of the building. Storage systems for greywater are smaller than those used for rainwater harvesting, since greywater systems do not have to store water for a long period before new greywater is supplied to the storage tank. Among the disadvantages of greywater in comparison to rainwater harvesting is that the system needs to be more complex and robust than for rainwater, with higher maintenance demands.

Although water recycling has been practised for some decades, technical systems have been developed only recently. Examples of available technologies include two stage filtration and chemical disinfection systems that remove coliforms, leaving the water high

in turbidity and organic pollution. Other devices include advanced filtration systems that reduce all components of grey water but do not reliably meet all recycling standards, and membrane bio-reactors that are presently very costly (Jefferson et al., 1999).

### **Other Costs**

The measures discussed in this paper to reduce mains water demand may have a material or technical component which will have environmental impacts associated with their manufacture, use and disposal. These costs have not been taken into account in this analysis. In order to fully assess these external costs a life cycle analysis may be required. Life cycle analysis methodology is commonly employed in waste management however it has not been applied to water saving technology currently on the market.

### **Other Issues**

Lack of motivation by customers

The incentive to install water saving devices in domestic and industrial buildings can be driven by cost savings or environmental considerations. The absence of domestic water metering and charges in Ireland provide no incentive for consumers to reduce their water consumption. Even in countries such as Germany where such technologies have a proven track record studies have shown that consumers consistently underestimate the effectiveness of such technologies and over estimate the cost of installation. In buildings where water bills are set on the basis of total volume consumed, individual residents do not have any incentive to install water saving devices as the benefits will average over the entire building. In many countries there is individual metering. Typically the landlord is responsible for the installation of such devices but the tenant will gain on any savings. In many countries installation of rainwater harvesting systems, water efficient fittings and appliances are conditions of the planning consent for new developments.

### **Conclusions**

The benefits of water efficiency measures, rainwater harvesting and greywater reuse are principally water savings and reduced volume of consumption. Cost savings can accrue to the water supplier and water user. These benefits can be felt at a local level. Only with widespread use of such technology will reduced pressure on water resources and the supply infrastructure be realised.

These technologies should be considered in the context of an overall water conservation strategy and each situation evaluated separately. A water audit should be undertaken to establish existing water usage and possible demands that can be met by using these technologies.

A programme to develop public awareness and to source and promote these technologies is also required. Standards for fittings and legal standards for rainwater quality are required if these technologies are to become generally installed.

The use of these technologies should be driven by the need to develop a sustainable strategy of urban water demand management.

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## 8. Benefits and Costs of Water Conservation Measures in Ireland

### Abstract

This study evaluated the potential benefits of implementing a domestic water conservation program in Ireland. The aim was to identify the effect of such a program on per capita consumption rates (PCC) and estimate the cost benefit to consumers and producers. A modified micro component analysis was used to calculate potential water savings. The predicted 2018 PCC was reduced from 147.17 l/hd/d to 82.75 l/hd/d, representing a potential saving of 44%. A net worth model and a capexdcf model were used to establish payback periods. The payback period was less than two years for certain conservation measures. The incentives and barriers to implementing a successful water conservation strategy for Ireland were reviewed.

**Keywords** – demand management, per capita consumption (PCC), water conservation, microcomponents, costs

### Demand Management

#### Introduction

Recent economic growth in Ireland has lead to pressure on water resources. The traditional approach to meeting increased demand in the water sector is to develop new resources to augment existing supply. This approach has economic implications with regard to infrastructure and associated environmental costs. However, alternative options have been identified using efficiency and conservation measures as solutions to water capacity problems, Haasz, (2002). This study showed the link between water use and economic growth can be broken, by utilising efficiency and water conservation measures, and substituting rainwater and greywater for treated potable water, where suitable.

#### Domestic Demand (Per Capita Consumption)

PCC refers to the water consumed by an individual on a daily basis. Water for domestic use is estimated to comprise 60% of the total demand for water in Ireland. The most recent and most comprehensive study of water in Ireland, The National Water Study, dealt with the PCC value by estimating it using two complimentary methods, firstly by looking at previous studies and secondly by reviewing domestic water consumption using a microcomponent analysis, WS Atkins (2000).

#### Previous Studies

The national water study reviewed five studies carried out in parts of the Republic, Northern Ireland and England. The Irish data was found to be unreliable and not representative of water consumption in Ireland. The North of Ireland study, while based on metered data, produced a PCC higher than that of the Republic, due to the higher proportion of people living in urban areas. The study of water use in England and Wales is of limited application to Ireland, due to the differences in domestic water use.

#### Estimated existing PCC values

A modified microcomponent analysis based on the National Waster Study was used in the present paper to calculate PCC values. Atkins used the UK Water Industry Research report as the basis for their analysis, Fenn & Kemlo (1998). This method involves taking the components that make up domestic demand, allowing for uptake, the frequency of use, and the volume of water used per occasion and calculating the consumption rate for each microcomponent. Both in house and out house uses are

included. It also takes into consideration occupancy rate, household type, age group and climatic variations. The estimated PCC value for 1997, based on this microcomponent analysis was 131 l/hd/d. This was based on an occupancy rate of 3.2 and a white good uptake of 0.8. White goods are defined as water efficient appliances.

### Estimating Future PCC values

Several factors influence the forecast demand, including housing construction rates, occupancy rates and appliance uptake, WS Atkins (2000). The issue of occupancy rates, with its implications for per capita share of water using activities, has a significant effect upon estimates for future demand. The Irish occupancy rate is set to fall by 0.75% in the years to 2006, and by 0.6% in the twelve years to 2018, from the estimated 3.2 of 1996, O'Sullivan (2002).

Table 20. illustrates the projected microcomponent analysis for 2018. The most substantial increase in water consumption is in the personal washing microcomponent. This is due to an increased uptake of power showers. The WC component is predicted to reduce slightly while steady increase in the uptake of appliances results in slight increases in the other microcomponents. Projections for the Irish PCC in 2018 average at 147.17 l/hd/d, based on an occupancy rate of 2.72 and a white goods uptake of 0.8. This PCC value compares with a value for Northern Ireland of 168.2 l/hd/d for 2018 and a value for England and Wales projected at 177 l/hd/d.

