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Addressing environmental inequalities: water quality

Science report SC020061/SR2

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Executive Summary

Addressing environmental inequalities is a key theme of the UK Sustainable Development Strategy and one of the three principles of the Environment Agency's social policy. Understanding more about the inequalities that may arise in relation to water quality, specifically river water quality and the river environment in general, is highly relevant to the Environment Agency's evolving social policy.

Aims of the Project

- To help the Environment Agency understand the social impacts of water quality and the policy context for addressing these impacts.
- To examine how good and poor river water quality is distributed in relation to patterns of social deprivation in England.
- To make recommendations for the most effective ways of addressing inequalities in relation to water quality.

Methodology

The researchers undertook a literature review on the social impacts of water quality and policy measures relevant to water quality and environmental inequalities. The deprivation characteristics of populations living near to good and poor quality river stretches in England and the English regions were examined using a GIS-based data analysis of biological river water quality.

Social Impacts of Water Quality and their Social Differentiation

There is little literature focusing on environmental justice and water quality (broadly defined). The research that does exist emphasises that it is extremely difficult to establish clear and direct causal relationships between deprivation and poor water quality. Much of the literature presents anecdotal or postulated links, rather than evidence of causal relationships verified by data analysis.

Whilst it is evident that equity concerns are relevant to different forms of water quality (drinking, bathing water and river water), for the purposes of this report detailed review and analysis work has focused on river water quality and the quality of the river environment.

Despite the lack of specific literature, enough research work exists to allow the potential social impacts of proximity to poor water quality to be reviewed. These impacts relate to: the health effects of coming into contact with contaminated river water; the economic impacts associated with poor river water quality (and conversely the economic *benefits* in areas where water quality is good); aesthetic and nuisance impacts; and the positive benefits associated with recreational use of the river environment.

In terms of the social differentiation of these impacts, there is little clear evidence available. Only in terms of the use made of 'natural environments' and green spaces is there a body of research which shows that despite natural places having a high level of attraction for all age groups and ethnic groups, levels of use vary from site to site. While some age groups and social groups are well represented, others are not.

This is particularly significant from an equity point of view. It is increasingly recognised that those who live in deprived areas, or who form part of deprived social groups, are simultaneously more in *need* of the recreational and well-being benefits that may come from their proximity to water resources and less likely to be able to take *advantage* of those benefits.

River Water Quality and Deprivation: Data Analysis

Analysis of deprivation and water quality was undertaken using a methodology that improves upon previous studies in terms of the resolution of population data and the quality of the river stretch map. Even so, methodological limitations are still significant and need to be taken into account in interpreting the results. These limitations include the lack of differentiation between sizes of river and between accessible and inaccessible river stretches and the use of a single distance of 600m for analysing the deprivation characteristics of populations living in proximity to rivers.

For England as a whole, the research identified a clear pattern of inequality in people's proximity to rivers with good and bad biological water quality. For those people living within 600m of a river, the researchers found that the more deprived you are the more likely you are to be living near to a poor rather than a good quality river. Conversely the less deprived you are the more likely you are to be living near to a good quality river. The pattern of distribution against deprivation is clear and consistent. Poor and bad quality river stretches have, in proportional terms, far more people living near to them than better quality river stretches and they tend to run largely through deprived areas. Although the length of rivers in England classified as bad or poor is now very small, in population proximity terms these rivers are significant because they run through heavily populated areas, which are also some of the most deprived in the country. This concurs with the broad findings of previous studies.

Analysis of the quality of rivers in relation to deprived populations within each English region showed that these overall national patterns are fairly consistently maintained across the regions, with deprived populations more likely to be living near to poorer quality rivers and the converse for those least deprived. However, the locations where poor quality rivers and substantial deprived populations coincide are concentrated in three regions – the North West, Yorkshire and Humberside, and London.

Policy Implications and Recommendations

Concerns about environmental inequality have not, as yet, featured significantly in policy for the management of river water quality. However, the Water Framework Directive is beginning to promote a more integrated river basin approach, which seeks to address environmental, economic and social issues within a sustainability framework.

The data analysis found a clear pattern of inequality in the physical association between poor river water quality and deprivation for England as a whole. However, this does not necessarily mean that this association is significant either for the management of water quality or to the lives of deprived people living near to poor quality rivers.

Given that the social impacts of river water quality are multidimensional and complex, and that river management also has to take account of multiple considerations and drivers – some of which are ecological and economic rather than social in nature, careful evaluation of the policy implications of evidence of inequality has to take place.

Policies that target protection and improvement for the worst quality rivers may already be benefiting deprived communities. However, it is also possible that decision-making and appraisal processes are not taking social concerns sufficiently into account.

This project makes the following recommendations.

- The multidimensional social impacts of a poor river environment and the relationship of these impacts to issues of inequality need to be further considered and evaluated.
- The policy significance of the evidence of an association between poor biological river water quality and deprivation needs to be carefully evaluated.
- Further work should be undertaken to explore the factors that may explain the association between poor river water quality and deprivation, including the role of decision-making processes in river management.
- The case for further targeting of policy interventions on poor quality rivers in deprived areas and the form that this could take needs to be examined.
- The management of river water quality needs to be pursued in a manner that provides realistic and 'joined-up' solutions, in which key partnerships between a range of stakeholders, including members of the public, can be successfully achieved.
- Further research is needed: to improve our understanding of the social impacts of water quality; to explore inequalities in relation to drinking and bathing water quality; to develop more sophisticated methodologies for analysing patterns of inequality in relation to river water quality; and to analyse changing patterns of water quality over time.

Contents

1 Introduction

This is one of five reports produced as part of a research project commissioned by the Environment Agency. In addition to water quality, this project has examined environmental inequalities in relation to flood risk, waste management in England and Wales, and cumulative impacts. There is therefore a general context for the project, which is outlined in this chapter, in addition to particular aspects of the policy and research context for environmental inequalities and water quality, which are discussed in later sections. The general objectives for the project are also detailed in this section, in addition to those relating specifically to the research work described in this report.

1.1 Context for the Project

The Environment Agency has a wide-ranging role to protect and improve the environment in the context of achieving sustainable development. It is developing a strong social dimension to its work, recognising that social exclusion can have important environmental dimensions and that all people should have a right of access to a decent environment and to essential environmental resources. The Environment Agency's social policy is defined through three principles.

- Understanding and communicating the social impacts of its work, including opportunities to deliver combined environmental and social benefits.
- Addressing environmental inequalities.
- Transparency, participation and access to information.

It has also developed a social appraisal framework (Warburton *et al* 2005), which subdivides the Environment Agency's social policy into six themes.

- Promoting health, safety and well being.
- Improving local communities.
- Promoting social justice and social inclusion.
- Demonstrating the Environment Agency's corporate social responsibility.
- Increasing access to information and participation.
- Capacity building and learning.

This project focuses on addressing environmental inequality, which is one of the three social policy principles and is most important in promoting the 'social justice and social inclusion' theme of the appraisal framework. In a recent position statement, the Environment Agency makes it clear that tackling environmental inequalities and ensuring access for all people to a good quality environment is critical to sustainable development (Environment Agency 2004). A position statement lays out the Environment Agency's role and calls for a series of policy solutions, which include '*developing a better understanding of environmental inequalities and the most effective ways of addressing them*'. It builds on a programme of sustained attention given to questions of environmental inequality and social justice within the Environment Agency over the past five years, working with and responding to the allied agendas of other organisations within and outside of government.

Below are some examples of the ways in which the wider political and policy context has evolved over this period.

- NGOs such as Friends of the Earth (FoE) have identified environmental justice as a campaign and research theme, with FoE Scotland in particular making environmental justice a key part of their advocacy work (Dunion 2003).

- A series of pamphlets and publications produced by NGOs, consultancies and political groups highlighted the links between the current Labour government's priorities on social exclusion and the social dimensions of environmental concerns (e.g. Jacobs 1999; Boardman *et al*. 1999; Foley 2004).

- Speeches by key political figures such as: Jack McConnell, Scotland's First Minister, who stated in 2002: 'For quality of life, closing the gap demands environmental justice too. That is why I said…that environment and social justice would be the themes driving our policies and priorities...' (McConnell 2002); and Tony Blair who argued in 2003 that 'by raising the standards of our local environments overall, we have the greatest impact on the poorest areas' (Blair 2003).

- Government departments and agencies have been exploring the connections between economic, social and environmental policy areas. For example: the Social Exclusion Unit's work on transport and social exclusion (Social Exclusion Unit 2003); the Sustainable Development Commission (2002) focusing on the connections between regeneration, poverty and environment; the Neighbourhood Renewal Unit reports on *Environmental exclusion* (Brook Lyndhurst 2004) and *Delivering environmental equity through neighbourhood renewal* (ODPM/NRU 2003).

- The 1998 Aarhus convention (UNECE 1999), which is a pan-European treaty that aims to give substantive rights to all European Union (EU) citizens on public access to environmental information, public participation in environmental decision-making and access to justice in environmental matters.

- The new National Sustainable Development Strategy *Securing the future* (Defra 2005) aims to 'ensure a decent environment for all' has clear commitments to address and research environmental inequalities and to 'fairness' in the development of sustainable communities.

Within the Environment Agency, key indicators of policy evolution have included the 2000 AGM debate on environmental equality and the *Urban Environment* report (Environment Agency 2002b), which provided some initial analysis of relationships between environmental quality and social deprivation. A research project undertaken by the universities of Staffordshire and Leeds for the Environment Agency (Walker *et al*. 2003a; 2003b) also explored evidence of inequalities and acted as a stimulus for debate (Chalmers and Colvin 2005) in three key areas of the Environment Agency's work – flooding, industrial pollution and air quality.

The research provided a literature review, scoping and gap analysis of potential topics for investigation, drawing on the expertise of a range of stakeholders. It provided an empirical analysis of environmental data sets against the Index of Multiple Deprivation at ward level (separately for England and Wales) and identified varied patterns of inequality. In developing policy and research recommendations for this work, the research team emphasised the need for careful consideration of methodological issues, the limits on what the analysis could reasonably conclude and the need for further research, including in the area of cumulative impacts.

There is now a growing body of related UK-based research examining questions of social distribution and environmental inequality. This has recently been reviewed in a Sustainable

Development Research Network (SDRN) rapid research and evidence review for the Department for Environment, Food and Rural Affairs (Defra) (Lucas *et al*. 2004). This review found that the research base is interdisciplinary in nature, drawing on a diverse range of quantitative and qualitative research methods and approaches. The available evidence suggests that patterns of environmental injustice are varied and complex, and that there is a need for some caution in making claims of inequality and to be wary of over-generalisation. However, there is mounting evidence that:

- Environmental injustice is a real and substantive problem within the UK
- Problems of environmental injustice afflict many of our most deprived communities and socially excluded groups
- Both poor quality local environments and differential access to environmental goods and services have a detrimental effect on the quality of life experienced by members of those communities and groups
- In some cases, not only are deprived and excluded communities disproportionately exposed to an environmental risk, they are also disproportionately vulnerable to its effects
- Whilst more needs to be known about both the causes and impacts of environmental injustice, research is also needed to support the development and effective implementation of policy measures to address and ameliorate the impacts of environmental injustice.

This project will add to the research and evidence base that already exists in key areas of responsibility for the Environment Agency. It will build directly on the previously commissioned research and contribute to the commitment to further research made in the National Sustainable Development Strategy.

1.2 Overall Objectives of the Project

The overall objective of the project is to gain a better understanding of environmental inequalities and the most effective ways of addressing them. The project is divided into two discrete parts.

Part 1 will:

- help the Environment Agency to understand the social impacts of waste management, flooding and water quality on deprived communities, and the policy context for addressing these;
- examine the social distribution of waste sites, areas at risk from flooding and river water quality, by conducting analyses for both England as a whole and for each of the English regions;
- make recommendations for the most effective ways to address inequalities in relation to waste management, flooding and water quality (for example, by identifying the policy interventions designed to address them with a range of stakeholders and evaluating their relative costs and benefits).

Part 2 will:

- help the Environment Agency to develop an initial understanding of the cumulative impacts of environmental issues on deprived communities;
- identify ways of assessing the cumulative impacts of environmental inequalities and compare their effectiveness;
- develop and propose an approach for conducting local case studies that will lead to an understanding of cumulative environmental inequalities and ways to address them.

1.3 Context and Objectives of Water Quality Component

This report focuses on water quality and is one dimension of Part 1 of the overall research project. The regulation of water quality and its monitoring and assessment is a key part of the Environment Agency's remit and operational function in England and Wales. Understanding more about the inequalities that may arise in water quality (specifically river water quality and the river environment in general) is highly relevant to the Environment Agency's evolving social policy.

As discussed in Section 6, water quality policy has undergone significant changes in recent years and will continue to do so. A key legislative driver will be the EU Water Framework Directive (2000/60/EC) and its requirements regarding the ecological status of water bodies for each European member state. The Water Framework Directive (WFD) has significant implications for water quality management in the UK and specifies the importance of managing river catchments as integrated wholes. This is to be achieved, in the first instance, through river basin characterisation. These changes are having, and will continue to have, significant implications for social impacts (both implicitly and explicitly), as well as for the extent to which these impacts are considered within the water quality management framework.

The specific objectives of the water quality element of the research project are to understand the relationship between water quality and deprived communities. These objectives are detailed below.

- Draw on current knowledge and research in order to understand the social impacts of river water quality and the river environment more generally on deprived communities, and the policy context for addressing these;
- Examine the social distribution of the good and poor river water quality in England and the potential impacts on deprived communities;
- Make recommendations for the most effective ways of addressing inequalities in relation to water quality, by identifying the policy interventions designed to address them with a range of stakeholders and evaluating their relative costs and benefits.
-

1.4 Summary of Methods

Three research methods have been applied to produce different types of evidence and quantitative and qualitative data.

A review of the academic and policy literature focused on the social impacts of water quality, and the existing and possible future policy measures that are relevant to shaping and addressing environmental inequalities. Evidence from the literature has been used throughout this report, and gaps are highlighted. In particular, conceptual and methodological issues regarding the investigation of potential environmental inequalities around water quality are discussed.

A two-day stakeholder workshop was held in February 2005 to examine issues of environmental inequalities[1], with participants including:

- the project team
- the Environment Agency policy and Regional Strategic Units
- the Department for the Environment, Food and Rural Affairs (Defra)
- the Welsh Assembly Government (WAG)
- Friends of the Earth
- Black Environment Network (BEN)
- OFWAT
- Local authorities in London

The workshop took place at an early stage in the project in order to shape and inform subsequent work, before the empirical data analysis had been carried out (see below). The participants did not therefore have an opportunity to review or respond to the empirical results. The workshop was particularly important in informing the work reported in section 4 on how social impacts could be conceptualised and assessed.
Data analysis. A GIS (Geographical Information Systems)-based analysis was undertaken using Environment Agency data on the biological quality of river stretches and the deprivation characteristics of populations living within 600m of these river stretches was examined. The analysis was undertaken for England as a whole and then separately for each of the English standard Government Office regions. A detailed discussion of the methodology used in this data analysis is provided in section 5.2.

[1] The workshop was facilitated and documented by Malcolm Eames of the Policy Studies Institute and Karen Lucas of the University of Westminster.

2 Definitions and concepts

This section defines ad discuses a number of terms and concepts that are central to the research. It is particularly important to be explicit about meanings and to distinguish between different but related concepts in an area of policy and research that is relatively new and undeveloped.

2.1 Environmental justice

Environmental justice is a term that, like many others, is open to varying definition and interpretation. It has been described by Agyeman *et al.* (2003) as a 'vocabulary for political opportunity', providing a means of highlighting questions of distribution and procedural fairness across a wide range of environmental policy domains (Stephens *et al*. 2001; Lucas *et al*. 2004). It has evolved over a 20-year period, originating in protests against the siting of toxic facilities in minority communities in the US and becoming part of the 'vocabulary' of environmental debate in the UK only during the past four or five years.

Environmental justice is generally defined in normative terms, specifying a set of conditions or expectations that should be aspired to, sought after or demanded. Two definitions provide examples.

The US Environment Protection Agency (USEPA 1998) defines environmental justice as:

> *'…the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including a racial, ethnic, or a socioeconomic group, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies. Meaningful involvement means that: (1) potentially affected community residents have an appropriate opportunity to participate in decisions about a proposed activity that will affect their environment and/or health; (2) the public's contribution can influence the regulatory agency's decision; (3) the concerns of all participants involved will be considered in the decision making process; and (4) the decision makers seek out and facilitate the involvement of those potentially affected.''*

The Scottish Executive (2005) defines environmental justice through two statements.

> '*The first is that deprived communities, which may be more vulnerable to the pressures of poor environmental conditions, should not bear a disproportionate burden of negative environmental impacts.*
>
> *The second is that all communities should have access to the information and to the means to participate in decisions which affect the quality of their local environment*.'

Environmental justice has also been conceived in terms of rights and responsibilities. For example Stephens *et al* (2001) identify two key assertions of environmental justice:

'that everyone should have the right and be able to live in a healthy environment, with access to enough environmental resources for a healthy life'

'that responsibilities are on this current generation to ensure a healthy environment exists for future generations, and on countries, organisations and individuals in this generation to ensure that development does not create environmental problems or distribute environmental resources in ways which damage other peoples health'.

A number of different elements or interrelated component parts of environmental justice can be identified from the range of definitions that exist:

- **Distributive justice** is concerned with how environmental goods (such as access to green space) and environmental bads (such as pollution and risk) are distributed amongst different groups and the fairness or equity of this distribution (see further discussion below).

- **Procedural justice** is concerned with the fairness or equity of access to environmental decision-making processes and to rights and recourse in environmental law.

- **Policy justice** is concerned with the principles and outcomes of environmental policy decisions and how these have impacts on different social groups.

- **Intranational justice** is concerned with how these distributions and processes are experienced and operate within a country, whilst

- **international justice** extends the breadth of concerns to include international and global issues, such as climate change.

- **Intergenerational justice** encompasses issues of fairness and responsibility between generations, such as emerge in debates over the protection of biodiversity. Such concerns are particularly important in relation to waste management policy, as the impacts of waste management facilities such as landfills may last for hundreds of years.

Whilst some people may recognise all of these component parts within their working definition or framing of environmental justice, others may take a more restricted or focused view. For example, much of the US literature on environmental justice has been concerned primarily with intranational distributive justice, whilst a recently formed non-governmental organisation 'Coalition for Environmental Justice' (2005) in the UK is focusing primarily on issues of procedural justice. There are also differences in the extent to which environmental justice is seen as only encompassing core environmental issues or extends, within a broader sustainability perspective, to include quality of life and social issues that have environmental dimensions to them (such as fuel poverty or access to transport).

In this project there is a focus on three core environmental topics (waste, water quality and flooding), but within the work on cumulative environmental impacts the case for taking a broader perspective is also considered. Whilst we are primarily examining questions of intranational distribution within the review on social impacts and the data analysis, questions of procedure are also raised at various points in each of the reports and connections with wider international issues are identified.

2.2 Environmental inequality

Environmental inequality, which is the key term used in this project, is a step back from, or sub-component of, environmental justice.

Inequality is a descriptive term. To observe or claim an environmental inequality is to point out that an aspect of the environment is distributed unevenly amongst different social groups (differentiated by social class, ethnicity, gender, age, location). There can be different degrees of inequality depending on how skewed an environmental parameter is towards or away from the social groups of concern. This inequality can encompass:

- negative aspects of the environment, such as exposure to pollution;
- positive aspects, such as access to green space; or
- procedural aspects, such as access to information or decision-making processes.

Inequality is different to an injustice or inequity. It does not necessarily follow that because the distribution of an environmental good or bad is unequal it is also unjust or inequitable. An evaluation or judgement has to be made to progress from inequality to injustice, and, as theories of justice make clear, substantially different perspectives can be taken (Young 1994, Liu 2001). Factors that may be relevant in considering the case for an environmental injustice are detailed below.

- The degree of inequality that exists.
- The degree to which individuals have been able to exercise choice in their exposure to an environmental good or bad.
- Whether or not an inequality has been created through the exercising of power by a public or private body (such as in taking facility siting or flood protection decisions).
- Whether or not a pattern of inequality is combined with other patterns of inequality (an accumulation of unequal impacts), or with a greater degree of vulnerability or need amongst a social group, when compared to others.
- The degree to which those exposed to an impact or risk also have a role (direct or indirect) in, or benefit from, its creation.

2.3 Social Impact

This project uses the term 'social impact' to consider the nature of the relationship between particular aspects of the environment and associated environmental management activities, and the impacts these have on humans.

Current definitions of social impact suggest that the concept should be understood in the broadest terms. For example, the International Association for Impact Assessment take the term to cover:

> '*all impacts on humans and on all the ways in which people and communities interact with their socio-cultural, economic and biophysical surroundings*' (IAIA Social Impact Assessment: International Principles 2003, p.2).

US guidelines for Social Impact Assessment provide a similarly broad definition:

> '*By social impacts we mean the consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another,*

organise to meet their needs and generally cope as members of society. The term also includes cultural impacts involving changes to the norms, values and beliefs that guide and rationalize their cognition of themselves and their society' (The Inter-organisational Committee on Principles and Guidelines for Social Impact Assessment 2003, p.231).

These definitions highlight the need to go beyond narrow understandings of social impacts as measurable effects upon individuals. Data about social impacts may not be available in a quantifiable form (for example information about changes to patterns of social interaction or culture) and consideration should be given to effects upon households and communities as well as individuals. Social impacts may also be direct or indirect, immediate or long term and both positive and negative in character.

The Environment Agency has a policy appraisal framework that adopts a broad view of the types of social impacts that need to be included in policy appraisal, and we have taken a similar approach in this report.

3 Environmental justice and water quality: review of literature

3.1 Introduction

This section provides the context for water quality and social impacts research by outlining a brief overview of the environmental justice literature in relation to water quality. It is clear from this overview of the literature that, of the four environmental topics included in this overall project, water quality is perhaps the most challenging to analyse in relation to social deprivation, since the existing literature base is extremely small and narrow in scope. The literature review discusses these issues, outlines some key parameters of the study in relation to water quality, and justifies the focus on river water quality that is adopted for the rest of the report. It then presents some of the existing research relating to deprivation and river water quality.

Section 4 considers the nature of the potential social impacts of proximity to poor river water quality. These include both positive and negative impacts, as the relationship between the ecological status of water bodies and people clearly has a number of dimensions, some of which are more significant than others. These issues will be discussed and a matrix detailing the potential impacts will be presented.

3.2 The parameters of the study

The concept of ‘water quality’, as outlined in the research literature, is potentially extremely broad and encompasses bathing water quality, drinking water quality, and river (and canal) water quality. All three of these water quality types will be briefly reviewed here before focusing on river water quality for a more detailed discussion.

3.2.1 Bathing water quality

The relationship between bathing water quality and health risk has been the subject of scientific and political debate since the 1950s. Legislation has been developed and enforced on an EU-wide basis to reduce the possible health risks from bathing and to improve aesthetically the marine environment. The Bathing Water Directive (BWD), which was drawn up in 1975, sets standards for compliance, and lists 19 physical, chemical, microbiological and aesthetic parameters that are measured regularly throughout the summer bathing season at set sampling locations for each designated bathing water. Compliance with the Directive is judged according to a two-fold classification: the Mandatory (or Imperative) Standards, which all waters should achieve; and the more stringent Guideline Standards, which are meant to denote excellent quality water and with which all waters must strive to comply.

There is much existing scientific research proposing a causal link between bathing in sewage-contaminated bathing waters and contracting diseases ranging from stomach upsets to enteric fever and hepatitis (for instance Cabelli *et al.* 1982, Kay 1998, Kay *et al*. 1994, Marino 1995, Rees 1998; see also later discussion in section 4.1.1). Defra (2002) estimated that around 1.3 million cases of stomach upset every year in England and Wales could be associated with bathing in faecally-contaminated bathing water. A second calculation, based on respondents' personal assessment of cases of stomach upset, found that the number of cases could be upwards of 2.2 million.

Even where bathing waters are compliant with European standards, research has shown that there is a potential health risk to those bathing or coming into contact with the water. Fleisher *et al*. (1998) undertook an epidemiological study at four different UK bathing waters, which were judged to be of acceptable quality under EU criteria between 1989 and 1992. Results showed that bathers are at an increased risk of gastro-enteritis, acute febrile respiratory illness, and ear and eye infections compared to non-bathers.

However, key methodological problems arise when attempting to link social deprivation to bathing water quality. It can be argued (as in Walker *et al*. 2003b) that the people who use bathing waters in the UK are likely to be predominantly visitors and tourists rather than the residential populations living in the immediate vicinity of the bathing water. Although the latter might be the most frequent and regular users of a particular stretch of coastline). An analysis of who is likely to be affected by poor bathing water quality would therefore need to examine the social deprivation profiles of all users, rather than only that of the population living in vicinity of the bathing water. An analysis that simply focused on the latter population would be at best tenuous and at worst completely spurious. As user data is not available on a reliable basis, no attempt has been made in this project to analyse the deprivation profiles of those most affected by poor bathing water quality. However, this is identified in section 7 as a recommended area for further work.

3.2.2 Drinking water quality

Much research has been undertaken in recent years to evaluate the links between poor drinking water quality and human health.There are several examples of empirical studies that investigate drinking water quality and its links to measures of socio-economic status.

Studies from the UK (as cited in Walker *et al.* 2003a) include investigations of links between: magnesium and acute myocardial infarction in north-west England (Maheswaran *et. al*. 1999); childhood diabetes and nitrates in Yorkshire (Parslow *et al.* 1997); and congenital birth defects and lead in Lancashire (Bound *et al*. 1997). Bound *et* al. found that houses in wards with ten parts per litre or more of lead in the water were more likely to have children born with neural tube defects. The link between low socio-economic status and incidence of dental caries is widely reported in the literature, and was demonstrated for seven health authority districts in the UK by Riley *et al*. (1999). The authors found that dental caries in five year olds increased in line with the deprivation score of the ward in which they lived.

Almost all water supplies in England and Wales (over 99 per cent) are provided by water companies, and are regulated by the Drinking Water Inspectorate (DWI). Even those properties that gain their water from private supplies, such as wells, are subject to regulation by the DWI. Outbreaks of Cryptosporidium, a parasite that causes severe diarrhoeal illness, is a potential health risk associated with drinking water. However, since 1999, when regulations were introduced that required the monitoring of supplies, there have been no known outbreaks associated with the public water supply in England and Wales (Environment Agency 2002a). A report by Defra in 2000 confirmed that 99.75 per cent of drinking water tests carried out in 1999 complied with the national standards, which are set at, or in some cases are more stringent than, the present European Union (EU) standards.

Although it is a relevant concern for environmental justice, drinking water quality will not be discussed further in this research report as it is not directly within the remit of the Environment Agency.

3.2.3 The river environment

As bathing and drinking water quality have been excluded from this project, water quality can be defined according to the parameters measured by the Environment Agency for the chemical, biological and aesthetic qualities of rivers (and canals) and their broader perceived quality in terms of the 'river environment' as a whole. Focusing on the 'river environment' will allow this analysis to take into account issues relating to water quality in the wider sense of green space and the whole river corridor, as much research has found that contact with nature and pleasant environments can have a calming effect and help reduce stress levels (Environment Agency 2002b).

The existing literature base of studies exploring the links between water quality and deprivation is extremely narrow, and much of the evidence is anecdotal. It is difficult to identify the positive and negative social impacts of water quality. This is because poor water quality does not pose a specific threat to those populations living in the vicinity in the same way that residents may be affected by living in close proximity to waste facilities or areas subject to flood risk.

It may be argued that the links between water quality and deprivation can be evaluated not only in the sense of the 'presence of a *bad*' in a neighbourhood and the effects that derive from it, such as litter and graffiti in the river corridor making it an unattractive resource to use. But also the 'absence of a *good*', such as the absence of benefits that would otherwise be there to be enjoyed by those living nearby if the water quality was better. It has long been recognised that rivers are a significant potential environmental resource that people should be able to take advantage of in the same way as forests, parks and other areas of green space.

Due to these complex issues, and the difficulty of assigning clear cause and effect to any relationships observed, most investment in improving water quality in recent years has not specifically targeted deprived areas, particularly as in many cases, cleaning up river stretches depends on other actions. For example, where poor water quality has been caused by runoff or seepage from industrial contaminants (as is the case in many urban areas with a history of heavy industry), cleaning up the watercourse alone will not remove the root cause of contamination. There are often complex policy and legislative implications for this kind of restoration or enhancement work. Nor has much attempt been made to consider what the key social impacts of the presence of poor water quality (and by implication the absence of *good* water quality) might be. This research project clearly has an important role to play in advancing this agenda.

3.3 The environmental justice literature and water quality

In recent years, there has been a large amount of research conducted both by academics and Government into the significance and benefits of access to green space and high quality environments. Many of the conclusions drawn from such research can be applied to the river environment, since high quality river environments (sometimes referred to as ‘blue spaces’), in both urban and rural areas, are important resources for recreation and amenity. The research and policy literatures on green space and woodlands could be usefully considered by those policy-makers working on issues of water quality.

The Urban Green Spaces Task Force (UGSTF), which was set up in October 1998 significantly advanced this agenda. It’s research suggests that green space can contribute significantly to social inclusion because: it is free and access is available to all; it provides a neutral ground for all sectors of society; and it can provide opportunities for social interaction (UGSTF 1999). The report *Green spaces, better places* suggests that parks and green spaces can help to promote healthy living and prevent illness by providing places for physical activities. Exercise has been shown to reduce anxiety and enhance recovery from psychosocial stressors. It can therefore be argued that those who live near to high quality environments can benefit significantly from these positive impacts.

As an element of such high quality green space environments, research has shown that rivers can be the richest and most beneficial of all sites (Gilbert 1989) and can contribute immensely to well-being. However, Williams and Green (2001) argue that there appears to be a relationship between levels of deprivation in an area and the condition of the surrounding environment, with empirical research showing that river environments in deprived areas are of poorer quality than those in more affluent areas. Therefore, if those living in deprived areas are less likely to enjoy high quality environments, they will miss out on the advantages that such environments can confer on those in more affluent areas.

On a more positive note, there is evidence that improving and upgrading local environments has a significant impact on the use of public space. Swanwick *et al’s* (2001) literature review found that there are economic, social and environmental benefits of green spaces and river environments.

1) **Economic**: attraction of inward investment, business retention, creation of employment opportunities, support for tourism, and increases in value and marketability of residential and commercial property;

2) **Social**: contact with nature, opportunities for exercise, involvement in social, cultural and community activities. All of these are beneficial to people’s physical and mental health and encourage social interaction and educational opportunities;

3) **Environmental**: improvement of urban air quality, climate amelioration, habitat and biodiversity gains, water management and reduction in noise levels.

3.4 The links between poor water quality and deprivation

There has been very little research into the relationship between water quality and deprivation, and that which has been conducted has not attempted to differentiate the relationships or impacts by social group or distance from the river/water body. A simple analysis of overall river water quality against deprivation at local authority district level for England and Wales (using Environment Agency data from 2001) found that the percentage of rivers classified as ‘not good’ was biased towards the 88 districts classified as neighbourhood renewal areas. Therefore, on the basis of the data analysed, lower river quality correlated with social deprivation (Brook Lyndhurst 2004).

Research into environmental quality has in general echoed these findings. It has found that there are more poor and bad quality rivers in the most deprived areas than in other areas, and that this relationship is more pronounced in urban areas than in rural areas. Indeed, Environment Agency figures (2002b) suggest that 15 per cent of urban rivers in areas where the population density exceeds 1000 people per square kilometre, and 23 per cent of rivers in metropolitan council areas, are of poor or bad chemical quality. These figures are much greater than the figure for national water quality of only six per cent.

The one published study that examines the social distribution of river water quality in England (Environment Agency 2002b) used several parameters to reflect the different aspects of the relationship between deprivation and environmental quality. The first parameter was a measure of river habitat modification; the second was a measure of chemical river water quality; and the third was the aesthetic river quality. The study simply related particular electoral wards, which were rated on the basis of the Index of Multiple Deprivation (IMD), with the quality of the water in a nearby river stretch. The results of the study showed that:

- river habitats were more likely to be highly modified (culverts, channelisation) in more deprived wards;
- rivers in deprived areas had a worse chemical water quality than in less deprived areas;
- no relationship was found between deprivation and aesthetic quality.

However, these findings, and the analysis on which they were based, were criticised by Walker *et al*. (2003b). They argued that the rationale for addressing river water quality was unclear, as the links between river water quality and health are poorly defined and tenuous (discussed further in Section 4.1.1). They also said that studying deprivation in relation to the amenity and recreational values of water quality had a more legitimate rationale. Even so, they raised key issues regarding the legitimacy of analysing data derived from spatial associations between the IMD and river reaches, pointing out that it would not necessarily be the populations living near to the river that would derive amenity value from it. It should not be implied that only those people who live near to rivers will benefit from their quality and aesthetic value (or conversely suffer as a result of proximity to poor quality rivers with low aesthetic values).

Fairburn et al (2005) undertook a study of the association between deprivation and river water quality in Scotland. The analysis focused only on those river stretches classified as poor quality or seriously polluted (classes C or D which account for only 3.2 per cent of the classified river length in Scotland), because of the potential negative impacts for children playing in or near to the water; people swimming or engaged in water sports; pets made ill through contact with polluted river water; and vermin and pest problems where water is stagnant.

The study identified a clear association between deprivation and proximity to these river stretches. The highest proportion of population living within 600m was found in the most deprived decile. 26 per cent of the population in the most deprived decile lived within 600m of a poor quality or seriously polluted river, compared to between 11-15% per cent in the least deprived deciles. Proportionally, poor quality river stretches were biased towards both the urban and rural poor, and therefore did not just reflect an urban phenomenon). The report notes that while river water quality is an issue for environmental justice, ‘the general river water quality classification is unable to provide a meaningful and robust indicator of the range of potential impacts related either to the river water itself or the characteristics and condition of the river corridor’ (p113). For this reason, Fairburn et al recommend that the results should be taken ‘only as a general and preliminary indicator, providing a basis for further analysis and to stimulate policy discussion’ (p113).

Poor quality water (as measured by biological and chemical indicators) does not necessarily equate with a lack of amenity or with a greater level of threat to human safety. A Grade A river (very high quality in ecological terms) may sometimes be dangerous to human users of the river environment, for example during times of high flow. By the same token, a Grade D river (although scoring poorly in terms of ecological quality indicators) is not necessarily the stereotypical watercourse filled with shopping trolleys and litter, and may be a beneficial environmental resource for nearby residents and visitors to the area.

It is clear from this review that the limits of what can be concluded from any association between river quality and deprivation need to be explicitly acknowledged. The difficulty of overcoming these methodological and conceptual issues might go some way towards explaining the lack of existing research into the links between deprivation and river water quality and the social impacts of living in close proximity to poor quality river environments.

4 The social impacts of water quality

4.1 Water quality impacts

This section examines the types of impacts that water quality has on people through a review of the academic and 'grey' literatures. As noted previously, there is little literature that focuses on environmental justice and water quality. What research does exist has emphasised that it is extremely difficult to establish clear and direct causal relationships between deprivation and poor water quality, and presents anecdotal or postulated links, rather than evidence of causal relationships verified by data analysis.

Nevertheless, enough research work exists to allow a review of the potential social impacts of proximity to poor water quality. These impacts relate to: the health effects of coming into contact with contaminated river water; the economic impacts associated with poor water quality (and conversely the economic *benefits* in areas where water quality is good); aesthetic and nuisance impacts; geographical and community impacts; and impacts on recreation and personal well being. In addition, where possible, the potential differentiation of impacts between different social groups will be considered, since some groups may be affected more adversely than others by the same impact.

It is clear that some dimensions of the relationship between deprivation and water quality are more significant than others. For instance, the positive benefits to amenity of the high ecological status of a river or canal will be more important than any negative health issues arising from poor water quality, since to a large extent it can be argued that the worst impacts of poor water quality can be avoided. This differentiates the issue of water quality from the other issues discussed in this project – waste management and flood risk – as the impacts associated with these issues are largely unavoidable for communities living either in close proximity to waste management facilities or in areas at risk from flooding.

After the potential impacts of poor water quality have been outlined, a matrix will be presented that summarises the impacts evaluated within section 4 of the report.

4.1.1 Health impacts

The links between water quality and health arise most directly from recreational use. There is a significant body of epidemiological research dating from the 1950s that is directed at estimating the extent of illnesses associated with exposure (mainly through swimming) to recreational water and identifying recreational water quality standards to protect public health. These epidemiological investigations have tended to focus on illnesses such as gastro-intestinal symptoms, eye infections, skin complaints, ear, nose and throat infections, and respiratory illness. Despite this, there appears to be no literature that explicitly aims to address the health dimensions of water quality (either in the UK or internationally) within a specific equity or justice framework.

There are currently no statutory standards or guidelines for monitoring the quality of recreational waters set by the UK government or the European Commission, unless the water is an identified bathing water for the purposes of the 1976 Bathing Water Directive

(BWD; Boon and Howell 1997). The World Health Organisation (WHO) has repeatedly been requested to issue authoritative guidelines on the quality of recreational waters for national health authorities and the general public.

Estimates of the levels of participation (per year) in water-sports in the UK are about: 100,000 for dinghy sailing; 800,000 for windsurfing; 600,000 for water-skiing; 1.1 million for canoeing; and 4.5 million for fishing. These numbers are still comparatively low and it is estimated that only about three per cent of the adult population over 15 years of age in the UK regularly participates in water-based sport and recreation. This must be borne in mind when assessing the significance of postulated links between water quality and human health, as well as the fact that these water-based recreational activities (and the academic and policy literatures discussing them) relate primarily to lakes, not rivers.

Pruss (1998) reviewed 22 studies on the health risks caused by the poor microbiological quality of recreational water (including seas, lakes and rivers). All of the studies assess water quality by measuring indicator micro-organisms (usually bacteria of faecal origin). They also include controlled cohort studies for UK recreational waters, which distinguish between population groups in terms of use characteristics and provide risk assessments specific to paddlers, swimmers, surfers, canoeists and sailors. Most studies reported a dose-related increase in health risk with an increase in the indicator bacteria count in recreational waters (the lower the water quality, the greater the risk of illness from recreational exposure).

Table 4.1 Summary of research into links between water quality and health

Author(s)	Indicator	Exposure measure	Health outcomes
Dufour (1984)	Enterococci	Immersion of head in water	Gastro-enteritis
Fewtrell *et al*. (1992)	Faecal Coliforms	White water canoeing	Flu; respiratory illness; ear/eye infection; gastro-enteritis; and skin complaints
Ferley (1989)	Faecal Streptococci	Bathing	Acute gastro-intestinal disease
Stevenson (1953)	Total Coliforms	Swimming	Flu; respiratory illness; gastro-enteritis; and skin complaints
Phillip and Bates (1992)	Cyanobacteria	Dinghy sailing	Gastro-enteritis and stomach ailments

Source: Compiled from Pruss (1998)

However, it is difficult to estimate the health impacts of exposure to water quality, and choosing appropriate indicator organisms for capturing health risks; characterising and monitoring water quality; and because of the unreliability of self-reported information about symptoms. Furthermore, vulnerability to polluted waters is affected by variables such as duration of contact, age, gender, general health condition, and changes in environment and/or daily habits (Machado and Mourato 2002).

Walker *et al*. (2003b) argue that if analysis is conducted on the basis of a hypothesised link between river water quality and psychological health, much of the analysis may be redundant as the links are often tenuous and not supported by the available evidence (Briggs 1999). Indeed, Pruss (1998) identifies several key factors affecting the validity of conclusions drawn from epidemiological studies into the links between water quality and health.

- The use of indicator micro-organisms for assessing water quality of exposure is a major source of bias.
- Temporal and spatial indicator variation is substantial and difficult to relate to individual bathers.
- The use of seasonal means of water quality rather than daily measurements increases inaccuracy.
- Limited precision of methods for counting indicator organisms adds substantial measurement error.
- Certain studies do not take into account the potential infection pathway for defining exposure, such as mainly head immersion or the ingestion of water for gastro-intestinal symptoms.
- Most observational studies rely on self-reporting of symptoms, which may be inaccurate.

Pets and other animals may also become ill or killed through contact with polluted river water. Vermin and local pests may be present where water is still or stagnant (Battersby *et al*. 2002). Webster and MacDonald (1995) conducted a survey of a wide range of parasites of wild brown rats in the UK to rectify the lack of baseline data on rat-borne infection. The rats were found to be infected with 13 zoonotic species, with a range of between two and nine simultaneously per rat. These results suggested that rats could pose a serious risk to the health of humans and domestic animals in the UK.

Deprived areas have been found to be more likely to harbour rats, especially in urban areas. In the English House Condition Survey 1996 (DETR, 1998), a high correlation was found between deprived and/or problem areas with widespread litter, vandalism, scruffy gardens and neglected and vacant buildings, and rat infestation. Langton *et al*. (2001) confirm that dwellings in areas with substantial problems such as dereliction and litter had a significantly higher prevalence of rats.

4.1.2 Economic impacts

Regeneration of high quality river and canal environments can have many economic benefits and knock-on effects. There are several examples of formerly deprived areas, which have seen significant increases in property values, and the numbers of tourists as a result of river restoration or investment in the river environment.

Several surveys (such as Wood and Handley 1999) have identified improved water quality as an important precursor to waterside economic regeneration. The Department for Transport, Local Government and Regions (DTLR; 2002) argued that greater investment in water quality adds value to regeneration, renewal and housing development, and can save costs in other areas such as health, education, environmental management and through the better overall use of public resources. Cleaning up waterways can provide attractive public spaces, footpaths and cycle routes, as well as improving the sense of place. Water quality has also been found to affect the value of property adjacent to, or in the immediate vicinity of, a water body. Pretty *et al*. (2002) argue that leisure and residential property can be devalued by as much as 20 per cent as a result of close proximity to consistently poor physical water quality.

Wood and Handley (1999) found properties on a waterfront attract a higher added value that those without - up to 15 per cent for office space; 25 per cent for leisure developments; and between ten and 40 per cent for residential prices in the UK. Similarly, Bateman *et al*. (2001) suggest that views of water can considerably influence a house's selling price. The GLA (2003) found that a one per cent increase in green space in a typical ward can be associated with a 0.3 to 0.5 per cent increase in average house price. The same relationships have been evident internationally – Leggett and Bockstael (2000) used hedonic techniques to show that water quality had a significant and measurable effect on property values along the Chesapeake Bay in Maryland, USA.

Improvements to water quality can encourage developers to use water as a valuable development feature (Environment Agency 2002a). Research by Howes (2001) links water quality directly to specific development outcomes (Table 4.2).

Table 4.2 Water quality and development planning

River grade	Quality	Development outcome
5	Very poor	Developers turn their back on the river and it has no recreational appeal
4	Fair, rubbish cleared, banks planted	Encourages access and discourages litter; less intimidating environment
3	Fair quality, no smell, suitable for coarse fish	Developers prepared to face the river rather than back onto it
2	Upgraded to good, suitable for all fish	Wildlife, anglers and others return; waterside location becomes a selling point
1	Very good quality	Developers make water a feature for restaurants, bars, housing and water sports

Source: Howes (2001)

There are several examples of urban regeneration schemes involving improvements to water quality. One of the most widely known and commonly cited is the Mersey Basin Campaign, which began in 1985. Since then, the length of watercourses able to support fish has increased from 56 per cent to 80 per cent, and up to 40 per cent has been added to the value of development sites in the region. Another such example is the restoration of a 2km length of the River Skerne in Darlington, County Durham. This is an urban river, highly contaminated by industrial runoff and sewage works, and providing poor amenity for local residents. The restoration involved the creation of several new river meanders, the reshaping of riverbanks to prevent erosion, and reshaping of the river bed to vary river flow and to allow riverside plants to grow. New footpaths and planting schemes have been well accepted by local residents for increasing the economic vitality and recreational value of the area by ‘bringing the countryside into the town’. Canals have also shown significant benefits associated with water quality improvements – In Birmingham, a £400 million redevelopment adjacent to the canal in the city centre has created ‘Brindley Place’, which has provided an attractive environment for apartments, bars, restaurants and offices.

An associated area of research is that related to benefits assessment and transfer. Numerous studies have been conducted that attempt to assess, in monetary terms, the value (including use and non-use attributes) of environmental quality, with the resulting valuations then used in cost-benefit appraisals. These studies use a range of techniques, such as stated preference (contingent valuation) and revealed preference (hedonic pricing), to value environmental improvements. There have been several recent UK studies of water quality improvement valuation, including Gaterell *et al*. (1999), Crabtree *et al*. (1999), and Georgiou *et al*. (1998).

Work has also been carried out in the US, with Desvousges *et al.* (1987) examining the use and non-use value of improving water quality in the Monongahela River, which flows through

Pennsylvania. The researchers asked a representative sample of households from the area about their willingness to pay (WTP), in terms of extra taxes, in order to maintain or increase the water quality for the river in three scenarios.

1) Maintain current quality rather than allow it to decline to a level unsuitable for any activity.
2) Improve the water quality from boatable level to a level where fishing could take place.
3) Further improve the water from fishable to swimmable quality.

Table 4.3 Willingness to pay for increases in water quality

Water Quality Scenario	Average WTP of whole sample ($ p.a.)	Average WTP of users' group ($ p.a.)	Average WTP of non-users' group ($ p.a.)
Maintain present quality	25.50	45.30	14.20
Improve from boatable to fishable quality	17.60	31.30	10.80
Improve from fishable to swimmable quality	12.40	20.20	8.50

The results show that people are prepared to pay a relatively high amount for an initial basic level of quality, but are prepared to pay progressively less for further increases to water quality.

The Environment Agency has also used these preference techniques to assess both surface water quality and river low flow improvements, based on the technical guidance presented in Foundation for Water Research assessment manual (FWR 1996, Environment Agency 1998).

4.1.3 Aesthetic and nuisance impacts

Those people who live near to or use river environments are likely to have a broader view of water quality than simply its chemical or biological quality, and tend to consider aesthetic factors such as litter or smells as very significant. It is therefore important to give appropriate weight to the aesthetic impacts of water quality, particularly as the aesthetic (and recreational) values of river corridors are known to produce many of the positive health and quality of life benefits identified in the literature on green space (Lucas *et al.* 2004). Talbot *et al*. (1987) note that the knowledge that nature is present near one's home can be a powerful factor in residential satisfaction.

In 2000, for the first time, the Environment Agency's General Quality Assessments (GQA) included an aesthetic measure of water quality. This measure was tested at 452 'popular river sites' i.e. those in both urban and rural areas across England and Wales that are frequently visited by members of the public. The aesthetic quality assessments were based on three key parameters:

- litter (gross litter, general litter, sewage litter and dog faeces);

- oil, surface scum, foam, sewage fungus, ochre, and
- colour and odour

A standard site comprises both the riverbanks and the water itself, with the standard sampling unit judged as an area extending 50 metres along the riverbank and up to five metres from the water's edge plus the river and its bed. Each parameter is allocated a score, from which the overall aesthetic grade of a site can be derived. Litter items are counted in the water and on riverbanks where there is public access. Oil and scum etc. are assessed as percentage cover of the water surface or riverbed; colour is assessed by using a modified Standing Committee of Analysts 'Blue Book' method, and odour is qualitatively assessed from the bank side, in terms of odour type and intensity.

The results of the 2000 survey are presented in Table 4.3.

Table 4.3 The aesthetic quality of selected river sites in England and Wales, 2000

Region	Number of sites	Good quality (%)	Fair quality (%)	Poor quality (%)	Bad quality (%)
England and Wales	452	30.8	36.3	17.5	15.5
Anglian	58	36.2	34.5	13.8	15.5
Midlands	57	15.8	33.3	31.6	19.3
North East	56	25.0	44.6	12.5	17.9
North West	59	44.1	40.7	5.1	10.2
Southern	41	29.3	34.2	21.9	14.6
South West	71	28.2	39.4	22.5	9.9
Thames	55	47.3	25.5	9.1	18.2
Wales	55	20.0	36.4	23.6	20.0

Source: Environment Agency (2002b)

The method was tested in November and December 2000 by the Environment Agency, which is now working with the National Aquatic litter Group to establish a new protocol that can be used by any organisation to monitor the aesthetic quality of rivers in England and Wales.