	Micocomponent	1997	2018	
			Forecast	
		% Total PCC	SubTotal ( l/hd/d)	% Total PCC
IN HOUSE USE	WC	27.16	32.12	21.82
	Personal Washing		60.07	40.81
	Clothes washing	10.20	15.76	10.71
	House cleaning	0.87	1.32	0.90
	Dish washing	6.33	11.28	7.66
	Waste disposal units	0.11	0.34	0.23
	cooking water	2.76	4.23	2.87
	drinking water	2.69	3.50	2.38
	Miscellaneous	7.59	11.04	7.50
EXTERNAL USE	Car washing	0.18	0.40	0.27
	Lawn watering	1.59	2.93	1.99
	Plant watering	1.73	3.20	2.18
	Paddling pool	0.03	0.07	0.04
	Swimming pool	0.05	0.12	0.08
	Miscellaneous	0.54	0.79	0.54
	Total	100.00	147.17	100.00

**Table 20 Microcomponent Analysis after WS Atkins (2000)**

## WATER CONSERVATION MEASURES

These measures reduce the amount of water required to accomplish a given task. There are four main areas of conservation.

### 1. Toilets.

Toilets account for 37% of domestic use . Volume reduction in toilets can be achieved by any of the following.

- A. **Low Volume Toilets.** These use 6 litres or less per flush. Dual flush toilets deliver 6 litres for solids and 3 litres for liquid wastes. Use of these toilets is widespread through out Europe. In the USA a \$297 million project saw 1.3 million lowflush toilets installed in New York. This resulted in water savings of 350 million litres per day, NYCDOEP (1997).
- B. **Waterless Toilets.** These may be chemical, vacuum, composting or incinerator toilets. Composting toilets may be self contained units or central composting systems. Current models are expensive and public acceptance of them is not widespread. Incinerator toilets use high temperatures to burn wastes to ash and are generally used in remote locations where plumbing and even compost toilets are not practical.
- C. **Displacement Devices.** These are retrofit and are installed in the cisterns of existing toilets. They displace their own volume in water thus leading to a reduction in flush volume. Displacement devices may be commercial devices or simple homemade devices such as a plastic bottle filled with water. Successful campaigns have been run in some European countries, Memon & Butler (2001).
- D. **Toilet Leak Repair.** Attention to seals, valves, ballcocks and other replacement parts can reduce potential for water loss.

#### Case Study : New York 1994-97

The New York Dept. of Environmental Protection sponsored a \$297 million rebate program for residential and commercial customers resulting in the installation of 1.3 million low flush toilets. The program achieved estimated water savings of 70 million gallons per day. A 29% reduction in water use was achieved among 67 apartment buildings surveyed.

### 2. Showerheads.

Water for showers accounts for 6.5% of PCC. Low volume showerheads improve spray patterns to give the same performance with reduced volumes. Retrofit devices can be fitted to existing showerheads, however recorded performance has not be as good as permanent low volume showerheads. A water efficiency programme that included free water efficient showerheads as one of its measures showed annual water savings of 1 ML, New South Wales Water Strategy, (1999).

**Case Study:** Rous county in New South Wales implemented a major water efficiency program designed to defer construction of a new reservoir to augment existing demand. The measures included the following:

- pricing and billing reform
- leakage detection and repair
- free water efficient shower heads
- free audits for commercial, industrial and institutional customers
- cash rebates at point of sale for purchase of front loading washing machines
- demonstration water efficient house and garden

A cost benefit analysis of the project indicated the financial benefits associated with the water savings of 1 ML/annum at more than AUS\$3,500.

### 3. Faucets.

The use of the handbasin contributes 11% to the PCC. Low volume faucets, faucet retrofit devices and leak repairs can affect water reduction. Low volume faucets incorporate aeration or spray features at the end of the faucet head, while faucet retrofit devices include aerators, metered valve, self closing faucets and sensor activated faucets. A study in the UK showed that installing limiting devices on taps resulted in 52% saving per hand wash and a payback period of less than 1 year, Howarth, (2002).

### 4. Appliances

Existing washing machines account for 10% of PCC while dishwashers account for 1.5%. Water reduction can be achieved by using water efficient models reducing the volume from 80 to 40 litres per use in washing machines and from 40 to 33 litres in dishwashers.

### 5. Rainwater Harvesting.

The application of rainwater harvesting technology can supply significant amounts of water to replace mains water used in washing machines, toilet flushing and external components such as garden use and car washing. Potential water savings can be up to 45% of the total PCC, McCarton and O'Hogain, (2003).

#### Case Study: Scotland

Scottish water is the manager of the main waste minimisation project in Scotland, named Resource Efficiency Action Program (REAP). This has involved working with their industrial customers to help manage water consumption, reduce costs and promote sustainable water use. Trials involving 22 companies were established. These involved carrying out site surveys (water audits) to establish the potential for using water efficiency fittings, the installation of water metering and a cost benefit analysis of actual savings achieved and payback periods. Case study results for 22 companies which have been involved in the pilot study are shown in Table xx. The figures represent combined annual savings of £1.5 million.

Table xx Water, Energy, Waste Savings from REAP.

Environmental Savings	Water use per m3	Energy use p.a.	Solid waste tons p.a.
baseline	875,438	4,290,941	635
reduction	140,764	430,935	67
Reduction as %	16.1 %	10.0 %	10.6 %
No. of Participants	7	10	4

### Summary.

Adoption of these water conservation measures have shown significant volume reductions in other countries. Water demand in Denmark has been reduced from 164 l/hd/d in 1991 to 131 l/hd/d in 2000, Napstjert, (2002). In assessing the suitability of a water demand strategy for Ireland, consideration must be given to the conservation potential of these measures. The technical feasibility and the cost benefits to the producer and the consumer are further considerations.

**PCC reduction methods.**

Table 21 summarises the water conservation measures considered and the modifications required to install them. Table 22. summarises the potential water savings calculated using the microcomponent analysis method. This involved estimating new values for the components listed in Table 20, and calculating the resulting reduction. Each water demand strategy was analysed separately, so the potential water savings from any combination of measures can be readily calculated from the results. The occupancy rate was taken as 2.72, and the baseline nominal average PCC rate was taken as 147.17 l/hd/d, WS Atkins, (2000).

<b>Water Measure</b>	<b>Efficiency</b>	<b>Action</b>
1. Displacement Device.	Water	A water displacement device to be installed in existing wc's
2. Dual flush wc's		All new houses to be fitted with dual flush 6/3 litre wc's
3. Faucets		All taps in new houses to be installed with flow limiters
4. Appliances		All new houses to be fitted with water efficient washing machines (40 l/use) and water efficient dishwashers
5. Harvesting	Rainwater	Rainwater harvesting technology introduced to replace existing demand for wc, clothes washing, waste disposal and garden use of potable mains water

**Table 21 Water conservation measures considered and modifications required to install them**

Component	Efficiency Measure	Micro Demand (l/hd/d)	Reduction in Demand (l/hd/d)	Total PCC (l/hd/d)	% Total Reduction in PCC	Household Water use (m <sup>3</sup> /yr)	Household water saving (m <sup>3</sup> /yr)
WC (no efficiency)		32.12	-	147.17	-	146.11	-
	1. Displacement Device	28.02	4.1	143.07	2.79	142.04	<b>4.07</b>
	2. Dual Flush WC	19.81	12.31	134.86	8.36	133.89	<b>12.22</b>
Clothes Washing (no efficiency)		15.76	-	147.17	-	146.11	-
	3. Efficient machines	10.96	4.8	142.37	3.26	141.34	<b>4.77</b>
Personal Washing (no efficiency)		60.07	-	147.17		146.11	
	4. Tap flow limiters	55.07	5	142.7	6.79	141.5	<b>4.96</b>
	5. Rainwater Harvesting		45.89	101.28	31.18	100.55	<b>45.56</b>

**Table 22 Potential water savings from water conservation strategies.**

### Potential Water Savings.

#### 1. WC Displacement device.

For a 1 litre displacement volume, placed in the cistern of an existing toilet, the micro component demand can be reduced from 32.12 l/hd/d to 28.02 l/hd/d. This would result in a PCC of 142.97 l/hd/d and an overall household saving of 4.07 m<sup>3</sup>/yr.

#### 2. Dual Flush WC's.

Dual flush toilets reduce the WC micro component from 32.12 l/hd/d to 19.81 l/hd/d. The reduction in demand is 12.31 l/hd/d in overall daily water use. This reduces the PCC to 134.86 l/hd/d, a saving per household of 12.22 m<sup>3</sup>/yr.

#### 3. Water Efficient Appliances.

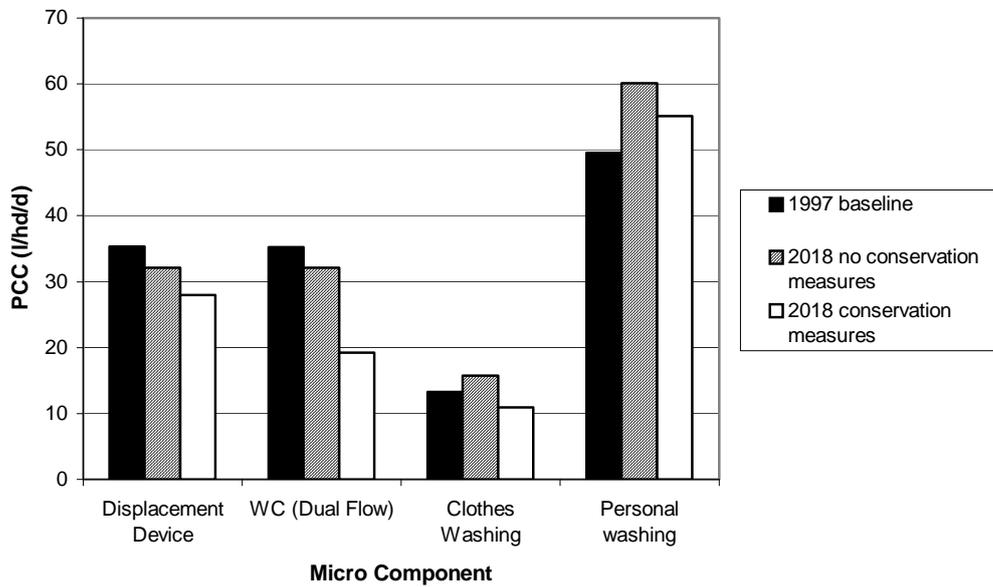
The installation of a water efficient washing machine would reduce the clothes washing microcomponent from 15.67 l/h/d to 10.96 l/hd/d. This would reduce the PCC to 142.37 l/hd/d, resulting in an annual water saving of 4.77 m<sup>3</sup>/yr per household.

#### 4. Faucets

A one litre reduction per use was used for calculations, Howarth, (2002).

This reduced the PCC to 142.17 l/hd/yr. This represents a saving of 4.96 m<sup>3</sup>/yr.

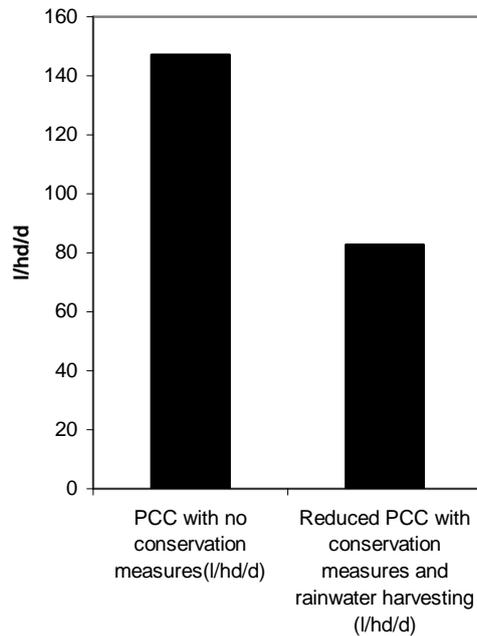
Fig 21 illustrates the potential reduction in PCC rates.



**Fig 21 Potential Reduction in PCC rates**

### 5. Rainwater Harvesting.

With no conservation measures installed, this technology has the potential to supply approximately 84% of the mains water demands for wc, clothes washing and garden use, reducing the PCC to 101.27 l/hd/d. If a domestic water conservation program was put in place, incorporating low volume dual flush wc's and water efficient washing machines, rainwater harvesting has the potential to supply 100% of the mains water demand for these activities. This results in a reduced PCC of 82.75 l/hd/d, representing a reduction of 44% from the projected PCC of 147.17 l/hd/d.



**Fig 22. Potential reduction in 2018 PCC**

### **Cost Benefit Analysis.**

#### **Cost benefits to the consumer and providers**

The absence of current domestic charges for water and wastewater mean that no cost benefit will accrue to the consumer. To quantify the theoretical cost benefit, a separate domestic charge of €1 per m<sup>3</sup> was assumed for water and wastewater supply respectively. A factor of 0.95 was used to estimate the wastewater saving per household. Additional benefits accrue to both the water and wastewater providers due to reduced treatment and pumping volumes. Table 23 summarises the cost of implementing the conservation measures and the cost benefits.

Water Conservation Measure	Implementation Cost	Cost Saving per household per annum (based a charge of €1 per m <sup>3</sup> )	
		Water €	Wastewater €
	<b>Hardware &amp; Installation</b>		
<b>WC Displacement</b>	Capital Cost: 0 if bought in bulk, €1 - €1.50 if bought individually	4.07	3.87
<b>Dual Flush WC</b>	Capital Cost: Similar to conventional unit. No additional costs if part of new house.	12.22	11.61
<b>Water Efficient Appliances</b>	Capital Cost :€500 - €1000 Reduced energy costs (506 kWh per yr per household)	4.77	4.53
<b>Faucet Flow limiters</b>	Capital Cost :€0 if bought in bulk, €1 - €5.0 if bought individually	4.96	4.71
<b>Rainwater Harvesting</b>	Capital Cost :€1,500 – €2,000 €50 per annum operating cost	45.56	43.28

**Table 23. Implementation costs and cost savings per household**

**1. WC Displacement Device.**

The annual projected cost saving for water and wastewater respectively is €4.07 and €3.87 per household per year.