The aesthetic impacts (including *perceived*) of water quality will vary according to a range of environmental factors such as season, temperature, vegetation cover and geographical location (Ryan 1998). Public perception of the aesthetic quality of the river corridor is often based primarily on sight and smell. These factors may or may not be related to the actual physical, chemical or biological quality of the watercourse, but are nevertheless significant factors for those living near to rivers or using them for recreational purposes. Leggett and Bockstael (2000) suggest that people may often perceive rivers as being polluted, even those that technically have very good chemical and biological quality. Tunstall *et al.* (1997) found that the most common factors cited as indicative of bad water quality were algal growth, muddy waters, strange odours, dead fish, rubbish in the water and strange colours. Interestingly, they note that the public have a clearer idea of what is considered to be a polluted river than of what constitutes 'clean water'. In the context of the current project, the Environment Agency GQA aesthetic assessments in 2000 may have been biased heavily towards less deprived areas in terms of site selection. This is because the primary criterion was 'popularity' of a river stretch, with those sites frequently visited by members of the public being chosen. Poor quality areas in which the river environment is a disamenity to those living nearby and is therefore not visited or heavily used recreationally would not have been chosen for aesthetic quality assessments by the Environment Agency.

4.1.4 Geographical and community impacts

The potential geographical or community impacts borne by those living in close proximity to rivers and canals are largely anecdotal and poorly delineated within the existing literature. Communities may become stigmatised once an area becomes associated with a polluted watercourse - already deprived areas may become more deprived as a result. In common with many other environmental issues, the psychological and external costs of poor water quality are borne locally by the neighbourhood immediately surrounding it, whilst the benefits associated with good water quality are likely to be distributed far more widely throughout society. Social divides and tensions may develop between those who live very close to a polluted water body and therefore bear the brunt of the negative impacts, particularly in an aesthetic sense, or in terms of reductions in property values, and those who live further away and who may not experience negative impacts to the same extent. However, to some degree, many of the worst impacts associated with proximity to poor water quality are avoidable, and are not of the same magnitude as the community impacts which might result for those living near to waste sites or in areas at risk from flooding.

Nevertheless, safe, well-maintained and attractive public spaces and environments have a critical role in creating neighbourhood pride, which is essential to building community cohesion. Dirty and dangerous places encourage graffiti, vandalism and anti-social behaviour, which in turn undermines public confidence and leads people to avoid those areas. It can lead to abandonment and dereliction, driving people, businesses and investment away. This ‘spiral of decline’ is highlighted in some of the poorest neighbourhoods, which show a strong relationship between levels of deprivation and the condition of the local environment (ODPM 2002a, 2002b).

Although these impacts relate to the environment in general terms, they may apply with equal validity to areas in close proximity to river corridors and canals. Burningham and Thrush (2001) have shown that small local environmental issues are often considered to be symbolic of deeper social and economic malaise in a community. Research carried out by the Environment Agency and Birmingham University on the SMURF (Sustainable Management of Urban Rivers and Floodplains) river restoration project found that local rivers often encompass a number of ‘big’ problems within an area, including graffiti, fly-tipping and vandalism, and are symbolic of the overall ‘health’ of the area and local perceptions about crime and anti-social behaviour.

4.1.5 Recreation and well-being

The proximity of nature and opportunities for outdoor recreation are generally seen as important aspects of the quality of people’s living environment. De Vries *et al*. (2003), in a study carried out using self-reported health indices, found that in a greener and higher quality environment, people have measurable improvements in their general levels of well-being, report fewer medical symptoms and have better levels of perceived general health. Walker *et al*. (2003b) also identify river water quality as having a number of potential links to well-being.

A research report by English Nature (2003) argued that environmental effects on mental health and psychological well-being can be divided into physical, social and cultural properties, after Freeman (1984). Henwood (2002) provides several explanatory frameworks for the mental health benefits of contact with nature. These include ‘stress recovery’ (immediate psychological benefits from contact with nature) and ‘attention restoration’ (longer term psychological benefits from contact with nature). In contrast, it has been argued that living in deprived areas and in disadvantaged communities exact a high toll on inhabitants well-being (Worpole, 2000). Deprived areas usually have limited access to local green space or river environments. Even if these environments are present in an area, they are likely to be poorly maintained and have negative associations.

Those living in deprived areas may experience several barriers of access to river environments, the majority of which are either physical and/or social.

1) **Physical barriers** – English Nature (1995) suggests that physical constraints to accessing nature and gaining the benefits of environmental amenity include distance from the home, severance factors like roads, and the degree of independent mobility enjoyed by particular groups of adults and children. Similarly, the UGSTF (1999) suggests that the notion of physical barriers relates not only to issues of proximity, but also to issues of getting to the river environments themselves and the ease of moving around them.

2) **Social barriers** – The UGSTF (1999) identifies five main social barriers deterring people from using the environment and green space. These are: the poor condition of facilities; the presence of other users who they consider undesirable; concerns about dogs and dog mess; safety and psychological issues; and issues of environmental quality, such as litter, graffiti and vandalism.

These barriers are not explicitly presented in the research literature as coming from an equity perspective. But it is clear that if those living in deprived communities are more likely to have poor quality environments in their locality, then those deprived populations will be correspondingly more likely to experience the stated physical and social barriers. This may result in an overall reduction in environmental amenity.

This is particularly important in terms of the cumulative impacts of environmental inequality. For, although living near to a poor quality river is not explicitly a problem in its self, a poor quality river *in addition* to other local social and environmental problems may have significant negative impacts. This is because: (a) urban areas are more likely to experience poor water quality than rural areas; (b) it is in urban areas where concentrations of deprived communities can most commonly be found; and (c) those living in deprived communities are likely to suffer the most from reductions in well-being and recreational opportunities, *despite* being in the most need of them. It is clear that there may be significant knock-on effects and cumulative impacts in relation to water quality and areas experiencing deprivation.

4.1.6 Social differentiation

The academic literature rarely offers an equity or justice perspective on the impacts of poor water quality and fails to delineate how certain social groups may be more or less affected than others. However, it is crucial for this research project that a preliminary attempt is made to consider some of the potential types of social differentiation that may be relevant in the context of water quality. It is important to note that the analysis in this section is derived from literature relating to environmental inequality *in general* and is not specific to water quality considerations. However, it may be argued that many of these general points apply with equal validity to water quality issues.

It is clear that the impacts of environmental problems are not distributed equally among all communities, particularly in the context of urban environmental problems (Lan Yuan *et al.* 1999). Despite research showing that natural places have a high level of attraction for all age groups and ethnic groups (Burgess *et al*. 1988), levels of use vary from site to site and visitor surveys have shown that while some age groups and social groups are well represented, others are not. There is unambiguous evidence to show that low-income earners, young people, older people, ethnic minorities, disabled people, and those without access to a private car are less likely to participate in the countryside and outdoor recreation (Slee *et al*. 2002). Rishbeth (2002) outlines a number of barriers to access that may account for this social differentiation:

- lack of time;
- financial costs;
- lack of appropriate activities to attract and provide a positive experience;
- lack of awareness of local initiatives and lack of perceived relevance;
- physical difficulty of access;
- lack of confidence and negative perceptions of the environment;
- lack of appropriate information at sites, inadequate signage and lack of publicity;
- a neglected or poorly maintained environment;
- negative feelings associated with previous experience;
- lack of accessible transport.

Burgess (1996a, 1996b), in research into the use of woodland by different social groups, noted that anxiety can seriously affect people's use of woodland and other natural spaces e.g. women feared being in woodland alone. Women from ethnic minority backgrounds in particular experienced exclusion in multiple ways, citing as major factors the fear of sexual attack and racial attacks.

Children may also be disadvantaged if they live in proximity to poor quality river environments (and natural spaces in general). Studies by the UGSTF (such as UGSTF 1999) show that proximity to green space and the opportunity to access nature are vital for child development, due to the scope for outdoor, imaginative and energetic play. Thus, the fact that children in deprived areas have less contact with nature has significant potential consequences for their development and well-being.

Relatively little work has been conducted on the experience of the disabled in outdoor recreation. Morris (2003) notes that there are 8.6 million disabled people in Britain, and one in four households have someone with some level of disability, yet visitor surveys have shown that disproportionately low numbers of people with disabilities visit parks, nature reserves and riverside areas.

The social group that has received the most attention in research on outdoor recreation is black and ethnic minority communities. Since research has shown that ethnic minority groups are more likely to live in deprived areas, this is clearly a key issue to consider. In research for OPENspace, Morris (2003) reviews the literature on under-representation in accessing the countryside and social exclusion issues. One key fact to emerge is that disproportionately low numbers of black and ethnic minority groups visit parks and nature reserves. The countryside is popularly perceived as a white landscape, predominantly inhabited by white people. Very few people from black and ethnic minority groups are members of organisations such as the National Trust, the Youth Hostel Association or the Ramblers' Association, for example. Madge (1997) showed that the fear of coming into contact with animals, and in particular dangerous dogs, was much higher for Afro-Caribbean and Asian groups than white groups. Morris (2003) outlines several key barriers to access and participation in outdoor recreation faced by members of ethnic minority groups (many of which are identified in other research as barriers faced by all deprived and low-income groups).

- lack of appropriate interpretative information at sites.
- lack of appropriate activities to attract ethnic minority and black communities and provide a positive experience.
- lack of confidence and negative perceptions of the environment (fears of getting lost, not knowing where to go, lack of support, feelings of vulnerability, fears for personal security, fears of racial persecution).
- negative feelings associated with previous experience of the countryside.
- financial costs incurred, lack of time and other commitments.

4.2 Water Quality Impacts Matrix

Table 4.4 summarises the main impacts that may be faced by those living in close proximity to environments with poor water quality.

Table 4.4 Matrix showing potential effects of poor water quality

Category of impact	Type of impact
HEALTH	• Gastro-enteritis from contact or immersion in polluted water • Flu symptoms, skin complaints • Stomach ailments • Death or illness to domestic animals from contact with polluted water bodies • Rat infestations and potential disease transmission
ECONOMIC	• Reductions in property values • Increased levels of neighbourhood deprivation • Lack of investment in residential and commercial property
AESTHETIC AND NUISANCE IMPACTS	• Unpleasant odours • Poor visual amenity caused by litter, foams and scum on water surface and river banks • Creation of a poor and undesirable environment
GEOGRAPHICAL AND COMMUNITY IMPACTS	• Stigmatisation of community • Decreased neighbourhood pride and reduced levels of community cohesion • Spiral of decline may develop – fly-tipping, crime, vandalism, graffiti

RECREATION AND WELL BEING	• Lower levels of well-being and mental health, increased levels of stress • Loss of recreational opportunities and amenity value of the surrounding area • Physical and social barriers to use of water resources • Fears for safety and security of visitors

4.3 Conclusion

The discussion suggests that there are many potential impacts for those living in deprived areas from the proximity of poor quality rivers and water bodies, and that the degree of impact experienced may be felt more strongly by certain social groups than others. In particular, women, the elderly, children, the disabled and ethnic minority groups were found to have to overcome numerous physical and social barriers to use the river environment. This is particularly significant from an equity point of view. It is increasingly recognised that those who live in deprived areas, or who form part of deprived social groups, are simultaneously more in *need* of the recreational and well-being benefits that may come from their proximity to water resources and less likely to be able to take *advantage* of those benefits for the reasons outlined in section 4.

5 River water quality and deprivation: data analysis

5.1 Introduction

This section discusses the methodology and results of a quantitative GIS-based analysis of the association between the water quality of classified rivers and multiple social deprivation in England and each of the English regions.

The analysis seeks to provide a more sophisticated analysis than that previously undertaken in England (see section 3.4) by analysing the deprivation characteristics of populations living within a corridor around each river stretch rather than relying on the geography of wards or districts to provide an indicator of deprivation profiles. However, as discussed in sections 3 and 4 there are a number of problematic methodological issues for environmental justice studies focused on river water quality:

- Rivers potentially have both negative and positive impacts on people who live near to them regardless of water quality.
- Some negative impacts may be eliminated by avoiding contact with the river water.
- Some positive and negative impacts, such as various forms of recreation, rely upon access to the river corridor, which may or may not be possible along any one river stretch.
- Different impacts will extend different distances from each water body (which vary substantially in physical size), depending upon their severity and local contexts and contingencies.
- There is no single measure of river water quality that can adequately provide an indicator of the range of positive and negative impacts that river water quality and the wider river environment may have on the local population.

For these reasons – and particularly the final reason – whilst the analysis discussed in this section is in some respects more sophisticated than previous studies, it does not provide a definitive or entirely satisfactory account of the relationship between river water quality and deprivation. Generalisations and assumptions have had to be made to allow a national-scale analysis to be undertaken. For these reasons, the conclusions and related recommendations drawn in section 7 emphasise the need to consider carefully the results produced and their implications for future analytical research.

5.2 Methodology

5.2.1 Datasets

5.2.1.1 Super Output Area Population and Deprivation Data

The spatial unit of analysis used for population and deprivation is the Super Output Area (Lower Level), of which there are 32,482 in England. Super Output Areas (SOAs) are aggregations of 2001 census output areas and are designed to be the core geography for small area statistics. SOAs are designed to contain roughly equal populations (approximately 1500 people). This means that the physical size of SOAs is density dependent, with small SOAs in urban centres and large SOAs in rural areas.

Deprivation was represented using the English Index of Multiple Deprivation 2004 (IMD 2004). The IMD is based on seven separate domains:

- income deprivation;
- employment deprivation;
- health deprivation and disability;
- education, skills and training deprivation;
- barriers to housing and services;
- living environment deprivation;
- crime.

Each domain score is produced from a number of indicators, totalling 37 overall, with the majority recorded in 2001. For each SOA, a score is produced for each indicator and then each domain. Individual domain scores are then weighted and summed to create the overall IMD score. This IMD score forms the basis for a final ranking of SOAs.

The 'living environment' domain of the IMD required further investigation because there could be potential for 'auto-correlation' in the environmental equity analysis. This domain is made up of two sub-domains, which are the 'indoors' living environment and the 'outdoors' living environment. The outdoors living environment sub-domain accounts for one third of the overall domain score and is made up of an air quality score and a road traffic accidents score.

For the purpose of this study there is no postulated causal link between air quality and river water quality. Thus, auto-correlation effects are not expected for the analysis undertaken.

Given the nature of the IMD, deprivation data in this project is consistently presented in the form of deprivation deciles that maintain the ranked ordinal form of the data. Details about the construction of these deciles can be found in section 5.2.2.

5.2.1.2 Address Location Data

To improve the spatial resolution of the analysis use has been made of the detailed AddressPoint spatial dataset, which records every residence (postal delivery address) in England. This is a point dataset that provides approximately 98 per cent (based on the interrogation of the datasets 'positional quality indicator') of locations to 1 metre accuracy. This data is used to locate residential address locations within a SOA. Locations were deemed residential if they were 'non-PO Box and did not have an organisation name' and were not classified as demolished.

5.2.1.3 River Water Quality Data

A number of possible indicators of river water quality were considered for use in this study. Initially it was intended that the data on the predicted risk of water bodies failing the 'ecological status' criteria under the WFD would be used, but this proved to be inappropriate for the form of inequality analysis that was to be undertaken. The various measures available under the GQA were then considered.

The GQA system provides an assessment of several aspects of water quality.

- Biological quality – an indicator of the overall 'health' of rivers (monitored on a five yearly basis).
- Chemical quality – an indicator of organic pollution in general through measurements of Biochemical Oxygen Demand (BOD) and concentrations of dissolved oxygen and ammonia (monitored every three years).
- Nutrient status.
- Aesthetic quality – assesses the amounts of litter, sewage-derived waste, oil, scum, foam, sewage fungus and ochreous deposits, and dog fouling at selected sites, as well as the colour and smell of the water.

Biological and chemical quality was measured at 7,000 sites in England and Wales, representing around 40,000 kilometres of the river and canal network. The Environment Agency reported on aesthetic quality for the first time in 2000, based on measurements taken at 452 'well visited' sites in England and Wales.

As discussed earlier, the river environment has a number of relationships with quality of life and well-being, only some of which (such as health impacts) relate directly to the quality of the river water. Whilst the aesthetic GQA indicator captures more of the quality of the river corridor, and how it may be used and perceived by local people, the measurement regime was felt to be too sparsely distributed to be reliably used for analysis of the relationship between river stretches and nearby populations. The biology GQA indicator was felt to provide a broader measure of the overall 'health' of rivers than the chemical indicator. Following guidance from Environment Agency personnel, the biology GQA indicator was therefore chosen for the analysis.

The GQA system grades rivers into six classes ranging from A to F, where A represents high quality rivers and F represents poor quality rivers. The criteria for assessment of biological quality are presented in Table 5.1.

Table 5.1 General Quality Assessment scheme for biological water quality

Grade	Description
A. Very good	Biology similar to (or better than) that expected for an average and unpolluted river of this size, type and location: high diversity of taxa, usually with several species in each, rare to find dominance on any one taxon
B. Good	Biology falls a little short of that expected for an unpolluted river, small reduction in the number of taxa that are sensitive to pollution, moderate increase in the number of individuals in the taxa that can tolerate pollution
C. Fairly good	Biology worse than that expected for an unpolluted river, many taxa absent, or number of individuals reduced, marked rise in numbers of individuals in taxa that tolerate pollution
D. Fair	Sensitive taxa scarce and contain only small numbers of individuals, a range of pollution tolerant taxa present, some with high numbers of individuals
E. Poor	Biology restricted to pollution tolerant species with some taxa dominant in terms of the numbers of individuals, sensitive taxa are rare or absent
F. Bad	Biology limited to a small number of very tolerant taxa such as worms, midge larvae, leeches, water buglouse, present in very high numbers, in the worst case there may be no life present

Source: Green and Faulkner (2000)

The biological quality element of the GQA uses RIVPACS (River InVertebrate Prediction and Classification System). This is a computer-based tool that uses macroinvertebrate sampling (Clarke *et al*. 2003) and which has become the principal tool used by the Environment Agency for assessing the ecological quality of rivers throughout England and Wales. RIVPACS depends on the use of a set of reference sites, which are short river stretches that are considered to be of high ecological and chemical quality, and representative of the best examples of their particular river type. Statistical models are then developed, relating the environmental characteristics of any reference site to its macroinvertebrate fauna. Discriminant analysis is then used to derive equations that represent the best fit between the biological classification and measured values at each reference site. Next, these variables are measured for any new site and the values are entered into the equations from the database of reference sites to predict the fauna to be expected at the test site, and to derive an index of ecological quality for that stretch of river.

5.2.1.4 River Stretch Data

To identify stretches of rivers where nearby population characteristics could be analysed, a reasonably spatially-precise indicator of the location of each river stretch is required. For this purpose, we were able to use the GQA stretch network data at the 1:50,000 scale. This data was still in a draft format, with the Environment Agency's quality assessment procedure incomplete, but this was not felt to be likely to have a significant effect on the overall results. This data was used because 1:50,000 was the minimum level of accuracy required for the analysis undertaken (the 1:250,000 scale stretch network data incorporated generalisations of parts of the river network and in many situations shifted the river course away from its true location). However, a limitation of this data set is that it provides no indicator of river size, so that when the river stretch is buffered (see section 5.2.5) for larger rivers a potentially significant proportion of the buffer area will actually be the water body itself. River stretches vary substantially in their length depending upon the geography of monitoring and assessment.

5.2.2 Creation of Super Output Area deprivation deciles

For the purpose of this study, the population of England was divided into groups so that we could determine the differences between them according to the level of deprivation indicated by the IMD. Ten groups containing equal populations were used and were known as deciles.

In order to create SOA deciles, the overall IMD 2004 rank was used to place each SOA into a decile of equal population (See Table 5.2). Deciles of equal population are preferred to those of equal SOA count, as the analysis then gives a population-based distribution, which is more meaningful for equity based studies. In all cases, decile 1 is the most deprived and decile 10 is the least deprived. It is important to understand what these deciles represent. Essentially, decile 1 has the largest concentration of deprived people, while decile 10 has the smallest concentration of deprived people. Population weighted deprivation deciles of this form are often referred to using shorthand terminology, but their precise definition needs to be remembered. Decile 1 is not 'the poorest 10 per cent of the population', as some of the poorest people will live in pockets within less deprived SOAs, nor is it 'the 10 per cent most deprived SOAs' as a population weighting has been applied.

The population within a SOA and within a decile will vary in their characteristics. The IMD provides a statistical measure for a group of people rather than a precise measure for every individual. Within area-based studies, this is a well-known limitation known as the ecological fallacy, which requires a caveat to be placed on any area-based analysis. However, it should be noted that the small population of SOAs will have helped to lessen this problem compared to a ward level analysis.

Table 5.2 Population weighted deprivation deciles for SOAs in England

Decile	Population	SOA Count	Rank	
			From	To
1	4,934,430	3,247	1	3,247
2	4,934,780	3,253	3,248	6,500
3	4,934,250	3,261	6,501	9,761
4	4,934,910	3,262	9,762	13,023
5	4,935,060	3,259	13,024	16,282
6	4,933,820	3,255	16,283	19,537
7	4,935,180	3,237	19,538	22,774
8	4,933,430	3,234	22,775	26,008
9	4,935,160	3,229	26,009	29,237
10	4,934,500	3,245	29,238	32,482
England	49,345,520	32,482		

5.2.3 National and Regional Analysis

This report examines the population living within 600m of river stretches that have a GQA biology grade. It is possible for people to live within 600m of more than one river stretch and the stretches may have different GQA biology grades. To address this issue and assess its significance, at a national level results will be reported in two ways:

- Population within 600m of rivers for each individual grade of river.
- Population for the best quality river within 600m (if an address is within 600m of a river graded A and a river graded E then that address will be classed as having a best river within 600m of grade A).

At a regional level within England, this report looks at the population within 600m of rivers for each individual GQA biology grade.

5.2.4 Spatial proximity measures

The analyses in this report make use of proximity analysis (what type of population lives within a set distance of a river). The distance used is a Euclidean or 'as the crow flies' distance. The choice of distance is problematic given the many different types of river environments and the multiple ways in which people and rivers can be related and impacts experienced. Rather than attempt to define in any precise way which people living near to a river may experience impacts (good or bad), the scope of analysis only allows a characterisation of the deprivation levels of areas through which the rivers run. A distance of 600m either side of the river (creating a 1200m wide buffer) was chosen. This is rather arbitrary and ideally a range of distances would be deployed to investigate any differences – however this was not feasible to do within the project resources.

The distance of 600m was chosen because this was identified in a previous environmental justice study (Fairburn et al 2005) as a typical distance that people are prepared to walk to get to green space or woodland (based on a review of a number of studies and policy guides). This distance, with many caveats, may also be appropriate for considerations of walking access to rivers and provides a reasonable area over which to assess deprivation characteristics, given the typical size of SOAs in urban areas. Nevertheless, it needs to be recognised that the distance is arbitrary. It can in no way be presumed that all of the people within the buffer around the river are going to experience impacts (good or bad) related to that river and that others outside of the 600m distance will experience no impacts.

As emphasised earlier it may not be possible for local residents to even see the river or to be able to gain access to it and other greenspace recreational opportunities may be closer and/or more important to them than the river.   This emphasises again that the study can only provide a characterisation of proximate populations rather than assume a clear positive or negative impact on wellbeing as a result of that proximity.

5.2.5 Estimating the population within 600m of rivers

When calculating the population living within 600m of a river it is not sufficient simply to use the overall SOA population that the river falls within. It may be, for example, that the part of the SOA that falls within 600m of the river contains no inhabitants (a particular issue in the larger rural areas). To use the social characteristics of this SOA within any analysis would be nonsensical because we would then be assigning river water quality indicators to people that didn't exist. Therefore, to improve the spatial resolution of the analysis, use has been made of residential address locations derived from AddressPoint.

Each residential address location was assigned to the SOA that it fell within. Each SOA population was then divided evenly across all of the addresses within it. This is an important point, because the total population of the addresses must match the population reported in the IMD. By assigning a SOA to each address the deprivation decile of each address is also known. The river buffers can be used to determine which residential addresses within a SOA are located inside a 600m buffer (See Figure 5.1). Using the populations assigned to the addresses, the population of the SOA within 600m of a river can now be estimated and resulting summary data produced.

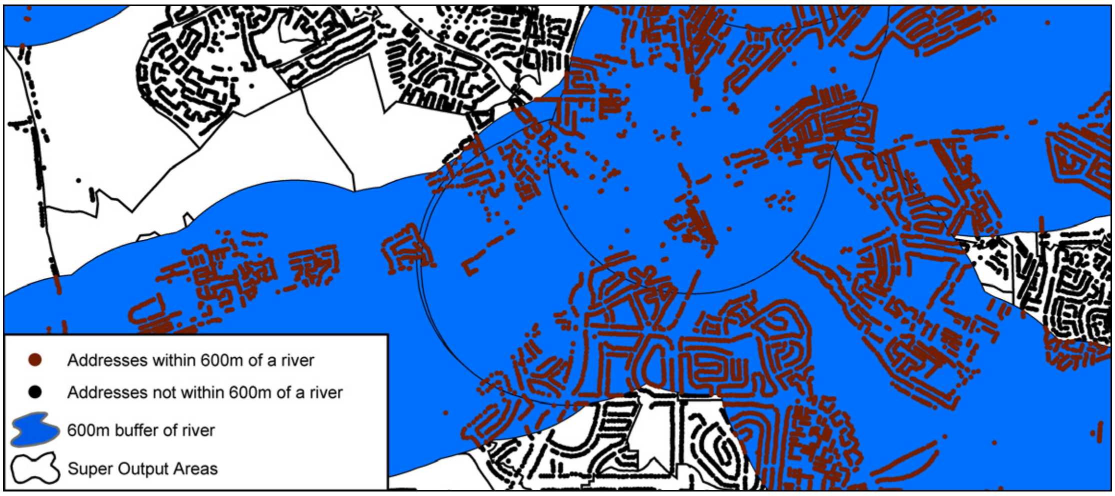

Figure 5.1 Residential address locations within and outside a 600m river buffer

This method is preferable to other methods often used in equity studies, such as calculating the proportion of the SOA area that is occupied by the river buffer and using this to estimate the proportion of the population.

Using AddressPoint data does not provide a perfect distribution of the population in each SOA, because in reality the population at each address location will vary slightly (although average household size does not tend to vary by a large amount within the same locality). Also, some addresses may be wrongly classified as residential or commercial. However, for the purposes of this study it provides a very good estimate of the proportion of the population within a SOA (and therefore each deprivation decile) that is within a set distance of a river.

In addition, large sites such as blocks of flats or apartments will be represented by single points sitting on top of each other. The limitation of these locations is that they will experience edge effects in any analysis because they are representing a large site with a large population as a single point location. Thus a point could fall outside a buffer zone, resulting in the population being missed out, while in reality part of the site and associated population is actually within the zone. In contrast, a point could fall within a buffer zone, resulting in all of the population being included, while in reality part of the site is outside the zone. It is important to be aware of these limitations when looking at the results, even though the population involved is only a very small percentage of the total population.

Although AddressPoint can help to improve the spatial distribution of population, it is important to note that it *cannot* provide a more detailed picture of the deprivation characteristics of that population. Therefore all the addresses within a SOA are still considered to have the same deprivation characteristics.

5.2.6 Comparative Environmental Risk Index (CERI)

In order to help compare results (deprivation patterns) between various differentiations in the analysis, use has been made of the Comparative Environmental Risk Index (CERI). This measure involves calculating a ratio of the population 'at-risk' as a proportion of the total population for any particular group over the ratio of the rest of the population 'at-risk' as a proportion of the total rest of the population.

The index produced is a quotient (a ratio of ratios) (Harner, Warner et al. 2002). In terms of the deciles used in this study, the index can be represented by the following equation, where X is any particular decile:

$$\frac{DecileX^{at-risk} / DecileX}{Not-in-DecileX^{at-risk} / Not-in-DecileX}$$

When looking at the results of this study, the group of people in question (Decile X) can refer to a group of deciles.

If the group reported in the results is 'Decile 1 and 2' and the CERI value is '1.228' (this is the case for the population within 600m of rivers with a GQA biology grade D) then this means that 'people living in decile 1 and 2 (as a group) are 22.8 per cent more likely to be living within 600m of a river with a GQA biology grade D compared to people living in deciles 3 to 10 (as a group)'. In presenting the results of analysis three CERI values are provided:

- Deciles 1 and 2 compared to all others;
- Deciles 1–5 compared to all others;
- Deciles 6–10 compared to all others.

5.3 River Water Quality in England

5.3.1 Total Numbers of People Living near to Rivers

How many people live near to river stretches of different water quality grades?

In total, nearly 11 million people in England (23 per cent of the total population) live within 600m of at least one stretch of the classified river network (Table 5.3). As would be expected, this total is divided unevenly across the different water quality grades, as there are very different total lengths of river falling within each of the six grades. However, the differences in percentage population within 600m of each quality grade do not directly match the differences in percentage river length across the quality grades, indicating that there is a clear population density difference between the grades. For example, Grade A rivers account for 38 per cent of the river length, but only 17 per cent of the proximate population; Grade E rivers account for 4.5 per cent of the river length but 14 per cent of the proximate population. This is potentially significant in terms of the social impact that poor quality rivers may have, given that there are larger numbers of people who could experience these impacts than might be expected. Overall, though, nearly two thirds of the people living within 600m of a river, are near to a very good, good or fairly good quality stretch of river.

Table 5.3 Total populations living within 600m of river stretches with biological grades A – F and lengths of rivers within each grade

	All rivers	A	B	C	D	E	F
Total Pop (best grade)	10,991,023	1,865,267	2,844,992	2,963,602	2,854,324	1,946,121	175,508
% of England Popn	100	16.97	23.54	22.43	22.03	13.90	1.13
Total river length (km)	33672	12875	10429	5961	2634	1507	266
% of river length	100	38.2	31	17.7	7.8	4.5	0.8

Note: The total population living within 600m of the different grades of rivers does not equal the total population for all rivers, as some people live within 600m of more than one river stretch with different grades

5.3.2 River Water Quality and Deprivation

Are deprived populations more likely to be living near to rivers with poor water quality than others?

There is a quite striking equality to the total numbers of people within each deprivation decile that live within 600m of a classified river stretch in England. As shown in Figure 5.2, the percentage of the people in each decile living within 600m of a river ranges only between 8.8 and 10.7%. At face value, people living at different levels of deprivation have a similar potential likelihood of living near to a river and potentially benefiting from this proximity in terms of amenity and recreational benefits. Although, as previously discussed, in practice there are a large number of factors that will influence whether or not these potential benefits are realisable or realised.

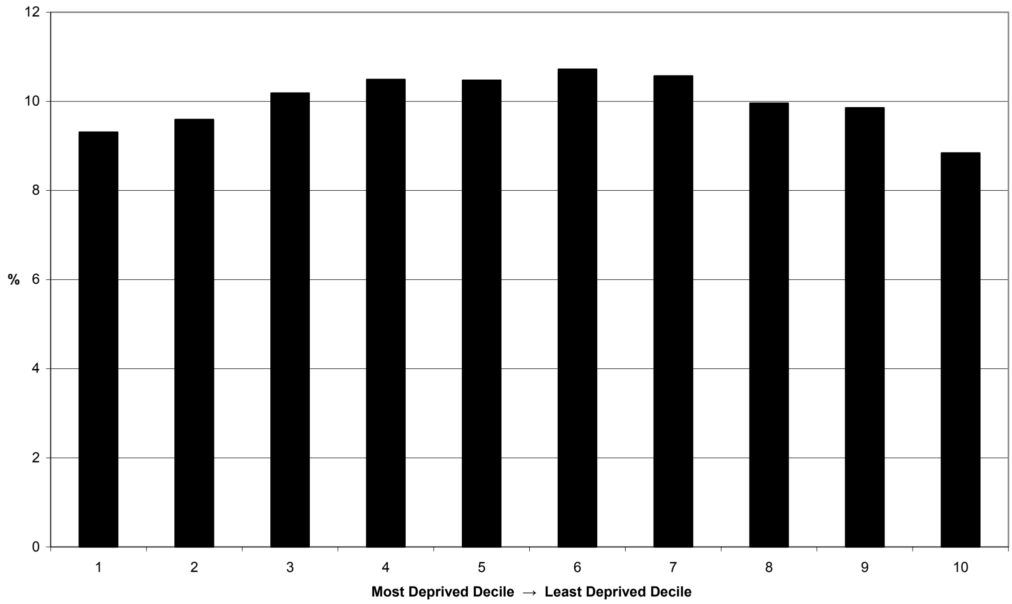

Figure 5.2 Percentage of people within each deprivation decile living within 600m of a classified river

If, however, the water quality grade of these river stretches are examined a strong pattern of *inequality* between the deciles emerges. Two sets of data are provided here. The first counts all people within 600m of river stretches of different quality (so that any one person may be counted more than once if they live close to more than one river stretch of different quality). The second only takes account of the best quality river stretch that any one person lives close to (avoiding double counting and focusing on the potential benefits that each person may be able to realise by living near to a good quality river). Both analyses show broadly similar patterns.

The ‘all river’ data (Table 5.4 and Figure 5.3) shows a clear transition across the deciles. The proportion of people from the most deprived decile living near to a poor or bad quality grade E or F river is far higher than from the least deprived decile – for a grade F river 26 per cent of people living within 600m are from decile 1 compared to only 2 per cent from decile 10. Conversely for the good quality rivers graded A and B, it is the least deprived who are far more likely to be living within 600m – for grade A rivers 12 per cent of the people living within 600m are in decile 10, compared to only 1 per cent in decile 1. Moving across the grades from A to F there is steady change in CERI and CI values, which indicate how the bias in distribution against deprivation shifts from the least to the most deprived populations – this is also represented visually by the changing shapes of clusters of bars in Figure 5.3.

Table 5.4 Totals and percentages of people living within 600m of river stretches with biological water quality grades A – F by deprivation decile

Decile	All rivers A to F	A	B	C	D	E	F
1	1,023,329	20,228	113,254	281,787	319,874	408,688	46,257
2	1,054,480	55,037	169,859	296,805	350,689	325,123	33,353
3	1,119,331	101,793	233,275	314,690	341,933	292,036	26,214
4	1,152,926	153,131	284,811	335,691	347,607	227,121	18,838
5	1,151,201	208,978	303,158	326,971	300,864	179,254	10,621
6	1,178,335	276,277	342,538	290,534	278,575	155,331	8,819
7	1,161,758	269,108	350,922	316,220	252,083	123,081	8,489
8	1,094,706	272,312	358,961	267,372	241,087	100,450	4,933
9	1,082,997	278,175	345,523	291,377	216,399	74,173	13,757
10	971,960	230,229	342,692	242,154	205,213	60,863	4,227
Total	10,991,023	1,865,267	2,844,992	2,963,602	2,854,324	1,946,121	175,508
Percentages							
1	9.31	1.08	3.98	9.51	11.21	21.00	26.36
2	9.59	2.95	5.97	10.02	12.29	16.71	19.00
3	10.18	5.46	8.20	10.62	11.98	15.01	14.94
4	10.49	8.21	10.01	11.33	12.18	11.67	10.73
5	10.47	11.20	10.66	11.03	10.54	9.21	6.05
6	10.72	14.81	12.04	9.80	9.76	7.98	5.02
7	10.57	14.43	12.33	10.67	8.83	6.32	4.84
8	9.96	14.60	12.62	9.02	8.45	5.16	2.81
9	9.85	14.91	12.14	9.83	7.58	3.81	7.84
10	8.84	12.34	12.05	8.17	7.19	3.13	2.41
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CI Values		-0.25	-0.15	0.02	0.10	0.32	0.37
CERI deciles 1 and 2		0.168	0.442	0.970	1.228	2.42	3.32
CERI deciles 1 to 5		0.407	0.634	1.105	1.392	2.79	3.36
CERI deciles 6 to 10		2.460	1.576	0.905	0.719	0.36	0.30

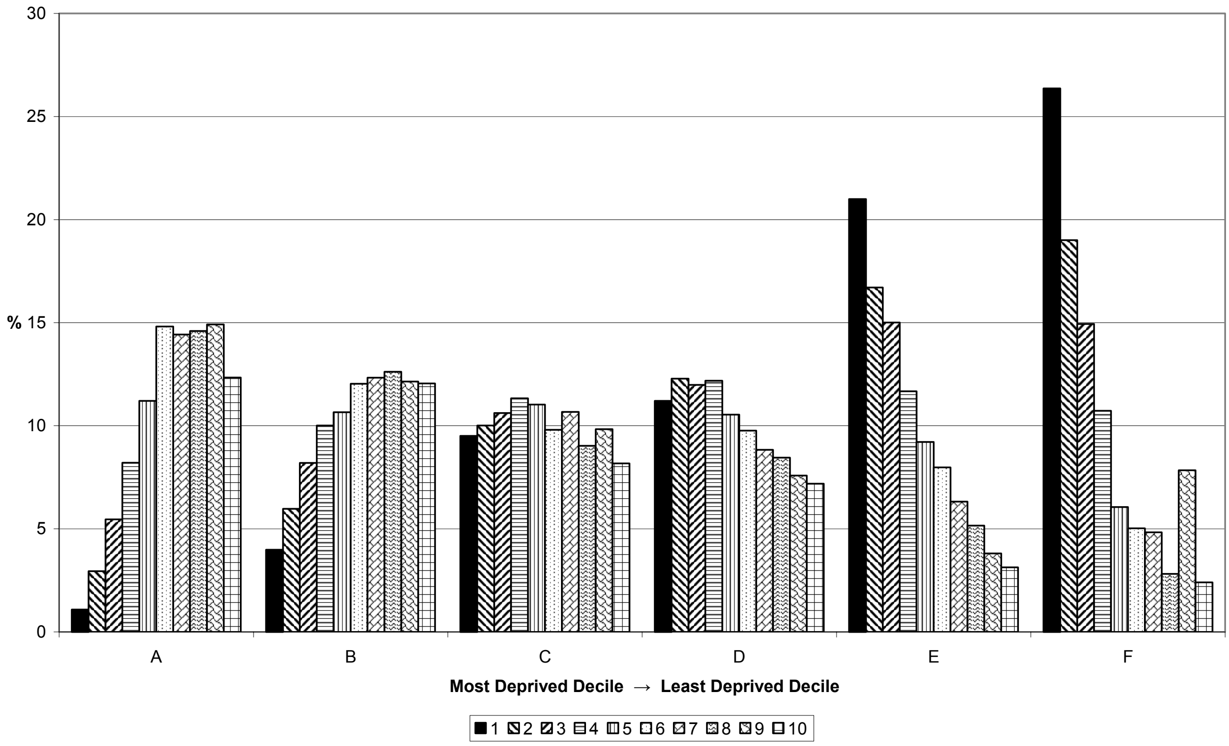

Figure 5.3 Percentages of people living within 600m of river stretches with biological water quality grades A–F by deprivation decile

Looking at the data across rather than down Table 5.4 also demonstrates the degree of difference between the least and most deprived deciles. Of all the people in the most deprived decile that live within 600m of a river, 44 per cent live near to a poor or bad quality river and only 13 per cent near to a good or very good quality river. Conversely of all the people in the least deprived decile that live within 600m of a river, over 59 per cent live near to a good or very good river and only 7 per cent near to a poor or bad quality river.

The 'best grade' data is shown in Table 5.5 and Figure 5.4 and displays very similar patterns to the 'all river' analysis. There are only marginal differences in the proportions of people within each decile living near to rivers of different grades, and only small changes in the CI and CERI indicators of degree of inequality. Any general direction of difference that can be identified is towards the distribution across the deciles being marginally more unequal for the 'best grade' data.

Table 5.5 Totals and percentages of people living within 600m of river stretches with the best biological water quality grade by deprivation decile

Decile	All rivers A to F	A	B	C	D	E	F
1	1,023,329	20,228	109,338	253,624	285,514	321,882	32,743
2	1,054,480	55,037	158,870	256,578	300,555	255,887	27,553
3	1,119,331	101,793	215,589	266,517	289,175	229,726	16,531
4	1,152,926	153,131	256,360	280,271	288,499	163,717	10,948
5	1,151,201	208,978	276,283	267,686	247,358	144,627	6,270
6	1,178,335	276,277	305,212	225,099	234,310	131,747	5,690
7	1,161,758	269,108	315,320	265,227	211,034	97,061	4,008
8	1,094,706	272,312	324,923	213,073	202,607	77,016	4,774
9	1,082,997	278,175	311,205	238,048	183,881	59,876	11,812
10	971,960	230,229	313,991	198,832	178,152	46,614	4,142
Total	10,991,023	1,865,267	2,587,092	2,464,954	2,421,086	1,528,154	124,471
Percentages							
1	9.31	1.08	4.23	10.29	11.79	21.06	26.31
2	9.59	2.95	6.14	10.41	12.41	16.74	22.14
3	10.18	5.46	8.33	10.81	11.94	15.03	13.28
4	10.49	8.21	9.91	11.37	11.92	10.71	8.80
5	10.47	11.20	10.68	10.86	10.22	9.46	5.04
6	10.72	14.81	11.80	9.13	9.68	8.62	4.57
7	10.57	14.43	12.19	10.76	8.72	6.35	3.22
8	9.96	14.60	12.56	8.64	8.37	5.04	3.84
9	9.85	14.91	12.03	9.66	7.59	3.92	9.49
10	8.84	12.34	12.14	8.07	7.36	3.05	3.33
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CI Values		-0.25	-0.14	0.04	0.10	0.32	0.36
CERI deciles 1 and 2		0.168	0.463	1.044	1.278	2.43	3.76
CERI deciles 1 to 5		0.407	0.647	1.162	1.397	2.71	3.09
CERI deciles 6 to 10		2.460	1.545	0.861	0.716	0.37	0.32

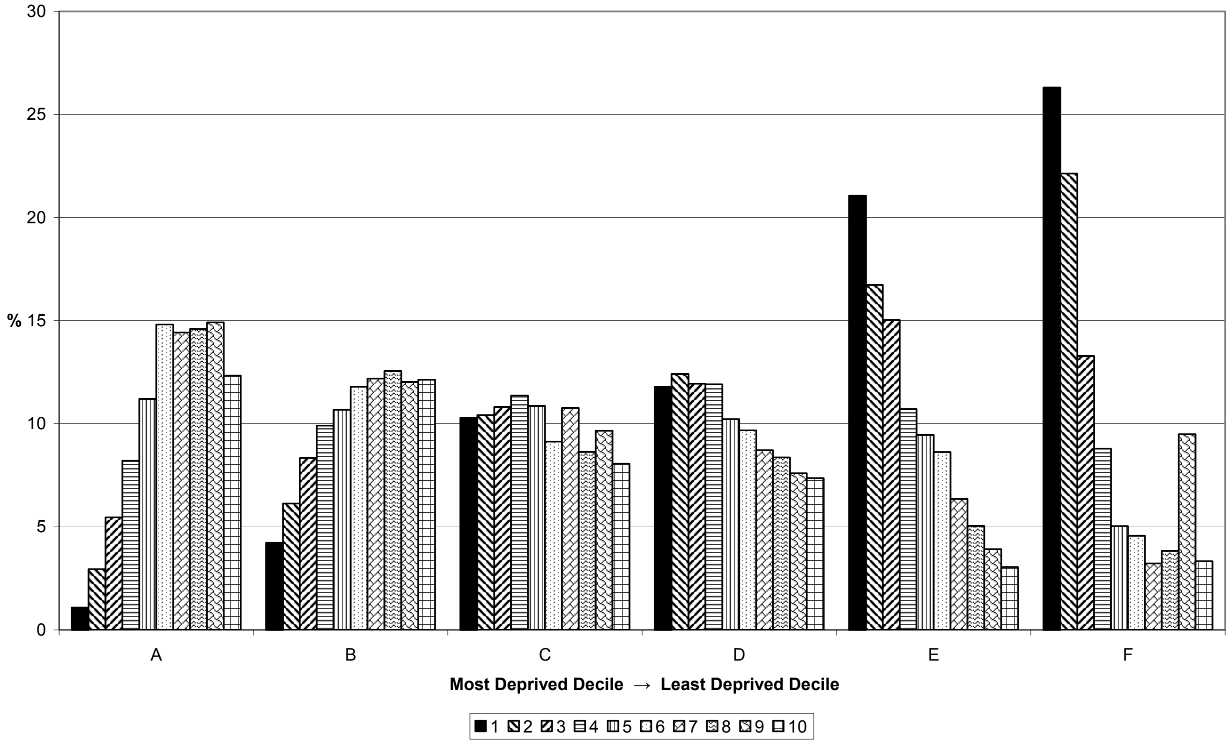

Figure 5.4 Percentages of people living within 600m of river stretches with the best biological water quality grade by deprivation decile

5.4 River Water Quality in the English Regions

5.4.1 Undertaking Regional Analysis

A regional analysis of the distribution of river water quality in relation to deprivation can consider the data in two ways. First, across the regions as a whole, considering how each region contributes to the national pattern, and second, within each region, considering the profile of relationship with deprivation within that region. Both of these analyses need to take account of the background differences in distribution of population and deprivation within each region (Table 5.6). For example, the South East contains a much greater number of people in total (16 per cent of population in England) than the North East (only 5 per cent). It also has 40 per cent of all the people in England in the least deprived decile 10, compared to only 1 per cent in the North East. We have chosen to continue to use the national ranked scores for the IMD and the associated population weighted population deciles within the regional analysis, rather than re-rank and score within each region and create new sets of deciles. This means that comparisons between regions can be more easily made, but also that care needs to be taken in interpreting results so that misleading conclusions are not reached.

Data is presented separately for each of the regions in Appendix 2.

Table 5.6 Percentage of the population in each deprivation decile falling within the standard regions of England

Decile	North East	North West	Yorks & Humber	East Mids	West Mids	East of England	London	South East	South West	Total %
1	10.91	28.40	17.44	6.74	14.66	2.20	14.38	2.36	2.90	100
2	8.38	16.66	12.30	7.99	13.76	4.55	24.81	5.92	5.62	100
3	6.62	15.82	10.81	8.41	10.72	6.98	23.69	9.45	7.49	100
4	5.84	13.23	10.36	9.29	10.01	9.52	18.72	11.73	11.30	100
5	4.51	12.57	9.37	8.16	11.10	11.59	15.27	14.07	13.36	100
6	4.33	12.43	10.70	7.77	10.76	12.41	13.92	14.66	13.02	100
7	3.82	11.77	9.37	8.95	10.53	13.63	11.57	16.81	13.55	100
8	3.16	9.99	9.14	9.48	9.72	14.76	9.86	21.92	11.97	100
9	2.30	9.71	6.46	10.07	8.57	16.36	9.88	25.21	11.45	100
10	1.11	6.42	4.68	7.77	7.13	17.36	5.96	40.27	9.30	100
Total	**5.10**	**13.70**	**10.06**	**8.46**	**10.70**	**10.94**	**14.81**	**16.24**	**10.00**	**100**

5.4.2 The Distribution of River Water Quality across English Regions

How is the population in England living within 600m of classified river stretches distributed across the regions?

The distribution of total population living near to rivers varies across the regions, reflecting the geography of river networks and population concentrations. The North West has the highest absolute number of people living within 600m of a river, followed by the South East and Yorkshire and Humberside. The East of England, North East and West Midlands have much lower total populations.

Looking by decile, the North West also has by far the highest proportion of people in the most deprived deciles living near to rivers – 43 per cent of the proximate population in decile 1 is in the North West. This region will therefore have a significant impact on the profile for England as a whole (along with Yorkshire and Humberside at 25 per cent). This high percentage reflects the fact that deprivation is concentrated in the North West (see Table 5.6) but that the deprived population is also concentrated near to rivers more than in other regions. This reflects the interconnected evolution of urban and industrial geography in this region, for example around the textile and chemical industries.

In contrast, the South East has a profile of proximity to rivers that is concentrated on the least deprived population. 49 per cent of the population in decile 10 lives within 600m of rivers in the South East, which is far higher than this region's overall proportion of population in decile 10 (16 per cent – Table 5.6). Such different scales and types of concentration indicate that both patterns of proximity to rivers and how these relate to patterns of deprivation are highly differentiated across the regions.