**2. Dual Flush WC.**

The price of a dual flush WC toilet is comparable to the conventional 9 litre model, in the region of €400 per unit. There are no additional installation costs associated with dual flush over a conventional fixture. No energy costs are associated with toilet retrofit devices. The annual projected cost saving for water and wastewater respectively is €12.22 and €11.61 per household per year.

**3. Water Efficient Washing machines.**

These devices can be up to €100 to €400 more expensive than conventional machines. The annual projected cost saving for water and wastewater respectively is €4.77 and €4.53 per household per year.

**4. Faucet flow limiters.**

The annual projected cost saving for water and wastewater respectively is €4.96 and €4.71 per household per year. Energy savings accrue from reduced hot water usage, these being costed at 0.4kWh per 2.64 person household, Vickers (1996). Figures from the US show that the use of water efficient shower heads and taps lead to annual cost reductions of between \$26 and \$170 per household D. Morgan . (1996).

### 5. Rainwater Harvesting technology.

The annual projected cost saving for water and wastewater respectively is €45.45 and €43.28 per household per year.

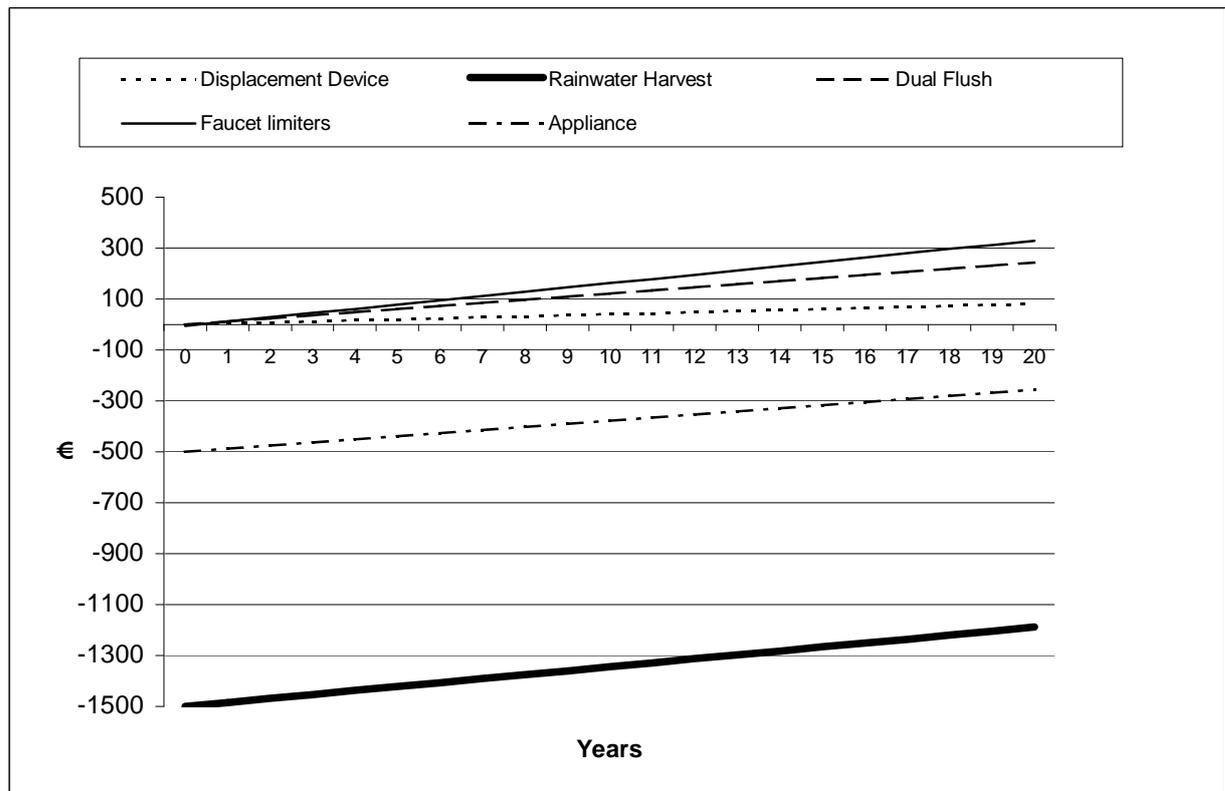
#### Payback Period.

The payback period for each measure was calculated based on potential reductions in water charges only. Two models were used, a Net Worth model, Grant (2002) and a CAPEXDCF model, Queally (2003). Table 24 summarises the payback period for each measure.

Water Conservation Measure	Net Worth Model	CAPEX DCF
Payback period in years		
1 WC Displacement device	< 1	<1
2 Dual Flush wc's (new house)	< 1	< 1
2 Dual Flush wc's (retro fit)	> 20	>20
3. Water efficient Appliances	> 20	> 20
4. Faucet flow limiters	< 2	< 1
5. Rainwater Harvesting	> 20	> 20

**Table 24. Payback period for each efficiency measure.**

The payback time to the consumer is less than two years for WC displacement devices, dual flush toilets and faucet flow limiters. Retrofitting dual flush toilets or installing rainwater harvesting technology are more expensive and have payback times in excess of 10 years. Fig 23 illustrates the comparison between payback periods for the conservation measures.



**Fig 23. Comparison of Payback periods based on Net Worth Calculations**

#### **Cost Savings to the Producer.**

Potential cost savings to the producer are difficult to accurately determine. However, it is likely that cost savings will be of the same order as those to the consumer, resulting from reduced water and wastewater treatment volumes.

#### **Water Conservation in Ireland.**

Significant reductions in PCC rates can be achieved by implementing a water conservation strategy. This would result in a sustainable water policy which would have financial and environmental benefits.

However, there are a number of barriers to the widespread acceptance of these conservation measures.

#### **Public Education.**

The general awareness of the effectiveness of simple conservation measures is not widespread among the general public.

#### **Lack of Design Standards**

The current lack of Irish standards for both rainwater harvesting and water efficient fittings is a barrier to the widespread adoption of water conservation methods by developers. This absence of design standards leads to widespread reluctance to use what is perceived as untested technology and equipment in new construction.

**Water Quality**

There are no Irish standards for the quality of water acceptable for non-potable domestic use.