Table 5.7 Total and percentage populations living within 600m of classified river stretches by region and deprivation decile

Decile	All Regions	North East	North West	Yorkshire & Humber	East Midlands	West Midlands	East of England	London	South East	South West
1	1,023,329	56,846	442,358	256,389	86,544	46,019	10,773	109,167	6,383	8,851
2	1,054,480	62,403	307,598	210,358	138,421	45,268	18,056	183,815	46,147	42,415
3	1,119,331	61,027	307,745	187,917	145,692	58,349	27,710	173,307	83,426	74,158
4	1,152,926	66,941	264,759	162,209	148,998	60,291	38,232	176,197	88,764	146,536
5	1,151,201	54,304	244,058	159,599	124,125	60,369	38,904	159,214	132,652	177,977
6	1,178,335	54,420	252,689	177,732	104,878	58,813	41,306	148,075	156,172	184,249
7	1,161,758	44,573	227,501	153,226	131,843	63,481	38,424	140,998	182,338	179,372
8	1,094,706	26,221	197,021	134,377	111,324	59,924	46,548	116,588	242,946	159,756
9	1,082,997	36,749	169,202	108,408	112,102	42,831	43,705	119,921	297,293	152,785
10	971,960	25,114	109,505	58,162	61,621	25,074	34,983	69,894	479,463	108,144
Total	10,991,023	**488,599**	**2,522,435**	**1,608,377**	**1,165,549**	**520,419**	**338,643**	**1,397,175**	**1,715,583**	**1,234,242**
Decile					**Percentages**					
1	100	5.56	43.23	25.05	8.46	4.50	1.05	10.67	0.62	0.86
2	100	5.92	29.17	19.95	13.13	4.29	1.71	17.43	4.38	4.02
3	100	5.45	27.49	16.79	13.02	5.21	2.48	15.48	7.45	6.63
4	100	5.81	22.96	14.07	12.92	5.23	3.32	15.28	7.70	12.71
5	100	4.72	21.20	13.86	10.78	5.24	3.38	13.83	11.52	15.46
6	100	4.62	21.44	15.08	8.90	4.99	3.51	12.57	13.25	15.64
7	100	3.84	19.58	13.19	11.35	5.46	3.31	12.14	15.70	15.44
8	100	2.40	18.00	12.28	10.17	5.47	4.25	10.65	22.19	14.59
9	100	3.39	15.62	10.01	10.35	3.95	4.04	11.07	27.45	14.11
10	100	2.58	11.27	5.98	6.34	2.58	3.60	7.19	49.33	11.13

How is the population living within 600m of rivers of different water quality grades and in the different deprivation deciles distributed across the regions?

The full results for all water quality grades and regions are provided in Appendix 1. To provide a comparison across the regions, the data for two nationally contrasting water quality grades (A and E) are compared in Tables 5.8 and 5.9.

For the grade A best quality rivers, the South East and South West combined have nearly 60 per cent of the total population within 600m. For the South East, most of this population is also concentrated in the least deprived deciles (8–10), whereas in the South West there is a concentration around the middle deciles (5–7). For all regions apart from London, it is the most deprived decile that has the lowest absolute numbers of people living near to the best quality rivers, indicating something of a consistent bias across the country.

Over 85 per cent of those people living within 600m of (grade E) poor quality rivers are in the North West, London and Yorkshire and Humberside. In all three regions most of these people living within 600m of a grade E river are those in the most deprived deciles 8, 9 and 10, mirroring the national data. This pattern is also found in the East Midlands, but not consistently in the other regions.

Table 5.8 Total populations living within 600m of grade A rivers by region and deprivation decile

Decile	All Regions	North East	North West	Yorkshire & Humber	East Midlands	West Midlands	East of England	London	South East	South West
1	20,228	2,434	396		5,770	2	1,724	7,104	0	2,797
2	55,037	2,649	1,971	3,936	14,835	0	5,150	6,782	5,463	14,251
3	101,793	12,395	9,249	6,025	15,056	2,909	4,875	1,718	19,737	29,829
4	153,131	11,946	8,420	6,924	24,581	9,226	7,459	5,591	13,138	65,847
5	208,978	11,422	8,693	22,275	18,557	12,834	8,778	4,008	29,091	93,320
6	276,277	22,787	15,063	31,288	25,031	10,880	17,183	2,510	47,733	103,802
7	269,108	8,928	21,850	25,021	30,609	9,297	10,169	1,428	66,707	95,098
8	272,312	8,967	8,390	32,786	27,492	9,301	11,740	1,275	90,180	82,181
9	278,175	6,122	3,869	24,560	27,423	10,682	13,938	1,315	108,860	81,406
10	230,229	6,000	2,484	20,383	18,042	5,556	4,973	342	122,520	49,929
Total	**1,865,267**	**93,650**	**80,385**	**173,197**	**207,397**	**70,686**	**85,988**	**32,075**	**503,430**	**618,459**
%	100	**5.02**	**4.31**	**9.29**	**11.12**	**3.79**	**4.61**	**1.72**	**26.99**	**33.16**

Table 5.9 Total and percentage populations living within 600m of grade E rivers by region and deprivation decile

Decile	All Regions	North East	North West	Yorkshire & Humber	East Midlands	West Midlands	East of England	London	South East	South West
1	408,688	2,384	210,675	88,858	15,536	7,162		82,712	0	1,362
2	325,123	1,784	133,674	70,576	11,569	8,868		94,004	2,833	1,815
3	292,036	2,819	139,623	48,172	16,541	13,223		55,739	11,694	4,224
4	227,121	6,579	95,685	36,508	12,211	7,891	804	54,985	3,330	9,129
5	179,254	3,558	86,518	19,220	11,608	5,649	14	43,272	6,358	3,059
6	155,331	4,136	82,626	20,120	5,695	5,731	526	31,466	1,356	3,674
7	123,081	2,446	62,050	13,608	8,836	3,660	1,122	29,166	1,375	819
8	100,450	352	59,801	9,386	6,455	4,803	1,035	17,787	790	41
9	74,173		33,540	8,857	5,931	2,395	2,052	16,021	5,251	127
10	60,863		33,383	3,245	869	2,029	4,698	5,105	5,575	5,959
Total	**1,946,121**	**24,058**	**937,574**	**318,548**	**95,250**	**61,411**	**10,251**	**430,256**	**38,564**	**30,209**
%	100	**1.24**	**48.18**	**16.37**	**4.89**	**3.16**	**0.53**	**22.11**	**1.98**	**1.55**

5.4.3 The Distribution of River Water Quality within each English region

We use two indicators to look for inequality in the distribution of river water quality risk within each region.

First, tables and figures are provided which show for each deprivation decile, in each region, the percentage of the population who live within 600m of both good quality (grade A) and poor quality (grade E) rivers.

For example, if there are 100,000 people in decile 1 (the most deprived proportion of the population) in region X, and 10,000 of those people live within the 600m of a grade A river stretch, then the percentage figure in this Table will be 10 per cent. If there are 5,000 people in decile 1 in region Y and 500 people live within 600m of a grade A river stretch, then the percentage figure in this Table will also be 10 per cent.

Second, CERI values are provided for each of the regions, which in their derivation also take account of the underlying population distribution across the deciles.

Looking at rivers with good water quality(grade A), the clear and strong bias towards the least deprived deciles that was identified for England as a whole, is largely maintained across the regions (Tables 5.10, 5.11 and Figure 5.5). All of the regions, with the exception of London and the East of England, have deprived populations that are much less likely than others to live near to very good quality rivers. CERI values for deciles 1 and 2 are all well below 1, while deciles 6 -10 have CERI values above 1. However, the degree of bias is variable. This is strongest in Yorkshire and Humberside and weaker in the South West and East Midlands, where the bias towards the population in the middle deprivation deciles is more significant, as can be seen in the shapes of clusters of bars in Figure 5.5). In London there is a reverse pattern. The proportions of people in the most deprived decile are higher than in the least deprived, although absolute numbers are low (Table 5.8)

Table 5.10 Population within 600m of grade A quality river stretches by deprivation decile as a percentage of the total population within each decile for each region

Decile	All Regions	North East	North West	Yorkshire & Humber	East Midlands	West Midlands	East of England	London	South East	South West
1	0.41	0.45	0.03	0.00	1.73	0.00	1.59	1.00	0.00	1.95
2	1.12	0.64	0.24	0.65	3.76	0.00	2.29	0.55	1.87	5.14
3	2.06	3.79	1.18	1.13	3.63	0.55	1.41	0.15	4.23	8.07
4	3.10	4.15	1.29	1.35	5.36	1.87	1.59	0.61	2.27	11.81
5	4.23	5.13	1.40	4.82	4.61	2.34	1.53	0.53	4.19	14.16
6	5.60	10.68	2.46	5.93	6.53	2.05	2.81	0.37	6.60	16.15
7	5.45	4.73	3.76	5.41	6.93	1.79	1.51	0.25	8.04	14.22
8	5.52	5.74	1.70	7.27	5.88	1.94	1.61	0.26	8.34	13.92
9	5.64	5.39	0.81	7.71	5.52	2.53	1.73	0.27	8.75	14.41
10	4.67	10.97	0.78	8.84	4.70	1.58	0.58	0.12	6.17	10.88
England	**3.78**	**3.72**	**1.19**	**3.49**	**4.97**	**1.34**	**1.59**	**0.44**	**6.28**	**12.54**

Table 5.11 CERI Values for Population within 600m of grade A quality river stretches by deprivation decile for each region

CERI values	All Regions	North East	North West	Yorkshire & Humber	East Midlands	West Midlands	East of England	London	South East	South West
CERI deciles 1 and 2	0.168	0.094	0.062	0.055	0.523	0.000	1.321	2.121	0.204	0.304
CERI deciles 1 to 5	0.407	0.314	0.323	0.195	0.665	0.423	1.032	1.938	0.422	0.728
CERI deciles 6 to 10	2.460	3.184	3.098	5.115	1.505	2.362	0.969	0.516	2.368	1.373

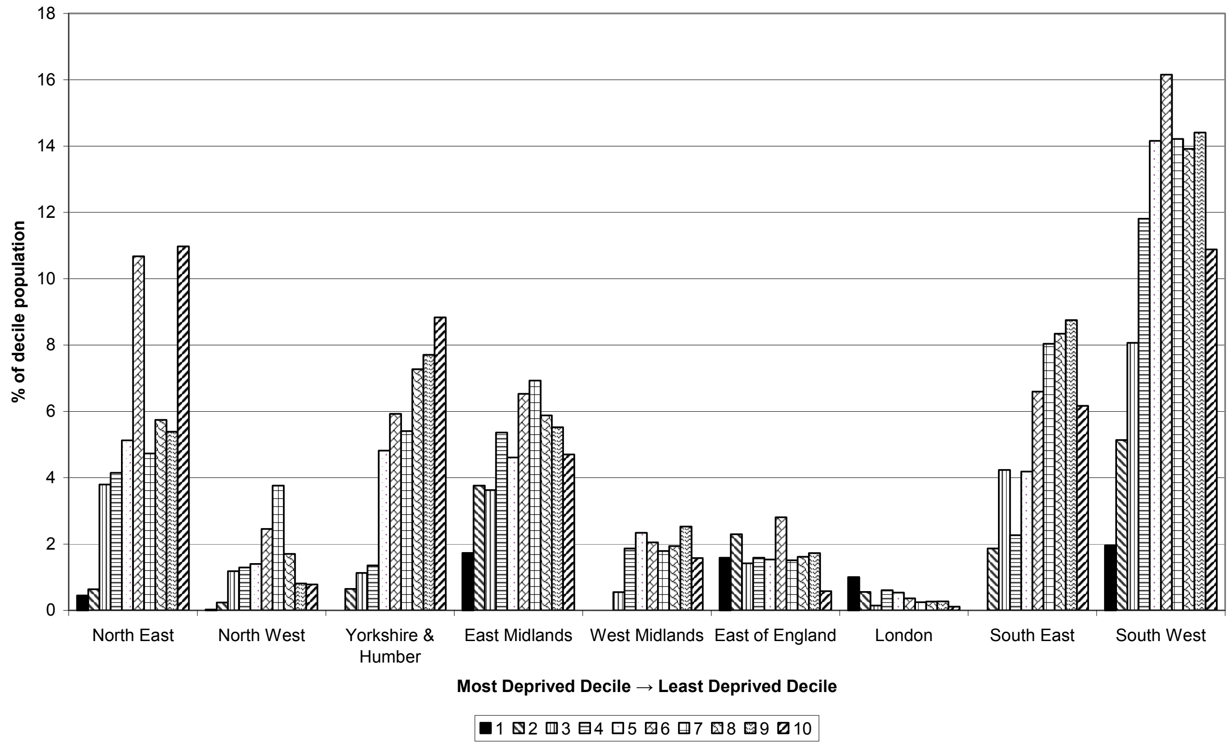

Figure 5.5 Population within 600m of grade A quality river stretch by deprivation decile as a percentage of the total population within each decile for each region

For poor quality grade E rivers, the clear and strong bias towards the most deprived deciles at a national level is again largely maintained across the regions (Tables 5.12, 5.13 and Figure 5.6). All of the regions apart from the North East, East of England and West Midlands have deprived populations that are, in proportional terms, more likely than others to live near to poor quality rivers. For deciles 1 and 2, CERI values are above one, although in no case is the likelihood, as indicated by CERI values, higher than for England as a whole. The North West, Yorkshire and Humberside, London and the East Midlands all have strong declining profiles in Figure 5.6, which echo that of the national data in Figure 5.3, although the most deprived decile does not always have the highest proportional population. In the East of England and, to a lesser extent, the North East there is a contrasting pattern that emphasises concentrations in the middle and least deprived deciles. However, particularly in the case of the East of England, the absolute total population is low (see Figure 5.9).

The above analysis has only considered two of the river water quality grades. Data for the other grades can be examined region by region in Appendix 1. It is difficult to compare rivers with the worst water quality (grade F) because some regions have no rivers in this class. For the other quality classes the transitions in patterns of association moving from grade A through to grade E can best be revealed by the Figures included for each region. These show that for Yorkshire and Humberside, the North West and South East the graduation in association between water quality and deprivation matches closely with the national profile. As we examine rivers with grades A through to E, there is shift from a low to a high concentration of deprived people. For London, South West and East and West Midlands, there is a similar graduation, but changing relationships are weaker and/or not as consistent. In London for example there is a more sudden shift between the profiles for grade D and E rivers. For the East of England no clear graduation of association can be found.

Table 5.12 Population within 600m of grade E quality river stretches by deprivation decile as a percentage of the total population within each decile for each region

Decile	All Regions	North East	North West	Yorkshire & Humber	East Midlands	West Midlands	East of England	London	South East	South West
1	8.28	0.44	15.03	10.33	4.67	0.99	0.00	11.65	0.00	0.95
2	6.59	0.43	16.26	11.63	2.93	1.31	0.00	7.68	0.97	0.65
3	5.92	0.86	17.88	9.03	3.99	2.50	0.00	4.77	2.51	1.14
4	4.60	2.28	14.66	7.14	2.66	1.60	0.17	5.95	0.58	1.64
5	3.63	1.60	13.95	4.16	2.88	1.03	0.00	5.74	0.92	0.46
6	3.15	1.94	13.47	3.81	1.49	1.08	0.09	4.58	0.19	0.57
7	2.49	1.30	10.68	2.94	2.00	0.70	0.17	5.11	0.17	0.12
8	2.04	0.23	12.14	2.08	1.38	1.00	0.14	3.66	0.07	0.01
9	1.50	0.00	7.00	2.78	1.19	0.57	0.25	3.29	0.42	0.02
10	1.23	0.00	10.53	1.41	0.23	0.58	0.55	1.74	0.28	1.30
England	**3.94**	**0.96**	**13.87**	**6.42**	**2.28**	**1.16**	**0.19**	**5.89**	**0.48**	**0.61**

Table 5.13 CERI values for population within 600m of grade E quality river stretches by deprivation decile for each region

CERI values	All Regions	North East	North West	Yorkshire & Humber	East Midlands	West Midlands	East of England	London	South East	South West
CERI deciles 1 and 2	2.421	0.344	1.184	2.388	1.887	0.976	0.000	1.936	1.476	1.261
CERI deciles 1 to 5	2.787	1.003	1.425	3.191	2.634	1.782	0.185	1.755	4.609	2.689
CERI deciles 6 to 10	0.359	0.997	0.702	0.313	0.380	0.561	5.393	0.570	0.217	0.372

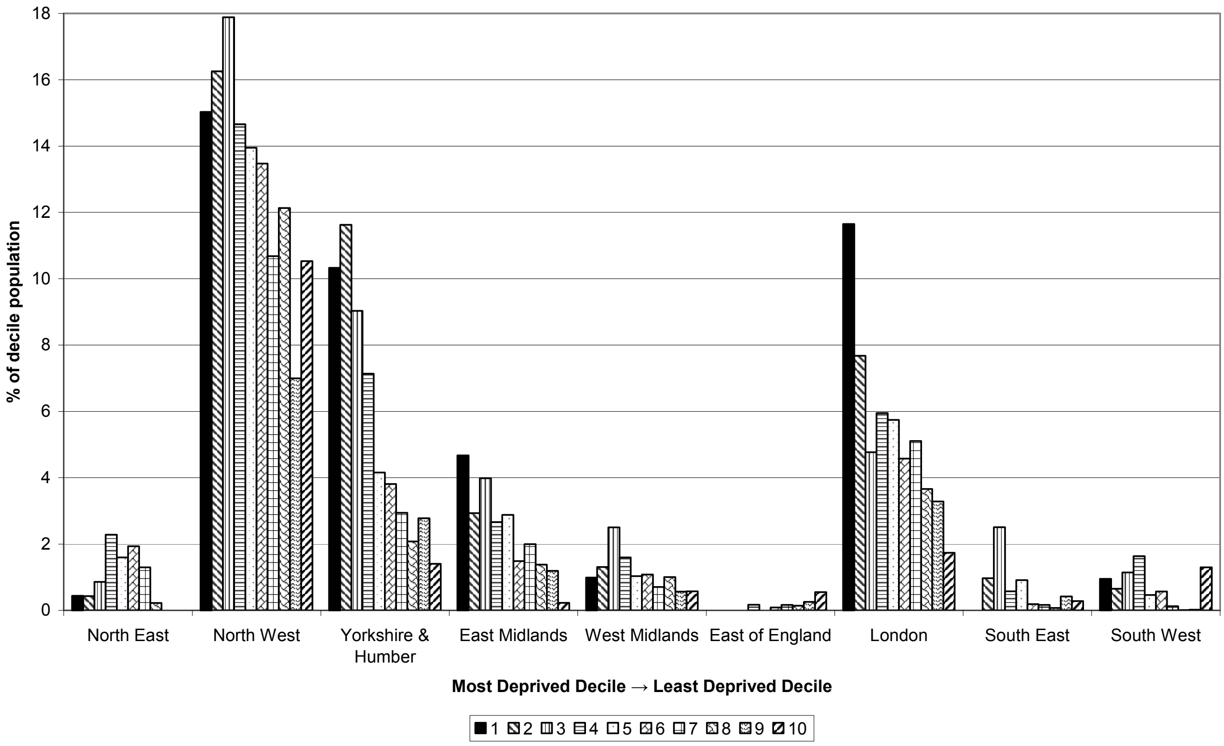

Figure 5.6 Population within 600m of grade E quality river stretches by deprivation decile as a percentage of the total population within each decile for each region

5.5 Conclusions

This analysis improves on previous studies, as it uses improved resolution of deprivation and household location data, better quality of the river stretch map and consistency of area size over which deprivation is being assessed. Even so, there are methodological limitations to this analysis:

- the use of biology water quality as an indicator
- the choice of 600m as a buffer distance and its application to all rivers regardless of size
- the lack of data on access to the river environment, and
- the necessary assumption that deprivation does not vary within a Super Output Area.

The analysis must therefore to some degree be taken as preliminary and exploratory and it is important not simplistically to equate numbers of people living near to rivers with numbers of people experiencing good or bad impacts on their quality of life.

However, within the parameters of the analytical design, the results obtained for England as a whole display a clear pattern of inequality in proximity to rivers with good and bad biological water quality. For those people living within 600m of a river, the more deprived you are the more likely you are to be living near to a poor rather than a good quality river – and conversely the less deprived you are the more likely you are to be living near to a good quality river. The pattern of distribution against deprivation is clear and consistent. It is also important to note that although the percentage of river length in England that is classified as poor (E) or bad (F) is very small (only 5.3%), the number of people that live near to these rivers is in proportional terms higher. To summarise therefore, poor and bad quality river stretches have in proportional terms more people living near to them than better quality river stretches and they tend to run largely through deprived areas. This overall outcome concurs with the broad findings of previous studies.

The regional analysis showed that in absolute terms the locations where poor quality rivers and substantial deprived populations coincide are concentrated in three regions – the North West, Yorkshire and Humberside and London. In proportional terms the regional analysis showed a reasonable degree of consistency with the national analysis. In most regions the deprived are more likely to be living near to poor rather than good quality rivers, and the converse for the least deprived. However, there is variation between the regions and in some cases this general association does not hold.

6 Policy Context

6.1 Introduction

Water management policy in the UK has changed significantly in the past decade and particularly since the introduction of the WFD. This will have far-reaching consequences for the way in which water quality standards are set, the manner in which compliance is assessed and the way that water quality improvements are targeted. The Directive recognises the importance of holistic river basin management to provide an integrated management policy that takes into account all of the pressures and user groups affecting the river basin.

Linked to this is the UK government's commitment to sustainable development, and, in this case, the sustainable management of water resources. This has led, in recent years, to the implementation of many river restoration schemes, some of which have been specifically targeted towards socially deprived areas. These schemes aim to capture the regional and community benefits that can follow from water quality improvements, such as economic regeneration and neighbourhood renewal.

This section of the report will outline these recent policy changes, beginning with the UK sustainable development strategy, and then provide a more detailed evaluation of the nature of water quality management policy as currently practised in England and Wales. The impact of legislative policy drivers such as the WFD will be analysed, followed by a consideration of the implications of holistic river basin management, and the benefits that can be derived from successful river restoration and rehabilitation schemes.

6.2 UK context for addressing environmental inequalities

6.2.1 UK Sustainable Development Strategy

The cornerstone of the sustainable development focus in UK policy is the UK Strategic Framework for Sustainable Development (HM Government, Welsh Assembly Government, Scottish Executive and Northern Ireland Office 2005). This framework has been adopted by all four devolved government administrations which make up the United Kingdom, and states that 'For the UK Government and the Devolved Administrations, the goal [of sustainable development] will be pursued in an integrated way through a sustainable, innovative and productive economy that delivers high levels of employment, and a just society that promotes social inclusion, sustainable communities and personal well-being' (2005: 7). It sets out five key guiding principles for achieving sustainable development across the UK:

- living within environmental limits;
- ensuring a strong, healthy and just society;
- achieving a sustainable economy;
- promoting good governance, and
- using sound science responsibly.

A crucial change in government policy, which includes sustainable development as a focus, is the emphasis on equality and diversity (ODPM 2005). Equality and diversity are not to be treated as 'fringe' issues, but must become part of the planning mainstream.

- They can now be material considerations in planning policies and decisions.
- They should be an integral part of everyday service delivery and not an added extra.
- Planners should take positive action to ensure that their practice and policies are inclusive and do not result in the systematic disadvantaging of some communities or individuals.

River water quality is one of the headline indicators of the UK Sustainable Development Strategy (DETR 1999, Defra 2005). This strategy relates to England only, with the devolved administrations each developing their own strategies and action plans. In Defra's (2002) strategy for the environmental quality of water, it is recognised that issues of social distribution in particular need to figure more centrally in water quality management policies. The strategy states that 'water policy needs to be clearly grounded in the Government's commitment to sustainable development, covering economic, environmental and social aspects' (Defra 2002, p.5).

6.3 Water quality in the UK

6.3.1 Determinants of water quality

Water quality can be affected by both point and non-point (diffuse) sources of pollution. In rural areas, water quality may be reduced by high levels of nitrates, which come mainly from agricultural run-off. Despite being essential for aquatic life, at elevated concentrations nitrates can adversely affect the ecology of rivers and their recreational potential. River stretches containing high concentrations of nitrates require extra treatment before being used to supply drinking water.

Many of the worst quality river stretches can be found in urban areas, as the number of pollutants and both point and non-point discharges are often extremely high in these areas. Urban areas (which comprise one ninth of the river network in England and Wales; Environment Agency 2002a) have large areas of sealed and impermeable surfaces. Rainwater runs over these surfaces into watercourses, picking up contaminants along the way. Pesticides and herbicides can reach rivers from road verges, railways, gardens, allotments and parks. Oil, diesel, heavy metals, road salt and other chemicals are washed off road surfaces and may find their way into watercourses. Water pollution incidents cause a temporary pollution load and biological damage that may take months or years to recover (Petts *et al*. 2001). Historically, these pressures have led to chronically poor water quality in urban river stretches. In recent years, a combination of pollution control measures, changes to industry and better urban planning have greatly improved urban water quality (Barrett *et al*. 1997). However, Environment Agency (2002b) data show that stretches in around one in six urban rivers have been assessed as being of either poor or bad quality.

Industrial effluents may also increase the pollutant load in parts of urban rivers. The exact nature of such effluents largely depends on the industrial processes being used, but heavy industrial processes such as metal working may cause an increase in metal concentrations (such as lead, copper, aluminium, iron and cadmium) in the river stretch. Urban areas can also have a major impact on groundwater quality due to present or historical industrial pollution, which can contribute heavy metals or inorganic chemicals from solvents or fuel.

The most important impacts on river stretches are from the discharge of sewage effluents, which form a significant source of phosphate, bacterial and organic matter contamination. There are 1600 sewage treatment works that serve areas of 2000 population equivalents or more, and around 700 that serve areas of 1000 population equivalents or more (Petts *et al*. 2001). Inputs from industrial and domestic sources have a significant impact on regional water quality in urban areas (Oguchie *et al*. 2000, Jarvie *et al.* 2000). Indeed, although pollution from sewage-related sources is being reduced as a result of significant investment by water companies in recent years, sewage effluents are still a major cause of poor water quality in urban areas.

6.3.2 Monitoring and assessment regime

The reporting of river classification in England and Wales began in 1970 with the publication by the Department of Environment (DoE) of the *River Pollution Survey*. An unofficial survey had been carried out in 1958, but the results of this survey were only published with the results of the 1970 survey. These surveys recorded the general state of rivers, canals and estuaries. They have been repeated every five years since 1970 and have allowed an assessment to be made of the effectiveness of the pollution control authorities in the UK to maintain and improve water quality. The classification exercise undertaken in 1970 placed rivers and canals into four classes based on measurements of BOD and other less precise criteria involving the type of effluents discharged and the number of complaints received. Biological quality was also measured.

After the creation of the Water Authorities in 1974, the National Water Council (NWC 1977) reviewed both the classification of water quality and the policy on setting consents for discharges. From 1978 to 1979, all Water Authorities classified their rivers using a new classification system, of which the main chemical determinants were BOD, dissolved oxygen and ammonia, (which are all particularly relevant to the assessment of water quality in rivers receiving effluents from sewage treatment works). The classes were defined in terms of the levels of those determinands needed to protect the more important uses of the watercourse, such as fisheries and abstraction for drinking water supply.

The Water Act 1989 provided a means of formally implementing a nationally consistent system, which incorporated European Commission directives and other use-related objectives specific to local needs. Inadequacies in the NWC system had emerged because the implementation of the standards required a high degree of subjective interpretation (Faulkner *et al*. 2000). The standards included both a classification function (an assessment of absolute water quality at a given point) and a use-related objective-setting function (an assessment of whether the water was at a suitable level of quality for its agreed uses). The distinction between these two functions was unclear. Furthermore, the NWC classification had no statutory basis. The National Rivers Authority (NRA) recommended that the classification and objective-setting functions should be separated, by using a GQA system to define water quality and then independently setting a range of use-related River Quality Objectives (RQO).

The GQA system provides an assessment of several aspects of water quality.

- Biological quality – an indicator of the overall 'health' of rivers (monitored on a five yearly basis, introduced by the Environment Agency in 1995).
- Chemical quality – an indicator of organic pollution in general through measurements of BOD and concentrations of dissolved oxygen and ammonia (monitored every three years).
- Nutrient status.

- Aesthetic quality – assesses the amounts of litter, sewage-derived waste, oil, scum, foam, sewage fungus and ochreous deposits, and dog fouling at selected sites, as well as the colour and smell of the water.

Biological and chemical quality was measured at 7,000 sites in England and Wales, representing around 40,000 kilometres of the river and canal network. The Environment Agency reported on aesthetic quality for the first time in 2000, based on measurements taken at 452 'well visited' sites in England and Wales.

The GQA system grades rivers into six classes ranging from A to F, where A represents high quality and F represents poor quality rivers. The criteria for assessment of biological quality are presented in Table 6.1.

Table 6.1 General Quality Assessment scheme for biological water quality

Grade	Description
A. Very good	Biology similar to (or better than) that expected for an average and unpolluted river of this size, type and location: high diversity of taxa, usually with several species in each, rare to find dominance on any one taxon
B. Good	Biology falls a little short of that expected for an unpolluted river, small reduction in the number of taxa that are sensitive to pollution, moderate increase in the number of individuals in the taxa that can tolerate pollution
C. Fairly good	Biology worse than that expected for an unpolluted river, many taxa absent, or number of individuals reduced, marked rise in numbers of individuals in taxa that tolerate pollution
D. Fair	Sensitive taxa scarce and contain only small numbers of individuals, a range of pollution tolerant taxa present, some with high numbers of individuals
E. Poor	Biology restricted to pollution tolerant species with some taxa dominant in terms of the numbers of individuals, sensitive taxa are rare or absent
F. Bad	Biology limited to a small number of very tolerant taxa such as worms, midge larvae, leeches, water buglouse, present in very high numbers, in the worst case there may be no life present

Source: Green and Faulkner (2000)

General Quality Assessments were last carried out in 2004. The biological quality element of the GQA uses RIVPACS (River InVertebrate Prediction and Classification System). This is a computer based tool that uses macroinvertebrate sampling (Clarke *et al*. 2003) and which has become the principal tool used by the Environment Agency for assessing the ecological quality of rivers throughout England and Wales. RIVPACS depends on the use of a set of reference sites, which are river stretches that are considered to be of high ecological and chemical quality and representative of the best examples of their particular river type. Statistical models are then developed, relating the environmental characteristics of any reference site to its macroinvertebrate fauna. Discriminant analysis is used to derive equations that represent the best fit between the biological classification and measured values at each reference site. Next, these variables are measured for any new site and the values are entered into the equations from the database of reference sites to predict the fauna to be expected at the test site, and to derive an index of ecological quality for that stretch of river.

6.3.2.1 Discharge consents and abstraction licensing

Under the Water Resources Act (WRA) 1991, it is an offence to cause, or knowingly permit, polluting matter to enter into ‘controlled waters’. Permission is obtained as a discharge consent from the Environment Agency. Each consent is based on the objectives set by the Environment Agency for the quality of the stretch of water to which the discharge will be made, as well as any relevant standards from EU Directives. In addition to preventing pollution from occurring, the Environment Agency is responsible for ensuring that water resources are managed effectively so that all user needs can be met. Anyone who wishes to take water from a surface or underground source must obtain a license to do so from the Environment Agency. Conditions placed on abstracting surface waters enable flow to be maintained at levels that the Environment Agency considers necessary to ensure that quality objectives are achieved.

6.3.3 Facts and figures

The biological and chemical quality of rivers has improved greatly since 1990. This is due to a combination of factors, including the clean-up of discharges from industry and sewage treatment works, tighter enforcement of discharge consents by the Environment Agency and a stronger focus on pollution prevention. The most recent data from Environment Agency assessments of water quality in England and Wales date from 2003 and are outlined in Table 6.2.

Table 6.2 Water quality in England and Wales, 2003

Parameter	Quality classification	Percentage of river reaches achieving standard	1990 figures	1990–2003 improvements
BIOLOGICAL QUALITY	Good	70%	90% were good or fair	31% of rivers improved in quality
	Fair	25%		
	Poor	4%		
	Bad	1%		
CHEMICAL QUALITY	Good	65%	85% were good or fair	37% of rivers improved in quality
	Fair	29%		
	Poor	5%		
	Bad	1%		
NUTRIENT STATUS	High phosphate levels (>0.1 mg/l)	53%	64%	-
	High nitrate levels (>30 mg/l)	27%	30%	-

Source: Environment Agency website (www.environment-agency.gov.uk)

In terms of aesthetic quality, two thirds of the 452 test sites were deemed to be aesthetically good or fair in the 2000 survey. The rest were assessed as either of poor or bad quality.

Despite the above improvements to water quality in England and Wales over the past decade, many of the worst quality water bodies are still found in urban areas.

- 41 per cent of urban rivers had good chemical quality (compared with 71 per cent in rural areas).
- 31 per cent of urban rivers had good biological quality (compared with 70 per cent in rural areas).
- 15 per cent of urban rivers where the population density was greater than 1,000 people per square kilometre and 23 per cent of rivers in metropolitan council areas were assessed as having poor or bad chemical quality (compared to the national picture of six per cent).

Given that the majority of deprived populations are found in urban areas, this urban bias to poor river water quality matches, and to some extent explains, the results of the analysis in section 5.

6.4 The changing context of water quality policy

6.4.1 Legislative drivers for water quality improvements

In recent years, EC directives and quality standards set at European level have increasingly driven water quality management policy. There are about 30 EC directives concerning water (Defra 2000). The Water Framework Directive (WFD) (2000/60/EC) is set to have the most far-reaching consequences for management policy in England and Wales, and represents the largest and most significant piece of EU water policy to be developed for at least 20 years.

6.4.1.1 The Water Framework Directive

The adoption of the WFD is widely considered to represent an important paradigm shift in the way that water bodies are managed across the EU. The Directive places greater emphasis on catchment-focused management and the interdependency between biological and physico-chemical elements and processes. It begins to view river management according to a systems approach and the river ecosystem as the interaction of ecology, hydrology and geomorphology (Clark *et al*. 2003). The driving force of the Directive is the ecological status of water bodies. It will require all member states, by 2015, to ‘protect, enhance and restore all bodies of surface water’ not designated as artificial or heavily modified, with the aim of achieving ‘good surface water status’, a state defined by a number of ecological, morphological and chemical parameters.

A key feature of the WFD is the introduction of a new definition of water status, which is concerned with the ecological health of surface water, as well as with chemical standards. Key requirements (as outlined by Clarke *et al.* 2002) are:

- To establish a holistic approach to managing the water environment, based on river basins, and integrate water quantity with quality considerations.
- To set quality objectives for all water bodies and meet those objectives by 2015 in most cases.
- To establish a quality classification system for surface water that includes chemical, hydromorphological and ecological parameters, using criteria set out in the Directive.

- To have statutory controls in relation to the pollution of water bodies from point and diffuse sources.
- To promote sustainable water use based on long-term protection of water resources.
- To achieve environmental objectives in a cost-effective way.

6.4.1.2 Other legislation and directives relating to water quality

A number of other key pieces of legislation and EC directives relate directly to water quality management in England and Wales.

- **Environmental Protection Act 1990:** Established statutory provisions for a range of environmental protection purposes, including integrated pollution control for dangerous processes.

- **Water Resources Act 1991:** Consolidated previous water legislation in respect of both the quality and quantity of water resources.

- **Environment Act 1995**: Established the Environment Agency and introduced measures to enhance the protection of the environment, including further powers for the prevention and remediation of water pollution.

- **EC Freshwater Fish Directive (78/659/EEC):** Aimed at protecting the health of freshwater fish populations, by designating waters in need of protection and setting quality standards for those waters.

- **EC Urban Waste Water Treatment Directive (91/271/EEC):** Sets requirements for the provision of collecting systems and the treatment of sewage according to the size of the discharge and the nature of the receiving water.

- **EC Nitrates Directive (91/676/EEC):** Requires the reduction in waters of nitrate pollution arising from agricultural inputs. Member states must identify polluted waters, designate those areas of land that drain into them as 'nitrate vulnerable zones' and thereafter establish and implement programmes of remedial action.

- **EC Dangerous Substances Directive (76/464/EEC):** On pollution caused by certain dangerous substances discharged into the aquatic environment.

As a requirement of the WFD, the Freshwater Fish and Dangerous Substances Directives will be repealed in 2013, along with several other water-related directives.

6.4.2 Holistic river basin management

Environmental management policy is increasingly encompassing a broader view of what counts as 'water management', comprising more than the traditional responsibilities of the water utilities (Defra 2002). During the past decade, it has been recognised that effective water resource management must be holistic and integrated, and policy approaches have been changed accordingly. For instance, in England and Wales the Environment Agency has introduced catchment abstraction management strategies that explicitly recognise that rivers have multiple users and that the needs of all users must be addressed in order to identify the optimal solutions for river management (McDonald *et al*. 2004). Similarly, the WFD requires the management of river basins as a whole. The first stage towards fulfilling these requirements is river basin characterisation. Whereas GQA water quality assessments focus on classifying rivers and other water bodies in terms of chemical and biological quality, river basin characterisations are used to assess and manage pressures on the water environment in an integrated and holistic way. A greater variety of criteria need to be assessed, particularly in terms of pollutant discharges.

Under the WFD, river basin characterisation comprises a two-stage assessment of water bodies. The first stage entails identifying water bodies and describing their natural characteristics. The second stage entails assessing the pressures and impacts of human activities on the water environment. This assessment identifies those water bodies that are at risk of not achieving the environmental objectives set out in the WFD. It also outlines monitoring programmes and improvement schemes to be implemented in the forthcoming years, targeted at achieving the good ecological status for all water bodies required by the WFD. The preliminary characterisation process has already been undertaken in England and Wales. Risk assessments have shown that 23.1 per cent of rivers are at risk of not achieving WFD objectives in terms of point discharges, while 82.4 per cent are at risk of not achieving WFD objectives in terms of diffuse pollution.

The WFD also requires the production of river basin management plans (RBMP) for all major rivers in all European member states by the end of 2009 (Environment Agency 2005). One key benefit of introducing an integrated and holistic approach towards river basin management is better integration of the current large number of separate local or regional river plans, including those covering environmental improvements, abstraction and flooding. Such an approach will also have key benefits in allowing improvements to be achieved in the most cost-effective way.

The main reporting unit for the RBMP is the River Basin District, which is defined as a river basin or several river basins, together with stretches of coastal waters. RBMPs are based on these districts and set out how the objectives for the district will be achieved. In 2005, there were 11 river basin districts identified in England and Wales. Of these, six are wholly in England, one is wholly in Wales, two span the England and Wales administrative boundary, and two span the England and Scotland administrative boundary.

Integrated River Basin Management will achieve the WFD objectives through six-yearly cycles of planning and action. The river basin planning process aims to:

- make environmental and economic assessments;
- establish monitoring programmes and means of analysing results;
- set environmental objectives;
- develop improvement programmes to achieve those objectives.

6.5 River restoration and enhancement

A key policy intervention related to water quality in England and Wales is river restoration and enhancement works, which have been attempted more often in recent years. Historically, more effort has been put into protecting good quality water rather than improving poor quality water. Increasingly, however, ecologically-based restoration activities are being conducted in order to improve degraded waterways. It is increasingly recognised that returning river stretches to their ‘natural’ state can bring widespread benefits, not just to biodiversity but also in terms of wider regeneration and renewal (Eden *et al.* 1999, 2000).

Despite little agreement as to what constitutes a successful river restoration effort (McDonald *et al*. 2004, Palmer *et al*. 2005), there has been widespread adoption of river restoration and river habitat enhancement schemes in North America, Australia and in a number of European countries. The UK River Restoration Centre, established in 1998, now has a database of more than 800 restoration projects undertaken in the UK (Janes and Phillip 2002). The floodplain restoration discourse has been influenced by the concepts of sustainability and sustainable development (Adams *et al*. 2004). In the UK, most river restoration projects, which are usually undertaken by, or in conjunction with, the Environment Agency, have been relatively modest, involving limited attempts to restore elements of the structure or function of river systems, and to increase aquatic or riparian diversity. Most UK projects were initially confined to river channel improvements or changes to the immediate banks of rivers. These have gradually been extended to the wider floodplain.

Once restored, a river can bring far-reaching changes to the surrounding area. Aside from the environmental and biodiversity benefits, a restored river or river stretch can give local people an accessible, high quality natural space within walking distance from their homes. River corridors can contribute to sustainable transport strategies by providing safe walking and cycling routes, and can encourage people to appreciate their local environment. Attractive rivers can also become a focal point for local people and help to promote a sense of community, as well as helping local economic development by attracting new businesses (Pedroli *et al*. 2001, Tunstall *et al*. 1999, Vivash *et al.* 1998).

River restoration schemes are increasingly recognising the holistic approaches adopted by in the management of green spaces and woodlands. Policy makers could usefully engage more with the research and policy into woodlands and green space to inform future water quality policy.

The fact that many of the most degraded rivers in the UK are in more deprived urban areas has meant that some waterway regeneration projects have targeted socially deprived areas. Perhaps the best known and most frequently cited example of a successful river restoration, and its potential to enhance the quality of the surrounding area, is that of the Mersey Basin Campaign. The Mersey was one of the most polluted and heavily engineered watercourses in Europe (Nolan and Guthrie 1998). It was degraded to such an extent that in 1985 the Mersey Basin Campaign was established as a partnership between central and local government, with a 25-year programme of water quality improvements and bank side development (Burton 2003).

Since 1985, water quality in the Mersey has improved, fish have returned to formerly polluted stretches of river and there has been substantial waterside regeneration (Jones 1999, Struthers 1997). The campaign is now seen as a model for engaging co-ordinated environmental action through a partnership approach. Indeed, the improvements have been so significant that in 1999 the Mersey Basin Campaign won the Australian River Symposium Prize for excellent river management and encouraging the restoration of problematic rivers.

6.6 Conclusion

The foregoing discussion shows the far-reaching changes that water quality management policy is undergoing in England and Wales, with the implications of the WFD still unknown in many senses. The move towards holistic river basin management clearly has significant potential benefits for the way in which water quality is managed, with its emphasis on integration and the ‘joined-up’ nature of both the pressures and solutions to water quality problems.

The final section outlines some policy recommendations regarding water quality and its impacts for social equity.

7 Recommendations

The relevance of issues of water quality to concerns about environmental inequality and injustice have been little examined in the research literature and have not, as yet, featured significantly in policy. In this report we have focused on river water quality, but noted that there are potential equity issues to be explored for other categories of water quality as well (see recommendation six below).

For river water quality alone, the social impacts that may be experienced for poor river water quality are multidimensional, to some degree uncertain in their scale and severity, and likely to be differentially rather than equally experienced. But this variance in experience is not necessarily along conventional lines of social differentiation (in terms of deprivation, ethnicity, gender, disability) or related to area-based social characteristics. For example, some of the impacts of poor water quality identified in section 4 (particularly those experienced by individuals rather than neighbourhoods as a whole) are entirely dependent on the use made of the river environment – if the river environment is avoided these impacts will not be experienced. The propensity or ability to use the river environment may be related to social characteristics, but also to interests and leisure choices that cut across social groupings.

For these reasons, the development of policy recommendations is not as straightforward as for the related area of flood risk (where the physical relationship between impacts/risks and social differentiation is more direct and established). There is therefore a need for the relationship between river water quality and social inequality, and its policy significance, to be carefully considered and discussed both within and beyond the Environment Agency. Such discussion could not take place within the time period of the research project and so should be pursued in alternative arenas.

Recommendation 1: The multidimensional social impacts of a poor river environment as identified in this report, and their relationship to issues of inequality, need to be further considered and evaluated.

The data analysis in this report has focused on one social parameter – multiple deprivation as recorded for census SOAs – and measured the physical association between people living in these areas and river stretches classified at different levels of biological water quality. The national scale analysis found a clear pattern of inequality in this physical association – the poorer the quality of the river stretch the greater the proportion of deprived people living in its vicinity. It was also observed that although the length of rivers in England classified as bad or poor is now very small, in population proximity terms these rivers are significant because they run through heavily populated areas, which are also some of the most deprived in the country. The regional analysis found that the national pattern of association with deprivation was maintained to some degree across most of the regions, although the proximity of deprived populations to poor quality rivers is concentrated in three regions (North West, Yorkshire and Humberside, and London). The comparatively simple relationship observed at a national level does, however, become more involved when disaggregated into its regional parts.

Whilst the association has been shown to exist, its significance in policy terms needs to be carefully evaluated. The existence of the association does not necessarily mean that it is significant, either for the management of water quality or to the lives of deprived people living near to poor quality rivers. This evaluation needs to take account of: (a) the complex characteristics of the relationships between river water quality and social deprivation outlined in earlier sections; (b) the methodological limitations of the analysis; and (c) the multiple drivers for intervention to protect or improve river water quality. The management of river water quality is pursued on a number of grounds. These include: to protect habitats and the intrinsic ecological value and biodiversity of rivers; to contribute to the provision of good quality drinking water; to protect the quality of fisheries, including for economic reasons; and to provide a functional, attractive and aesthetically pleasing environment for those people who use and experience the river and river corridor in various ways. These drivers clearly engage with populations and social characteristics to different degrees. A driver focused on habitat protection may be less concerned with social concerns and issues of inequality than will be a driver focused on multi-functional recreational amenity (although social concerns about habitat enhancement featured heavily in the SMURF river restoration project).

Recommendation 2: The policy significance of the evidence identified in this report of an association between poor biological river water quality and deprivation needs to be carefully evaluated.

As soon as evidence of an inequality has been established, it is usual to ask why it might exist – what causal factors may have led to this unequal situation. Finding causal factors that explain the association between poor river water quality and deprivation has not been within the remit of this research project. Nevertheless, it is possible to conjecture that the following factors could be relevant.

- Heavily urbanised and industrial areas impose a heavy pollution load on rivers, and these are also the areas where most deprived populations tend to be concentrated. Conversely the best quality rivers are found in rural areas where population densities and (some) pollution inputs are typically much lower and where significant deprivation (as measured by the IMD) is rarely found.

- Housing markets may have developed over time to reflect local environmental quality, including the quality of the river environment, such that better quality housing is found near to good quality river environments;.

- Decisions on interventions to protect and/or improve river water quality may have, for various reasons, not valued river environments in urban deprived areas as highly as those in other areas.

This last potential factor is particularly speculative, but raises potentially significant questions about how decisions on the deployment of management resources are made and how equitable these decisions are (including the use of policy or investment appraisal techniques). Further work could potentially be undertaken to explore these and related issues.

Recommendation 3: Further work should be undertaken to explore the factors that may explain the association between poor river water quality and deprivation, including the role of decision-making processes in river water management.

If the evidence of inequality in the social distribution of river water quality is considered to be robust and significant in policy terms (as outcomes of recommendations one and two), the need for additional policy interventions should be considered. In what ways might the management of river environments need to change to incorporate justice concerns? One argument might be that if the poorest quality rivers are to be targeted for improvement in any case, including through the implementation of the WFD, then deprived communities are going to benefit the most, as they are living near to these prioritised river stretches. If this *is* the case, then justice concerns are simply added alongside other drivers, which are already directing attention towards the worst quality river environments. If, however, processes of prioritisation are not already working in this way, then the case for further targeting of interventions in deprived areas needs to be considered.

There are significant potential impacts for environmental inequality in the WFD. Although the primary WFD objective is to ensure that all water bodies achieve 'good' status, there is the possibility that derogations, which are allowed for specific water bodies, may be biased towards areas of social deprivation, meaning that water quality improvements in those areas may not be fully realised.

It is also important to recognise the limits of what can be achieved through policy. Despite some river restoration projects targeting poor water quality in deprived urban areas, it must be remembered that urban rivers are affected by their urban environment, in terms of the way they have been engineered. They are often culverted and channelised, but cannot be extensively remodelled because of the various knock-on effects that the change would have, such as to flood risk control.

Recommendation 4: The case for further targeting of policy interventions on poor quality rivers in deprived areas and the form that these interventions could take needs to be examined.

The key challenge is arguably to improve the quality of public spaces in disadvantaged neighbourhoods and ensure that people are not excluded from enjoying the benefits of high quality local environments. In the past, tackling such issues in deprived areas has too often resulted in short-term, unsustainable investment in patched-up solutions, rather than dealing with the underlying problem. The Social Exclusion Unit (2001) states that the joined-up nature of social problems is a key factor underlying social exclusion, but often these social problems do not received a joined-up response. The best results can be achieved only when all the different sectors and interests work together. This includes the development of local Strategic Partnerships, involving the community, public, private and voluntary sectors, and everybody with an interest, to allow the voices of local communities to be heard and to foster a sense of shared objectives.

The WFD and related policy measures now emphasise the need for the participation of stakeholders and communities living within river catchments. Improving the level of community engagement is particularly important, given drivers like the Aarhus Convention (UNECE, 1999) and the considerations of environmental justice embodied within it. Participatory processes need to be appropriate to the challenges involved in encouraging effective participation within deprived communities. Carefully monitored case study experiments along these lines could be a next step forward for policy development.

Recommendation 5: The sustainable development and inequality agenda in relation to river water quality needs to be pursued in a manner that provides realistic and 'joined-up' solutions, in which key partnerships between a range of stakeholders, including members of the public, can be successful.