**Domestic Water and Wastewater charges**

Water charges for domestic use in urban areas in Ireland were abolished on January 1<sup>st</sup> 1997. Current government policy requires local authorities to apply charges to the non domestic sector which reflect the capital and operational costs of supplying water and wastewater services. There are currently no domestic wastewater charges in Ireland. Therefore there are no financial paybacks to the consumer from the adoption of water saving devices.

To succeed, a water conservation policy will have to incorporate the following issues:

**Public Awareness Campaign.**

Education campaigns to raise public awareness about the need for conservation are critical to the success of a conservation program. This should include postal literature, television and radio advertisements, media coverage, demonstration projects, school curriculums, water audits for specific users and local workshops and training groups.

**Standards and Information on technologies and fittings.**

A standards committee should be set up to advise and inform professional bodies on best practice in the area of water conservation and the technologies and designs available.

**Incentives.**

The introduction of legislation to ensure all new developments incorporate water conservation technologies, should complement any water conservation program, Dublin Corporation, (2003). Legislation such as the Water Framework Directive will force member states to introduce consumer incentives to reduce water consumption.

**Sustainable Demand Management.**

Increasing water efficiency by reducing the amount of water required to accomplish a given task can significantly contribute towards balancing supply and demand. The production of new water by reducing the per capita demand and thereby mobilising new supply, is normally the least cost option, particularly when the environmental and social costs of developing new resources are included in the analysis.

**Conclusions.**

- Water conservation measures form an essential part of developing a sustainable water management policy.
- The PCC can be reduced by up to 44% by adopting water conservation measures.
- The reduction in PCC demand will have the effect of increasing the volume available for supply.
- Financial benefits can accrue to both consumers and providers by adopting water conservation measures.
- The absence of domestic water charges in Ireland means that there is no financial incentive to the consumer to introduce water conservation measures.

- A public awareness campaign to promote water conservation in Ireland is required.

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## **APPENDICES**

8. Implementation of the Rural Water Programme to December 2002.
9. Water Demand Per Capita Consumption Model
10. Survey of Non Domestic Water Charges in Ireland 2003
11. Survey of domestic water and wastewater charges in UK regions
12. CAPEX Financial Justification Model
13. CAPDCF Financial Justification Model

## **Appendix 1: Summary of the Implementation of the Rural Water Programme to December 2002. (ref report)**

### **Northern Region**

#### **Cavan**

In 2001, Cavan secured the highest per capita allocation towards capital works of any county and implementation of the Rural Water Programme progressed satisfactorily. A draft strategic plan was formally adopted in January and the final plan was agreed by September. Partnership between the statutory authorities and group water schemes proved a key factor in ensuring such rapid progress. The secondment of a Senior Executive Engineer to assist the work of the National Rural Water Monitoring Committee, was evidence of Cavan County Council's positive approach to tackling defective drinking water. Similar commitment was demonstrated by the County Monitoring Committee which met every two months to agree on a common strategy. The official opening of Cliffernagh treatment works in February 2001 and the commissioning of works at Dernakesh and Annagh provided practical examples of what could be achieved in a relatively short time. Several amalgamations, recommended in the strategic plan, were given the go-ahead by group schemes. These included an amalgamation between Vale GWS and Knockbride GWS (now Drumkeery GWS); Turfad GWS, Tullyunshin GWS and Tonyduff/Seeoran GWS (now Mountain Lodge GWS); Butlersbridge GWS and Redhills GWS (Annagh GWS). An amalgamation between Garty Lough GWS, Bruskey GWS and Killydoon GWS was also agreed, pending positive identification of a reliable water source. Towards the end of 2001, group schemes in west Cavan decided to form a 'bundle' for the purpose of upgrading treatment facilities for nine GWS. Groups in east Cavan were considering forming of a similar 'bundle', thereby ensuring that County Cavan as a whole would meet the target date for achieving a quality water standard.

#### **Donegal**

Donegal County Council has administered capital grants for group water schemes since the early 1970s. Since 1997, its policy has been to take over (with agreement) some 350 schemes over a five-year period. The pace of takeover has, however, been somewhat slower and at the end of 2001, there were 28 private and 274 part-private group schemes in the county serving more than fifty persons each. Approximately 6,500 people (some 5% of the overall population) obtain drinking water through group water schemes.

The draft strategic plan was agreed in September 2000 and the 2001 allocation towards capital works for group schemes totalled IR£2 million in 2001, while IR£500,000 was allocated for the takeover of schemes. Four of the larger private GWS were in the process of becoming part private. These include Meenacahan/Meentinadea GWS, Tullintain GWS, Carrowmeena GWS and Desertegney GWS.

#### **Louth**

Most group water schemes in the county have been taken over by the County Council and today some 4,000 people (approximately 9% of the rural population\*) are served through eighteen schemes, eleven private and four part-private. These include Killanny/Reaghstown GWS which is supplied from a lake in neighbouring County

Monaghan and is included under the strategic plan for that county. The 2001 allocation towards capital works in the GWS sector totalled IR£.52 million, with a further IR£100,000 allocated for takeover of schemes. At the end of 2001 plans were underway for the takeover of Jenkinstown GWS in the north of the county. A pilot scheme examining the use of Sanolin as a substitute for Chlorine was launched by Tullyallen GWS in 2000.

\*Excludes populations of Dundalk & Drogheda

### **Meath**

There are fifteen GWS in the county, only six of which serve more than fifty people. Of these, two (Meath Hill and Kiltale) are private GWS, while four (Ballinaclose, Kilskyre, Newcastle/Oldcastle and Ongenstown) are part-private. Group schemes provide water to 3,500 people in totle or 3% of the population. The county's allocation in 2001 totalled IR£.235 million for capital works on GWS, while IR£140,000 was set aside for the takeover of schemes. The draft strategic plan for the county was adopted in October 2000.

### **Monaghan**

The strategic plan, launched on 5 February 2001, included a recommendation that a 'bundle' be formed as a means of providing upgraded treatment works for the county's group water schemes and several smaller public schemes. Discussion around this recommendation dominated activity in the county throughout 2001, especially when Monaghan was chosen as a national pilot project in respect of 'bundling'. Following several information meetings throughout the autumn, on 20 November the recommendation received the go-ahead from GWS in the county. A formal launch of the project was held on 19 December when the Minister, Noel Dempsey, TD, described the Monaghan initiative as a 'fantastic example to the rest of the country', 'a huge step forward'. The contract was awarded to the Kilkenny-based firm Bowen/Vivendi Water. Four GWS opted not to participate in the 'bundle' which now includes seven GWS and three small public schemes. Almost 19,000 people (representing 36.5% of the population) receive their water supplies from thirteen GWS and the final rural water strategic plan in respect of these was adopted in September 2001.

## **Connacht Region**

### **Galway**

With a total of 662 group schemes, supplying some 51,600 people (39% of the population of the county), the GWS sector is very strong in Galway. Early difficulties in regard to the partnership arrangements for delivering the rural water programme were largely overcome in 2001 and there is an acceptance now that GWS must be party to any decisions made that might impact on their future. Upgrading took place at Clarren and Glinsk group water schemes. Preliminary work began in amalgamating four schemes in the vicinity of Tuam (Milltown, Milltown North East, Milltown, Belmont and Kilaphrasogue). Here, as in other parts of the county, efforts were directed towards the DBO route as the best means of upgrading facilities.

Plans were also laid for the launch of a national pilot scheme focusing on the Quality Assurance Scheme. Barnaderg GWS, Cahermorris/Glenreevagh GWS and Caherlistrane GWS agreed to participate in this critical pilot which would determine how private schemes might cope with implementing ongoing measures to ensure quality water.

**Leitrim**

The strategic rural water plan for Leitrim was adopted in June 2001 and preparations have been ongoing to upgrade the fifteen GWS throughout the county that serve more than 50 persons. Upgrading work commenced at six group schemes; Keelagh/Bornacoola GWS, Gortinty GWS, Cloonsarn GWS, Rossinver/Dooard GWs, Eden/Coragowna GWS and Cooladoonnel GWS. A further seven schemes were preparing to tender for upgrading works. A proposal that schemes with water quality problems connect to the North Leitrim Regional Supply was being considered. The capital works allocation to the county for the year was IR£1.3 million, with a further IR£175,000 set aside for takeover. GWS as a whole provide water to some 16,000 people or 64% of the population of Leitrim.

**Mayo**

There are more than 300 GWS in Mayo, 102 of which are private schemes serving more than 50 people. Almost 61,000 people, 54.5% of the population, receive water through the GWS sector. The final rural water strategic plan for the county was adopted in December 2001. With an allocation of IR£1.5 million for capital works, construction was completed on nineteen schemes in the county during 2001, with upgrading continuing on a further seven schemes. The completed GWS include Funshona/Cross, Ballykinava, Attawala/Lakeshore, Kiltane, Cornboy, Rosserk/Lecarrow, Derryquay, Barnagh/Lurgacloy, Gardenfield/Caher, Glencullen/Glenturk, Bohola Stage II, Killaturley Stage II, Cashel/Shanwar, Bollinglanna, Rathfran, Cloontakilla, Raheenbar Ext., Laveymore and Kilmore. A further IR£750,000 was allocated for takeover of group schemes by the local authority. The pilot membrane treatment plants located in Belderrig and Bohola began providing water in compliance with the drinking water regulations. The first leak detection and location course directed at group water schemes took place in November in the Regional Centre, Castlebar. There is a great demand for such training and further courses were planned for 2002.

**Roscommon**

Although there are 185 recorded GWS in the county, many of these are no longer functional, a situation that pertains to other counties also. There are, however, 33 private GWS in Roscommon serving more than fifty persons. These and a further 23 smaller private schemes provide water to almost 7,300 people in total. With a capital works allocation of IR£.4 million and IR£175,000 towards takeover of schemes, work continued on the Pollacat and Cavetown treatment works, with water being monitored for quality. Disinfection facilities were installed and are working on nineteen of the twenty-one schemes which formed part of a DBO bundle. These include the following GWS; Annaghmore/Corraslira, Ardkenagh, Ballinderry/Rathmore/Castleminne, Ballymacurley/Killultague, Carnalasson/Caggle, Carrowcrim/Holywell, Clooncullane/Clooncunny, Cloneygrasson, Clooneyquinn, Derrane/Coolteigue, Derrincartha/Cloonlumney, Derryphatten, Donamon, Grange lower, Grange/Four Mile House, Ogulla/Tulsk, Peake/Mantua, Rathcarren and Rathcroghan/Tulsk. Legal difficulties have held up work on the remaining two GWS, Carane/Ballintubber and Corristoona. Attention focused on the remaining larger group schemes throughout the county. Some were extended and upgraded, including work on distribution systems.

**Sligo**

With the adoption of the draft rural water strategic plan in August 2001, all fifteen private schemes serving more than fifty persons submitted plans to the county council in respect

of proposed treatment works. The annual allocation for capital works totalled IR£.8 million, while IR£190,000 was allocated for takeover. Ballinafad GWS was upgraded during the year, doubling its delivery capacity, while several schemes with deficient supplies were connected to the public mains. Seven new schemes were organised. Discussions took place between the GWS and the County Council with regard to the formation of a 'bundle' which would include twelve GWS. The group sector in Sligo supplies water to approximately 10,000 people, representing some 18% of the overall population of the county.

## **Midland Region**

### **Kildare**

There was an excellent attendance at an information meeting for group schemes in the county, held in Kilkea Castle on 2 October. In addition to Deirdre Byrne and Damien Woods, representing the Federation, there were speakers from Kildare County Council and the Eastern Regional Health authority. The County monitoring committee met in June and again in October when they approved the Draft Rural Water Strategic Plan for the county. Eleven schemes have been prioritised in the plan, amongst these the seven private GWS serving more than 50 persons. A total of 2,660 Kildare people receive water from the group water sector. With an allocation of IR£1.2 million for capital works in 2001, work continued on the treatment works and distribution network of Rathcoffey GWS, with 22 miles of piping being laid to serve 400 households. Rathcoffey GWS was scheduled for takeover in 2002.

### **Longford**

Major infrastructural works commenced in the upgrading of Moydow GWS, the largest private scheme in the county. The allocation for GWS capital works throughout the county totalled IR£.4 million. Work continued in relation to the Rural Water Strategic Plan, and information meetings co-hosted by the County Council and the Federation being well attended by representatives of local GWS.

### **Offaly**

There are some 17 GWS serving more than 50 people. With a capital allocation grant of IR£.89 in 2001, upgrading was completed at several GWS: Ballyclare, Clareen, Cloonfinlough and Knocknamase. In addition, several new schemes were planned, including one at Ballycommon (near Tullamore) and Rath (between Birr & Kilcorran).

### **Westmeath**

With only two GWS (Mount Temple and Multyfarnham) serving more than 50 people, the sector is weak in Westmeath. Nonetheless, a large part-private scheme was completed in the North of the county in 2001 and work was continuing on the rural water strategic plan. Westmeath had a IR£1.6 million allocation towards capital works, with a further IR£100,000 set aside for takeover of GWS.

## **Southeast Region**

### **Carlow**

Only IR£63,000 was allocated for capital works in the group water sector throughout the

county in 2001. There are 23 GWS in the county, nine of which are private schemes providing water to more than 50 people. The total population served by the group water sector in the county stands at just under 3,000.