It has been noted at various points in this report that the existing literature and evidence base on the social impacts of water quality and its social distribution is less developed than for other topics we have examined. There is therefore a need for further research building on the review and analysis undertaken in this project.

Recommendation 6: Further research is needed.

- **To improve our understanding of the social impacts of water quality and their differential impacts on different social groups (including disaggregation beyond simple measures of deprivation).**

- **To explore to what extent other forms of poor water quality, including drinking water and bathing water, have impacts that are experienced unequally by different social groups. Such research may need to develop new datasets.**

- **To develop more sophisticated methodologies for analysing patterns of inequality, which take account of different indicators of the quality of the river environment, different measures of social difference, and different physical relationships/distances that might apply across the range of positive and negative impacts that exist for a river stretch.**

- **To analyse how improvements in river water quality have, over time, been distributed socially and how future quality objectives may affect some groups more than others.**

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List of abbreviations

BOD	Biochemical Oxygen Demand
BWD	Bathing Water Directive
Defra	Department of the Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions
DoE	Department of the Environment
DWI	Drinking Water inspectorate
EA	Environment Agency
EC	European Community
EEC	European Economic Community
EJ	Environmental Justice
EU	European Union
FoE	Friends of the Earth
GIS	Geographical Information Systems
GQA	General Quality Assessment
IMD	Index of Multiple Deprivation
NRA	National Rivers Authority
NWC	National Water Council
ODPM	Office of the Deputy Prime Minister
RBMP	River Basin Management Plans
RIVPACS	River InVertebrate Prediction and Classification System
RQO	River Quality Objectives
SDRN	Sustainable Development Research Network
UGSTF	Urban Green Spaces Task Force
WFD	Water Framework Directive
WHO	World Health Organisation
WRA	Water Resources Act
WTP	Willingness to Pay

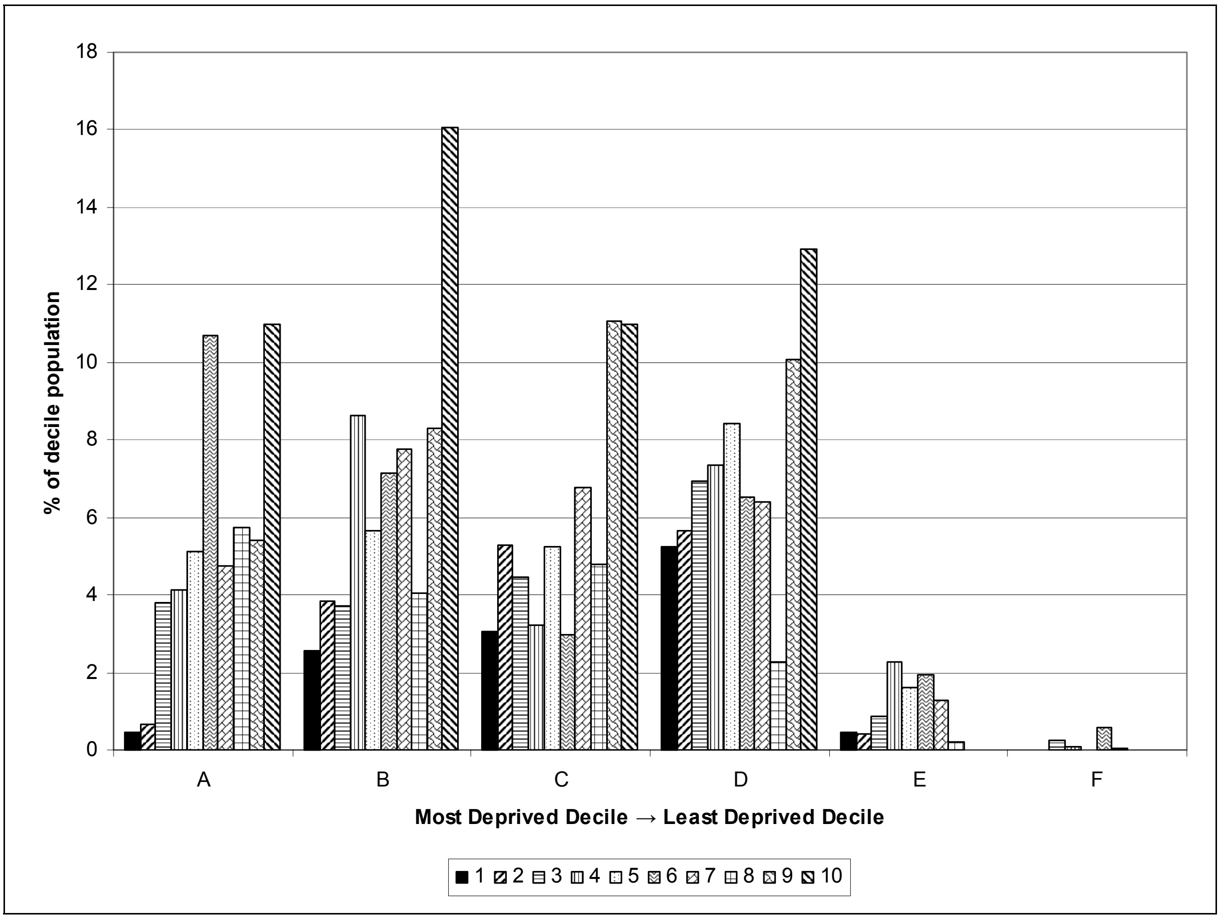
Appendix 1: River water quality and deprivation in the English regions

North East

Table A1.1 North East population within 600m of rivers by GQA biology grade

Total Population			GQA biology grade					
Decile	Population	All graded rivers	A	B	C	D	E	F
1	538,120	56,846	2,434	13,817	16,351	28,312	2,384	
2	413,640	62,403	2,649	15,948	21,829	23,383	1,784	
3	326,620	61,027	12,395	12,069	14,526	22,620	2,819	762
4	287,980	66,941	11,946	24,814	9,289	21,104	6,579	294
5	222,730	54,304	11,422	12,579	11,691	18,755	3,558	
6	213,390	54,420	22,787	15,244	6,338	13,931	4,136	1,222
7	188,600	44,573	8,928	14,613	12,732	12,068	2,446	68
8	156,090	26,221	8,967	6,299	7,497	3,521	352	8
9	113,580	36,749	6,122	9,411	12,558	11,432		
10	54,670	25,114	6,000	8,772	5,995	7,054		
North East	2,515,420	488,599	93,650	133,565	118,807	162,181	24,058	2,354
Percentage of decile population								
1	538,120	10.56	0.45	2.57	3.04	5.26	0.44	
2	413,640	15.09	0.64	3.86	5.28	5.65	0.43	
3	326,620	18.68	3.79	3.70	4.45	6.93	0.86	0.233
4	287,980	23.24	4.15	8.62	3.23	7.33	2.28	0.102
5	222,730	24.38	5.13	5.65	5.25	8.42	1.60	
6	213,390	25.50	10.68	7.14	2.97	6.53	1.94	0.573
7	188,600	23.63	4.73	7.75	6.75	6.40	1.30	0.036
8	156,090	16.80	5.74	4.04	4.80	2.26	0.23	0.005
9	113,580	32.36	5.39	8.29	11.06	10.07	0.00	
10	54,670	45.94	10.97	16.05	10.97	12.90	0.00	
North East	2,515,420	19.42	3.72	5.31	4.72	6.45	0.96	0.094
CERI values								
dec 1 & 2	951,760	0.53	0.094	0.471	0.778	0.769	0.34	
dec 1–5	1,789,090	0.65	0.314	0.592	0.663	0.966	1.00	0.33
dec 6–10	726,330	1.53	3.184	1.689	1.508	1.036	1.00	3.03

Figure A1.1 Percentage of North East population within 600m of rivers by GQA biology grade

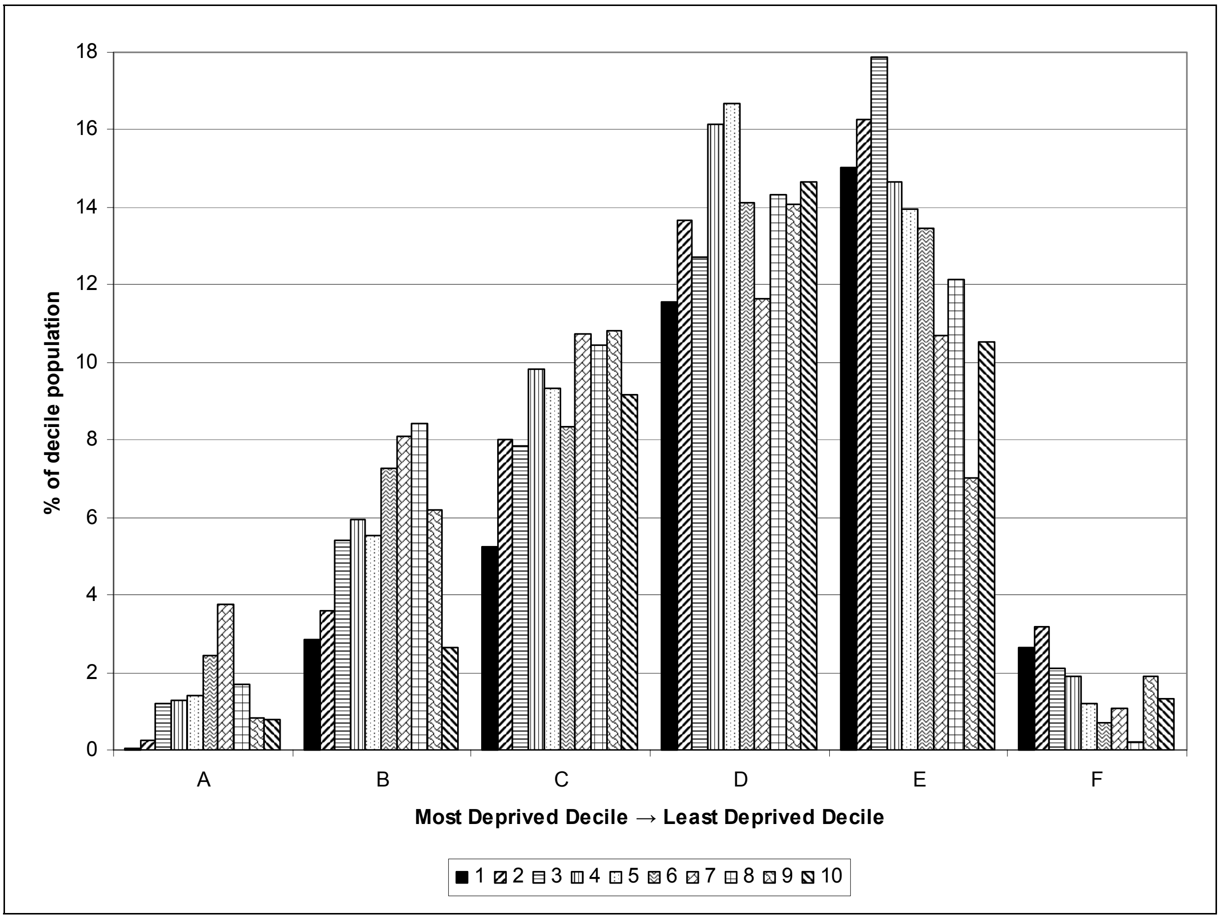


North West

Table A1.2 North West population within 600m of rivers by GQA biology grade

Total Population			GQA biology grade					
Decile	Population	All graded rivers	A	B	C	D	E	F
1	1,401,540	442,358	396	40,117	73,301	162,041	210,675	36,873
2	822,230	307,598	1,971	29,464	65,978	112,240	133,674	26,042
3	780,730	307,745	9,249	42,095	61,178	99,287	139,623	16,557
4	652,710	264,759	8,420	38,791	64,256	105,304	95,685	12,359
5	620,170	244,058	8,693	34,185	57,740	103,341	86,518	7,452
6	613,250	252,689	15,063	44,579	51,123	86,476	82,626	4,190
7	580,880	227,501	21,850	47,055	62,274	67,602	62,050	6,125
8	492,710	197,021	8,390	41,484	51,478	70,513	59,801	1,053
9	479,220	169,202	3,869	29,636	51,738	67,525	33,540	9,179
10	316,920	109,505	2,484	8,361	29,036	46,408	33,383	4,127
North West	6,760,360	2,522,435	80,385	355,766	568,104	920,736	937,574	123,958
Percentage of decile population								
1	1,401,540	31.56	0.03	2.86	5.23	11.56	15.03	2.63
2	822,230	37.41	0.24	3.58	8.02	13.65	16.26	3.17
3	780,730	39.42	1.18	5.39	7.84	12.72	17.88	2.12
4	652,710	40.56	1.29	5.94	9.84	16.13	14.66	1.89
5	620,170	39.35	1.40	5.51	9.31	16.66	13.95	1.20
6	613,250	41.20	2.46	7.27	8.34	14.10	13.47	0.68
7	580,880	39.16	3.76	8.10	10.72	11.64	10.68	1.05
8	492,710	39.99	1.70	8.42	10.45	14.31	12.14	0.21
9	479,220	35.31	0.81	6.18	10.80	14.09	7.00	1.92
10	316,920	34.55	0.78	2.64	9.16	14.64	10.53	1.30
North West	6,760,360	37.31	1.19	5.26	8.40	13.62	13.87	1.83
CERI values								
dec 1 & 2	2,223,770	0.86	0.062	0.496	0.663	0.866	1.18	2.10
dec 1–5	4,277,380	0.95	0.323	0.626	0.762	0.998	1.42	2.34
dec 6–10	2,482,980	1.05	3.098	1.596	1.312	1.002	0.70	0.43

Figure A1.2 Percentage of North West population within 600m of rivers by GQA biology grade

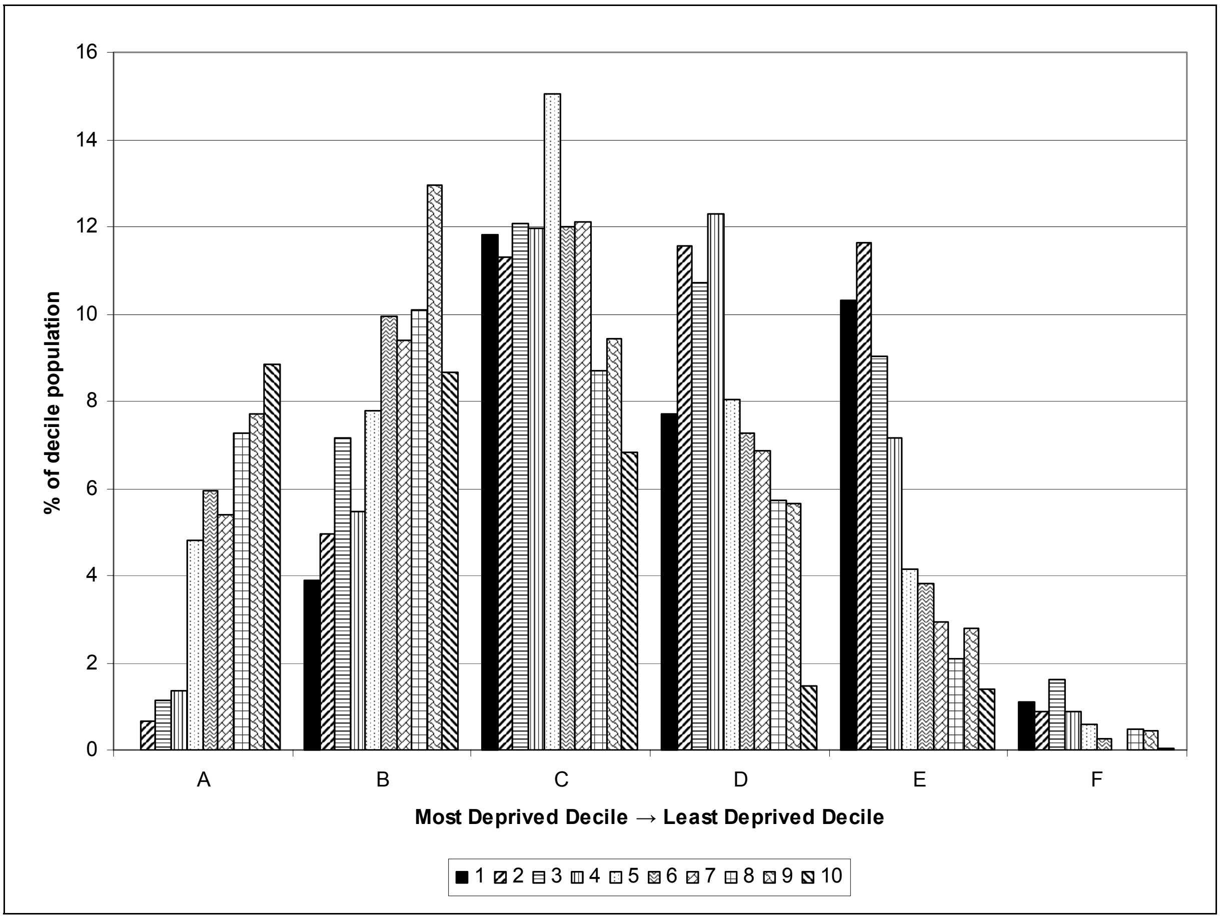


Yorkshire & Humberside

Table A1.3 Yorkshire and Humberside population within 600m of rivers by GQA biology grade

Total Population			GQA biology grade					
Decile	Population	All graded rivers	A	B	C	D	E	F
1	860,490	256,389		33,621	101,664	66,404	88,858	9,384
2	607,000	210,358	3,936	29,976	68,648	70,124	70,576	5,283
3	533,410	187,917	6,025	38,124	64,473	57,220	48,172	8,585
4	511,450	162,209	6,924	27,961	61,122	62,799	36,508	4,574
5	462,400	159,599	22,275	36,036	69,623	37,181	19,220	2,631
6	527,830	177,732	31,288	52,423	63,334	38,440	20,120	1,420
7	462,490	153,226	25,021	43,428	56,066	31,777	13,608	12
8	450,810	134,377	32,786	45,507	39,221	25,749	9,386	2,185
9	318,670	108,408	24,560	41,316	30,024	17,966	8,857	1,427
10	230,700	58,162	20,383	19,939	15,770	3,382	3,245	60
Yorkshire & Humber	4,965,250	1,608,377	173,197	368,330	569,946	411,042	318,548	35,561
Percentage of decile population								
1	860,490	29.80	0.00	3.91	11.81	7.72	10.33	1.09
2	607,000	34.66	0.65	4.94	11.31	11.55	11.63	0.87
3	533,410	35.23	1.13	7.15	12.09	10.73	9.03	1.61
4	511,450	31.72	1.35	5.47	11.95	12.28	7.14	0.89
5	462,400	34.52	4.82	7.79	15.06	8.04	4.16	0.57
6	527,830	33.67	5.93	9.93	12.00	7.28	3.81	0.27
7	462,490	33.13	5.41	9.39	12.12	6.87	2.94	0.00
8	450,810	29.81	7.27	10.09	8.70	5.71	2.08	0.48
9	318,670	34.02	7.71	12.97	9.42	5.64	2.78	0.45
10	230,700	25.21	8.84	8.64	6.84	1.47	1.41	0.03
Yorkshire & Humber	4,965,250	32.39	3.49	7.42	11.48	8.28	6.42	0.72
CERI values								
dec 1 & 2	1,467,490	0.97	0.055	0.497	1.016	1.185	2.39	1.67
dec 1–5	2,974,750	1.03	0.195	0.547	1.197	1.675	3.19	3.99
dec 6–10	1,990,500	0.97	5.115	1.827	0.836	0.597	0.31	0.25

Figure A1.3 Percentage of Yorkshire and Humberside population within 600m of rivers by GQA biology grade

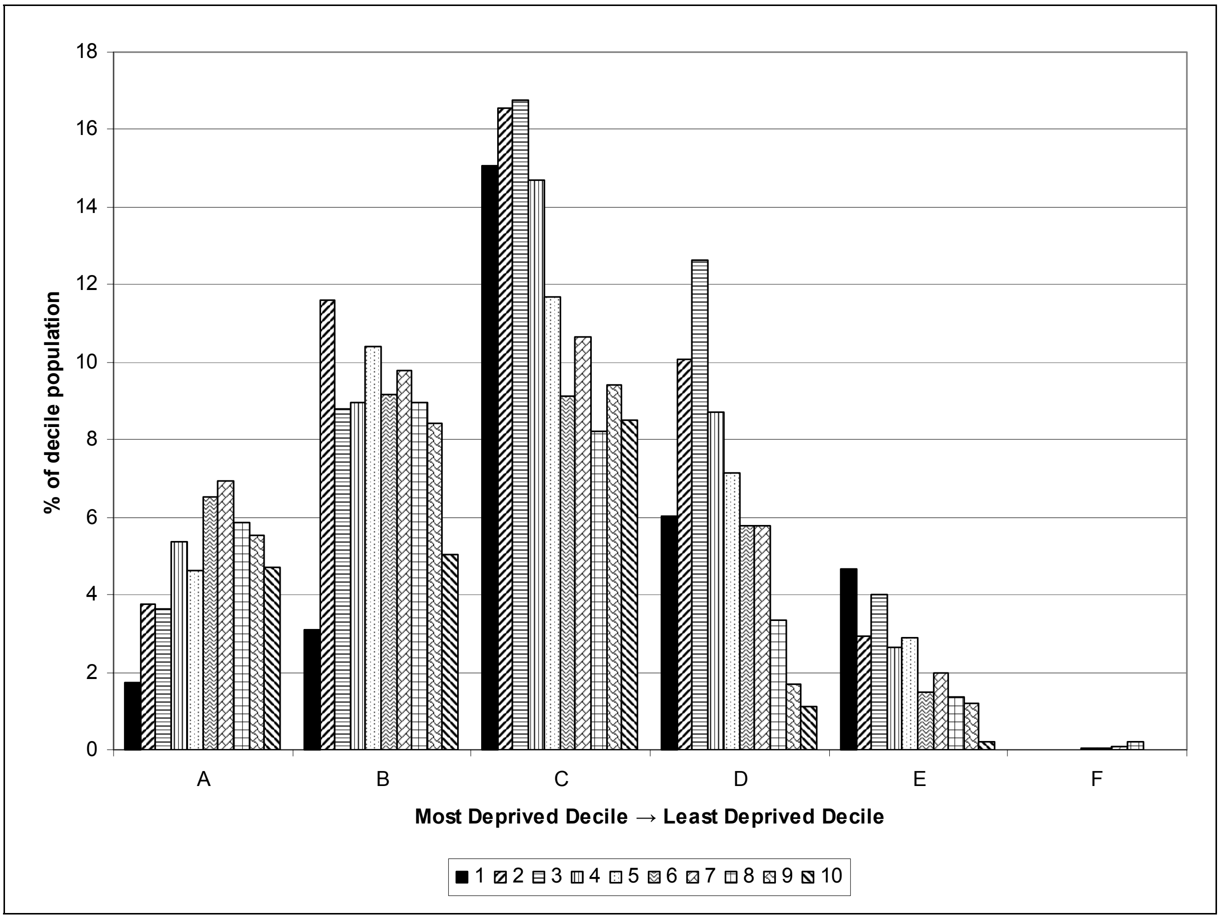


East Midlands

Table A1.4 East Midlands population within 600m of rivers by GQA biology grade

Total Population			GQA biology grade					
Decile	Population	All graded rivers	A	B	C	D	E	F
1	332,650	86,544	5,770	10,339	50,170	20,043	15,536	
2	394,390	138,421	14,835	45,710	65,241	39,752	11,569	
3	414,930	145,692	15,056	36,486	69,559	52,499	16,541	
4	458,590	148,998	24,581	41,128	67,462	40,006	12,211	22
5	402,690	124,125	18,557	41,871	47,016	28,833	11,608	121
6	383,240	104,878	25,031	35,055	34,968	22,181	5,695	131
7	441,660	131,843	30,609	43,206	46,990	25,540	8,836	329
8	467,640	111,324	27,492	41,920	38,354	15,565	6,455	960
9	496,780	112,102	27,423	41,764	46,709	8,397	5,931	
10	383,560	61,621	18,042	19,276	32,603	4,314	869	6
East Midlands	4,176,130	1,165,549	207,397	356,755	499,072	257,130	95,250	1,570
Percentage of decile population								
1	332,650	26.02	1.73	3.11	15.08	6.03	4.67	
2	394,390	35.10	3.76	11.59	16.54	10.08	2.93	
3	414,930	35.11	3.63	8.79	16.76	12.65	3.99	
4	458,590	32.49	5.36	8.97	14.71	8.72	2.66	0.005
5	402,690	30.82	4.61	10.40	11.68	7.16	2.88	0.03
6	383,240	27.37	6.53	9.15	9.12	5.79	1.49	0.03
7	441,660	29.85	6.93	9.78	10.64	5.78	2.00	0.07
8	467,640	23.81	5.88	8.96	8.20	3.33	1.38	0.21
9	496,780	22.57	5.52	8.41	9.40	1.69	1.19	
10	383,560	16.07	4.70	5.03	8.50	1.12	0.23	0.002
East Midlands	4,176,130	27.91	4.97	8.54	11.95	6.16	2.28	0.04
CERI values								
dec 1 & 2	727,040	1.13	0.523	0.884	1.427	1.437	1.89	
dec 1–5	2,003,250	1.34	0.665	1.051	1.627	2.585	2.63	0.11
dec 6–10	2,172,880	0.75	1.505	0.952	0.615	0.387	0.38	9.16