### **Kilkenny**

After years of planning, tenders were received for the construction of a new GWS at Castlewarren and it was expected that work would begin in 2002. This scheme has been several years in planning. Upgrading work was completed on Tullaroan/Bawnmore GWS. There are more than 200 GWS in Kilkenny, with 22 private schemes serving more than 50 people. The First stage Rural Water Strategic Plan was adopted in July 2001 and the capital works allocation for the year was IR£.75 million, with a further IR£25,000 provided for takeover.

### **Laois**

The major news in Laois in the course of 2001 was the completion of work at two GWS, Errill and The Heath. Several part-private schemes were taken over by Laois County Council. The capital works allocation for the year was IR£.38 million, while IR£125,000 was set aside for takeover. Of the total of 78 GWS in the county, half are private schemes and of these, 14 schemes supply more than 50 people.

### **Wexford**

The Rural Water Strategic Plan, adopted by the County monitoring Committee in December 2000, was ratified by the County council in June 2001. With a capital works allocation of IR£.32 million and a further IR£75,000 set aside for takeover, work undertaken during the year included the establishment of several small part-private GWS. Planning underway in relation to the upgrading of several private GWS; Blackstairs, Temple Udigan and Kilernin. Wexford has an estimated total of 133 GWS, only nine of which are private schemes serving more than 50 people. Some 5,600 people receive their water supplies via the group water sector in the county.

### **Wicklow**

Just over 2,000 Wicklow people (representing 2% of the overall population of the county) are served by group water schemes. Six of these schemes provide water to more than 50 persons, and each of these received allocations towards capital works in 2001, as did a further four smaller schemes. The Department allocated IR£190,000 for capital works on group schemes in the county, with IR£8,000 set aside for takeover. The actual allocation by the County Council to 31 December 2001 was slightly in excess of €600,000, of which €450,000 was paid to six schemes, between them serving 179 households. These included Rosbawn/Tinahely, Barnasliggan/Enniskerry, Ballinagate/Carnew, Gormanstown/Cryhelp, Ballygannon/Kilcoole and Manor Kilbride. Meetings of the County Monitoring Committee were held in July and in September, when the draft rural water strategic plan was approved. This draft was somewhat unsatisfactory in terms of detail and it is expected that the final plan will address this shortcoming.

## **Southern Region**

**Clare**

Ir£2 million was allocated towards capital works in 2001, with a further IR£450,000 set aside for takeover of schemes by the County Council. Although there are more than 250 GWS in Clare, only 12 cater for more than 50 people. Work in the county in 2001 focused on securing the agreement of four group schemes to form a bundle for the purpose of securing tenders under DBO. Following initial agreement to the proposal in May, the October meeting of the Rural Water Monitoring Committee confirmed that four schemes – Kilmaley/Inagh, Dysart/Toonagh, Lissycasey and Killone — would progress as a bundle. Between them, these schemes serve more than 2,500 homes in the mid-Clare region.

**Cork**

County Cork is divided into three areas for the purposes of administration by the county council, each with its own Rural Water Monitoring Committee; these are Cork North, Cork South and Cork West. In total, there are some 300 GWS throughout the county, of which 40 serve more than 50 people each. With 16 private GWS serving more than 50 people, out of a total of 203 Cork North had a relatively low allocation in 2001, with capital works expenditure of just IR£.1 million and nothing at all towards takeover of schemes by the council. Three new private schemes were established in North Cork at Gragie, Coolagowan and Lisnabue. A further three part-private schemes were established in Carker, Omerrabue and Cuillawillin. A capital works allocation of IR£.4 million was secured by Cork South in 2001, with a further IR£500,000 made available for takeover of schemes. Several GWS completed upgrading in 2001, amongst these Cappagh (Kinsale), Kilmacsimon, Tulligmore and Lower Killeens. With only eight GWS serving more than 50 people, Cork West secured capital works funding totalling IR£.85 million.

**Kerry**

Some 60 group schemes availed of grants under the 2001 capital works allocation, which amounted to IR£.75 million. Two private GWS (Coolnagreagh & Kilmurray/Cordal) agreed to be taken over by the County Council as a means of addressing poor water quality. Three private schemes (Cappanalea, Dawros, Lyreanes) completed upgrading work.

Amongst the part-private schemes which began construction in 2001 was the ambitious Brosna/Knocknagoshel GWS, aiming to supply some 350 households. Although part-private, the initiative for this scheme came from within the community which pushed hard to make their dream a reality. The local contribution towards capital works was between IR£500-IR£600 per house, excellent value for money. Both the people of Brosna/Knocknagoshel and Kerry County Council deserve congratulations. The private GWS sector in Kerry is relatively small, with only 15 schemes serving more than 50 people. An overall total of 115 GWS (private and part private) provide water to nearly 13,000 people.

**Limerick**

Several new part private schemes were constructed in the county in 2001, drawing down a portion of the IR£.4 million allocation for capital works. The new schemes include those at Castlematrix, Glascurran, Honeypot, Ballinruane and Tankardstown, while a small private scheme was established at Shrove. Existing private schemes that drew down money from the allocation towards upgrading work included Borrhigone/Craggs, Meenoline, Athlacca, Ballyduff, Ballinamona,

Barna/Glendarragh, Kilfinny and Ballyshonick. With an allocation of IR£250,000 towards takeover, five small GWS were brought under the control of the County Council. These were: Breska, Corcamore, Trevoe, Newbridge/Cooltomin and Plouncagh. Some 25,000 people in County Limerick receive water from more than 300 GWS, 60 of which are private schemes serving more than 50 people.

### **Tipperary North**

About 40 group schemes drew down finance in the course of 2001. With a total allocation of IR£.9 million for capital works, several groups completed upgrades. These included Abbeyville, The Frolic, Fantane, Graniera, Cloneybrien No. 3, Tinvoher, Castlecranna and Rathsalla. Schemes involved in ongoing upgrading work include Ashill, Tonatha, Gurteenakilla, Graigue, Shevry and Bawn/Kilgriffith/Kilmore. There are an estimated total of 267 group water schemes (private and part private) in Tipperary North, supplying water to almost 12,000 people.

### **Waterford**

There are only four GWS in Waterford serving more than 50 people. The total population served by GWS in the county is 1,600. Capital works allocations in 2001 totalled IR£.35 million, while IR£50,000 was set aside for takeover of schemes by the County Council.

### **PILOT SCHEMES**

As previously reported, many of the pilot projects have been installed and are operational for the past few years. All the sites have been variously monitored during 2002 to a greater or lesser extent. However, it is the intention of the National Rural Water Monitoring Committee (NRWMC) to initiate a full formal monitoring programme on all of the pilot projects early in 2002, including a detailed sampling and analysis regime. After a period of approx 6-12 months, a full technical report will be prepared by the NRWMC on each pilot site.

Brief summary/history of various pilot projects:

#### **Roscommon**

"Bundle" of 20 approx schemes for disinfection: Most of the installations for this project had taken place by the end of 2001. Delays were encountered where there no proper access roads in place. Also where there was insufficient title to pump-house sites, etc. However, while some problems did persist and are still ongoing many others were successfully resolved. In the light of the most recent additional legislative instrument (S.I. 439/2000) and the proposed Water Services Bill, this particular pilot project may have to be revisited as 'disinfection' facilities alone may not provide a drinking water in compliance with the E.U. Drinking Water Directive. With the expected success of the DBO route to achieve compliance in this regard, a good case could now be made to extend the pilot process to include full treatment (filtration as appropriate). The federation will be pursuing this option during 2002.

Undersink/Wholehouse

Units:

Some 30 plus units have been installed by a number of suppliers to meet the drinking

and domestic requirements on householders across 3 small schemes. An interim report was prepared by Roscommon County Council for the steering group involved with this pilot project towards the end of 2001. It was envisaged that the steering group would meet early in 2002 to review available results and trends and set a deadline for the completion of the detailed monitoring which has been ongoing in a very efficient and professional manner by Roscommon Co. Co. for the past 12 months approx. A final report is expected before the end of 2002.

Pollacat Springs & Cavetown Lake  
Both of these pilots were full DBO projects. Planning and other issues, including tendering etc have all been largely successfully dealt with during 2001 and construction should commence at both sites in early 2002, with a completion target date set for mid 2002. The contractor selected for Cavetown Lake pilot is Fay Environmental Ltd., while the Pollacat Springs contract was awarded to Vivendi Water. Monitoring on both sites will commence as soon as successful commissioning of the treatment works have taken place.

Mayo

Belderrig:

The membrane technology used in the treatment process on this 60 house scheme appears to be operating very successfully, following some brief "teething" problems. The raw water source – mountain lake/stream – can often be problematic with sometimes high colour and turbidity. The plant will be the subject of a more detailed monitoring programme through the NRWMC in 2002 with a final report expected towards the end of the year.

Bohola

This group water scheme has a much higher daily demand throughput as it is serving the needs of upwards of 400 Houses plus farming requirements. The treatment process again incorporates membrane technology. Some serious initial problems were encountered – involving damage to the membrane bank from the backwashing process – but full replacement of membrane bank etc were put in place at the Contractors expense at all times. Towards the latter part of 2001, the pilot plant appeared to be operating very effectively and efficiently. Again, the NRWMC will arrange for a detailed monitoring programme on the plant for early 2002, with a final report expected towards the end of the year.

Monaghan

Lough

Emy

Pilot

Project:

This was one of the first pilot schemes initiated by the Federation back in late 1998/early 1999. Construction work began in the late spring of 1999 and all works, including the installation of the actual treatment facilities (Ozone/Carbon process) were completed early in 2002. The formal official opening ceremony was preformed by the Minister for the Environment and Local Government on 14th February 2000. This plant was tendered on a design/build (DB) basis as it predated the wider DBO concept. The local GWS, Glaslough/Tyholland are currently endeavouring to secure an appropriate and acceptable "O&M" contract for the next 10 to 20 years and have engaged specialist consultants in this area to assist them with the detailed requirements of such a contract. However, it is somewhat disappointing to report that despite the long period of time that has elapsed since the plant was officially opened, the Consultant Engineer employed by the group scheme has to-date been unable to produce a Certificate of Completion of the works. Such a Certificate is necessary before an "O&M" Contract is put in place.

Again, through the NRWMC, a detailed monitoring regime will be put in place early in 2002 and a full report is expected later in the year.

Monaghan DBO "Bundle" Pilot Project:  
The planning phase, including public tendering of the Monaghan DBO "Bundling" National Pilot Project was successfully completed during 2001. Five water utility consortia were shortlisted in early January 2001 and the more detailed tendering got underway after Easter. Some inevitable delay occurred due to the foot and mouth outbreak in February/March 2001. All aspects of the evolving pilot project were examined and discussed at several meetings of the Project Steering Group and also at the monthly County Monitoring Committee meetings. The final closing date for receipt of tenders in Monaghan County Council was fixed as 25th September 2001. Four completed tenders were received and opened in the County Council offices on the evening of the 25th September 2001. After the standard recording procedures, the tender documents were handed over to T. J. O'Connor & Associates, the Clients Representatives for the project. Steering group meetings were held on 28th September 2001 and 30th October 2001. Details of the emerging winning bid were disclosed at the latter meeting. Arrangements were then made to meet with the eleven group schemes on 6th, 13th and 20th November 2001 to inform them of the outcome of the tendering process. At the meeting on 20th November 2001, seven group schemes agreed to participate in the "Bundle" contract along with 3 smaller local authority schemes. Four of the eleven group schemes decided against joining the "bundle".

Monaghan County Council Management then endorsed the "10 scheme bundle" contract and submitted all documentation, including the Report on Tenders, to the DOELG at the end of November 2001. The DOELG, following detailed technical and economic evaluation, gave its approval in mid December 2001. Full Ministerial approval followed swiftly with the formal launch of the project by Minister Noel Dempsey T.D. at a ceremony in the Nuremore Hotel, Carrickmacross on 19th December 2001. Construction work on the project is due to get underway in the summer 2002.

The NFGWS would like to record its thanks and appreciation to all concerned with this unique and exciting National Pilot Project. In particular, we would like to thank the senior officials in the DOELG and Monaghan Co. Co., whose expertise and support was of vital importance in bringing the Pilot Project to full fruition. Finally, a special mention must be given to the seven group scheme management committees which, having given very careful consideration to all issues and aspects arising from the pilot, decided to participate in the project. This management decision will have far reaching consequences not only for their own schemes but for all schemes around the country. As a direct result of the success of the Monaghan DBO "Bundle" Project, the "bundle" approach to solving quality deficient supplies on group schemes has now been adopted as official policy of the NRWMC and the DOELG. The "bundle" concept is now being replicated in many counties and concrete proposals in this regard are expected to emerge in these counties during 2002. For the record, the seven group schemes which decided to participate in and facilitate the pilot project are as follows:-

Churchill/Oram,  
Doohamlet,  
Stranooden,  
Truagh.

Farmoyle/Baraghy,  
Drumgole,  
Tydavnet

## **APPENDIX 7**

### **Site Visits:**

**University of Wales, Bristol.  
Green Shop, UK.  
Centre for Alternative Technology, Wales.**