Figure A1.4 Percentage of East Midlands population within 600m of rivers by GQA biology grade

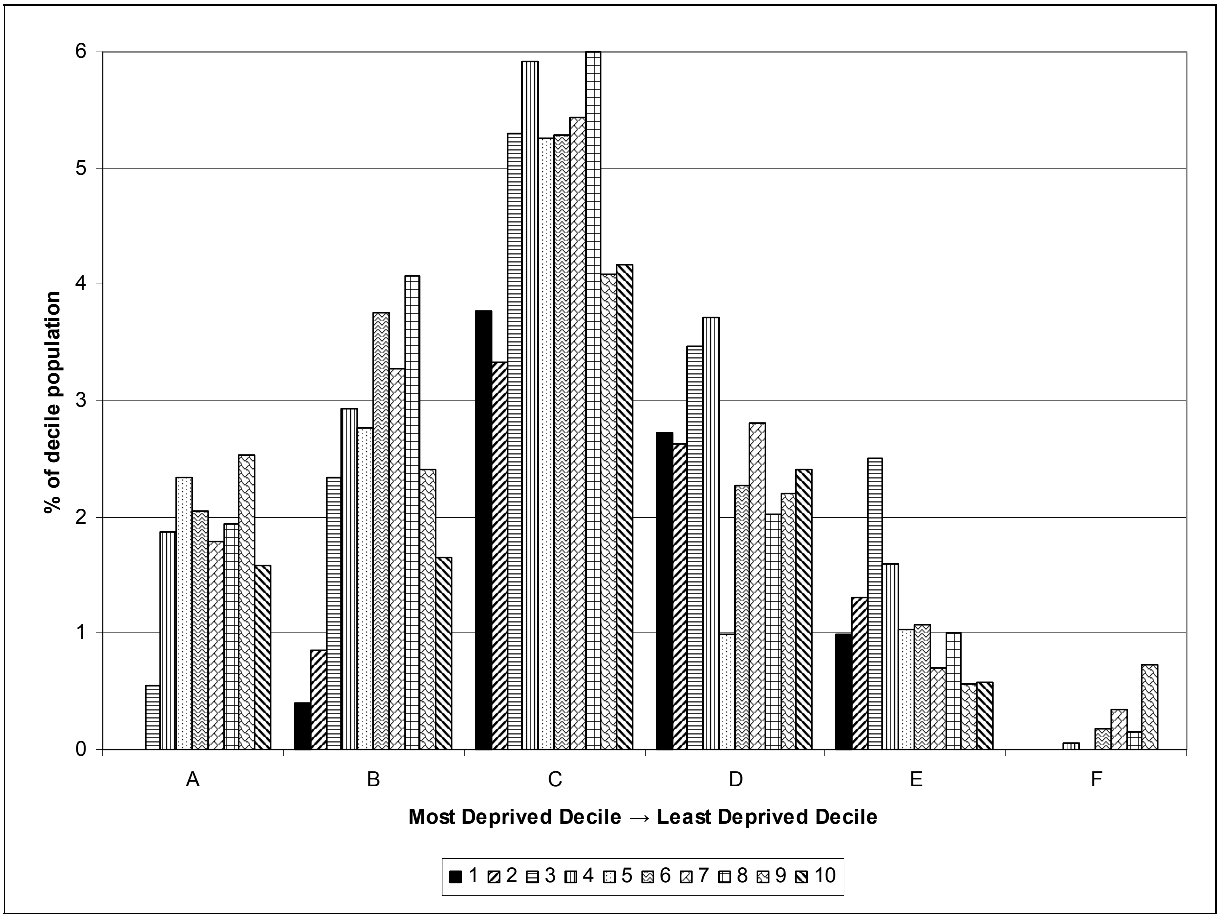


West Midlands

Table A1.5 West Midlands population within 600m of rivers by GQA biology grade

Total Population			GQA biology grade					
Decile	Population	All graded rivers	A	B	C	D	E	F
1	723,580	46,019	2	2,912	27,260	19,670	7,162	
2	679,250	45,268		5,828	22,576	17,883	8,868	
3	529,050	58,349	2,909	12,393	28,062	18,335	13,223	9
4	493,930	60,291	9,226	14,456	29,250	18,359	7,891	282
5	548,010	60,369	12,834	15,128	28,821	5,399	5,649	
6	531,040	58,813	10,880	19,983	28,071	12,092	5,731	957
7	519,820	63,481	9,297	17,015	28,224	14,628	3,660	1,806
8	479,750	59,924	9,301	19,572	28,785	9,693	4,803	726
9	422,920	42,831	10,682	10,192	17,265	9,332	2,395	3,090
10	351,800	25,074	5,556	5,796	14,673	8,451	2,029	
West Midlands	5,279,150	520,419	70,686	123,275	252,987	133,841	61,411	6,871
Percentage of decile population								
1	723,580	6.36	0.0002	0.40	3.77	2.72	0.99	
2	679,250	6.66		0.86	3.32	2.63	1.31	
3	529,050	11.03	0.55	2.34	5.30	3.47	2.50	0.002
4	493,930	12.21	1.87	2.93	5.92	3.72	1.60	0.06
5	548,010	11.02	2.34	2.76	5.26	0.99	1.03	
6	531,040	11.08	2.05	3.76	5.29	2.28	1.08	0.18
7	519,820	12.21	1.79	3.27	5.43	2.81	0.70	0.35
8	479,750	12.49	1.94	4.08	6.00	2.02	1.00	0.15
9	422,920	10.13	2.53	2.41	4.08	2.21	0.57	0.73
10	351,800	7.13	1.58	1.65	4.17	2.40	0.58	
West Midlands	5,279,150	9.86	1.34	2.34	4.79	2.54	1.16	0.13
CERI values								
dec 1 & 2	1,402,830	0.59		0.211	0.678	1.078	0.98	
dec 1–5	2,973,820	0.84	0.423	0.542	0.901	1.139	1.78	0.03
dec 6–10	2,305,330	1.19	2.362	1.846	1.110	0.878	0.56	29.14

Figure A1.5 Percentage of West Midlands population within 600m of rivers by GQA biology grade

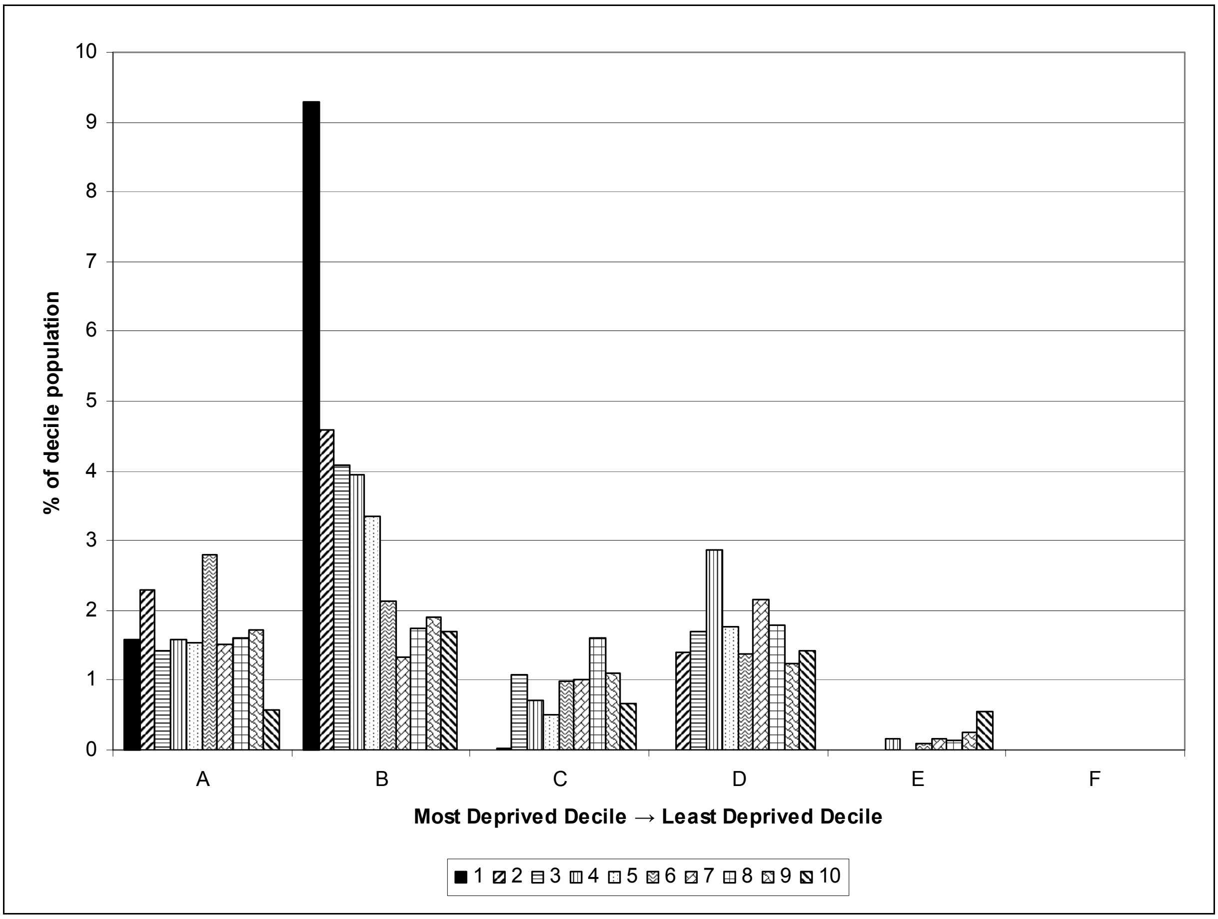


East of England

Table A1.6 East of England population within 600m of rivers by GQA biology grade

Total Population			GQA biology grade					
Decile	Population	All graded rivers	A	B	C	D	E	F
1	108,610	10,773	1,724	10,090				
2	224,490	18,056	5,150	10,302	61	3,119		
3	344,550	27,710	4,875	14,085	3,705	5,875		
4	469,910	38,232	7,459	18,578	3,366	13,441	804	
5	572,210	38,904	8,778	19,191	2,924	10,171	14	
6	612,210	41,306	17,183	13,103	6,033	8,434	526	
7	672,590	38,424	10,169	8,919	6,742	14,576	1,122	
8	728,290	46,548	11,740	12,639	11,726	13,037	1,035	
9	807,540	43,705	13,938	15,362	8,959	10,067	2,052	
10	856,770	34,983	4,973	14,575	5,625	12,097	4,698	
East of England	5,397,170	338,643	85,988	136,843	49,140	90,817	10,251	0
Percentage of decile population								
1	108,610	9.92	1.59	9.29				
2	224,490	8.04	2.29	4.59	0.03	1.39		
3	344,550	8.04	1.41	4.09	1.08	1.71		
4	469,910	8.14	1.59	3.95	0.72	2.86	0.17	
5	572,210	6.80	1.53	3.35	0.51	1.78	0.002	
6	612,210	6.75	2.81	2.14	0.99	1.38	0.09	
7	672,590	5.71	1.51	1.33	1.00	2.17	0.17	
8	728,290	6.39	1.61	1.74	1.61	1.79	0.14	
9	807,540	5.41	1.73	1.90	1.11	1.25	0.25	
10	856,770	4.08	0.58	1.70	0.66	1.41	0.55	
East of England	5,397,170	6.27	1.59	2.54	0.91	1.68	0.19	0
CERI values								
dec 1 & 2	333,100	1.41	1.321	2.662	0.019	0.541		
dec 1–5	1,719,770	1.39	1.032	2.391	0.550	1.198	0.19	
dec 6–10	3,677,400	0.72	0.969	0.418	1.818	0.835	5.39	

Figure A1.6 Percentage of East of England population within 600m of rivers by GQA biology grade and deprivation decile

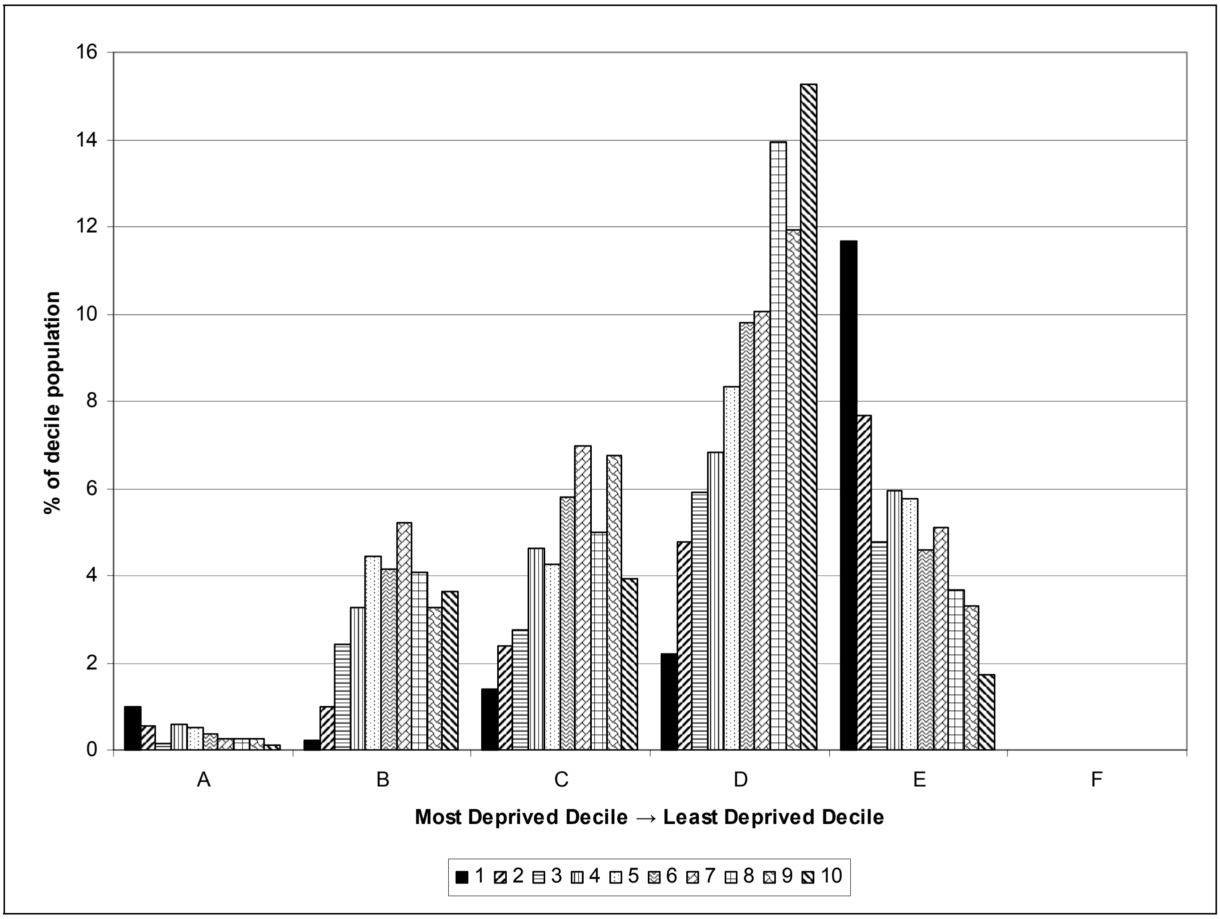


London

Table A1.7 London population within 600m of rivers by GQA biology grade

Total Population			GQA biology grade					
Decile	Population	All graded rivers	A	B	C	D	E	F
1	709,740	109,167	7,104	1,629	10,025	15,745	82,712	
2	1,224,350	183,815	6,782	12,274	29,207	58,575	94,004	
3	1,169,000	173,307	1,718	28,474	32,230	69,252	55,739	10
4	923,960	176,197	5,591	30,127	42,762	62,964	54,985	86
5	753,370	159,214	4,008	33,407	32,145	62,743	43,272	
6	686,970	148,075	2,510	28,466	39,954	67,270	31,466	33
7	570,830	140,998	1,428	29,768	39,860	57,489	29,166	
8	486,200	116,588	1,275	19,877	24,251	67,880	17,787	
9	487,390	119,921	1,315	15,934	32,911	58,156	16,021	
10	293,980	69,894	342	10,730	11,569	44,842	5,105	
London	7,305,790	1,397,175	32,075	210,687	294,913	564,916	430,256	129
Percentage of decile population								
1	709,740	15.38	1.00	0.23	1.41	2.22	11.65	
2	1,224,350	15.01	0.55	1.00	2.39	4.78	7.68	
3	1,169,000	14.83	0.15	2.44	2.76	5.92	4.77	0.001
4	923,960	19.07	0.61	3.26	4.63	6.81	5.95	0.009
5	753,370	21.13	0.53	4.43	4.27	8.33	5.74	
6	686,970	21.55	0.37	4.14	5.82	9.79	4.58	0.005
7	570,830	24.70	0.25	5.21	6.98	10.07	5.11	
8	486,200	23.98	0.26	4.09	4.99	13.96	3.66	
9	487,390	24.60	0.27	3.27	6.75	11.93	3.29	
10	293,980	23.77	0.12	3.65	3.94	15.25	1.74	
London	7,305,790	19.12	0.44	2.88	4.04	7.73	5.89	0.002
CERI values								
dec 1 & 2	1,934,090	0.74	2.121	0.196	0.426	0.421	1.94	
dec 1–5	4,780,420	0.71	1.938	0.534	0.521	0.481	1.76	1.56
dec 6–10	2,525,370	1.41	0.516	1.873	1.921	2.078	0.57	0.64

Figure A1.7 Percentage of London population within 600m of rivers by GQA biology grade

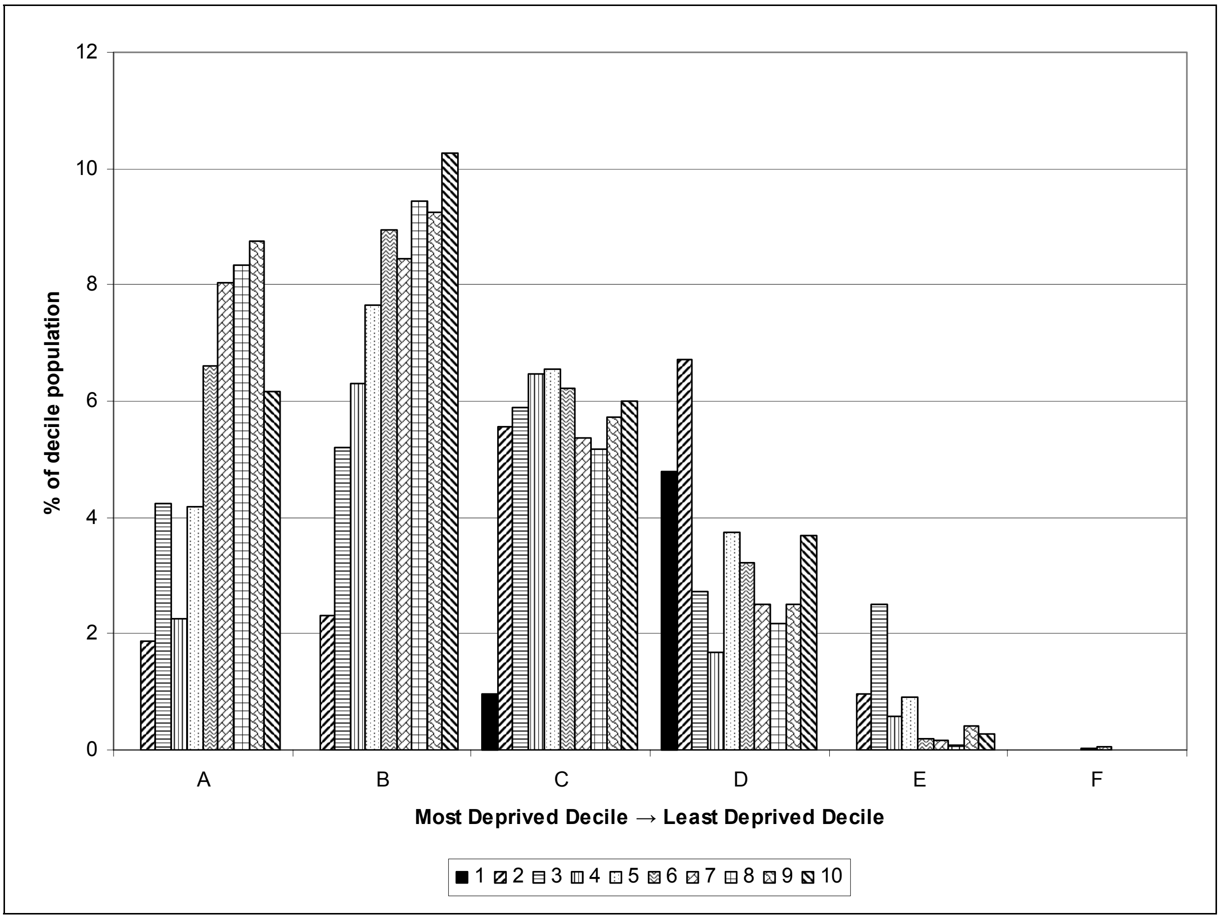


South East

Table A1.8 South East population within 600m of rivers by GQA biology grade

Total Population		GQA biology grade						
Decile	Population	All graded rivers	A	B	C	D	E	F
1	116,560	6,383			1,139	5,571		
2	292,020	46,147	5,463	6,784	16,206	19,594	2,833	
3	466,230	83,426	19,737	24,248	27,433	12,697	11,694	
4	578,700	88,764	13,138	36,499	37,385	9,676	3,330	
5	694,300	132,652	29,091	53,058	45,441	25,943	6,358	229
6	723,300	156,172	47,733	64,784	44,922	23,263	1,356	355
7	829,470	182,338	66,707	70,067	44,457	20,691	1,375	74
8	1,081,360	242,946	90,180	101,966	55,818	23,412	790	
9	1,244,020	297,293	108,860	115,096	71,123	31,298	5,251	62
10	1,987,300	479,463	122,520	203,976	118,980	73,175	5,575	33
South East	8,013,260	1,715,583	503,430	676,479	462,904	245,319	38,564	752
Percentage of decile population								
1	116,560	5.48			0.98	4.78		
2	292,020	15.80	1.87	2.32	5.55	6.71	0.97	
3	466,230	17.89	4.23	5.20	5.88	2.72	2.51	
4	578,700	15.34	2.27	6.31	6.46	1.67	0.58	
5	694,300	19.11	4.19	7.64	6.54	3.74	0.92	0.03
6	723,300	21.59	6.60	8.96	6.21	3.22	0.19	0.05
7	829,470	21.98	8.04	8.45	5.36	2.49	0.17	0.01
8	1,081,360	22.47	8.34	9.43	5.16	2.17	0.07	
9	1,244,020	23.90	8.75	9.25	5.72	2.52	0.42	0.005
10	1,987,300	24.13	6.17	10.26	5.99	3.68	0.28	0.002
South East	8,013,260	21.41	6.28	8.44	5.78	3.06	0.48	0.01
CERI values								
dec 1 & 2	408,580	0.59	0.204	0.189	0.725	2.128	1.48	
dec 1–5	2,147,810	0.72	0.422	0.592	1.039	1.168	4.61	1.19
dec 6–10	5,865,450	1.39	2.368	1.688	0.962	0.856	0.22	0.84

Figure A1.8 Percentage of South East population within 600m of rivers by GQA biology grade

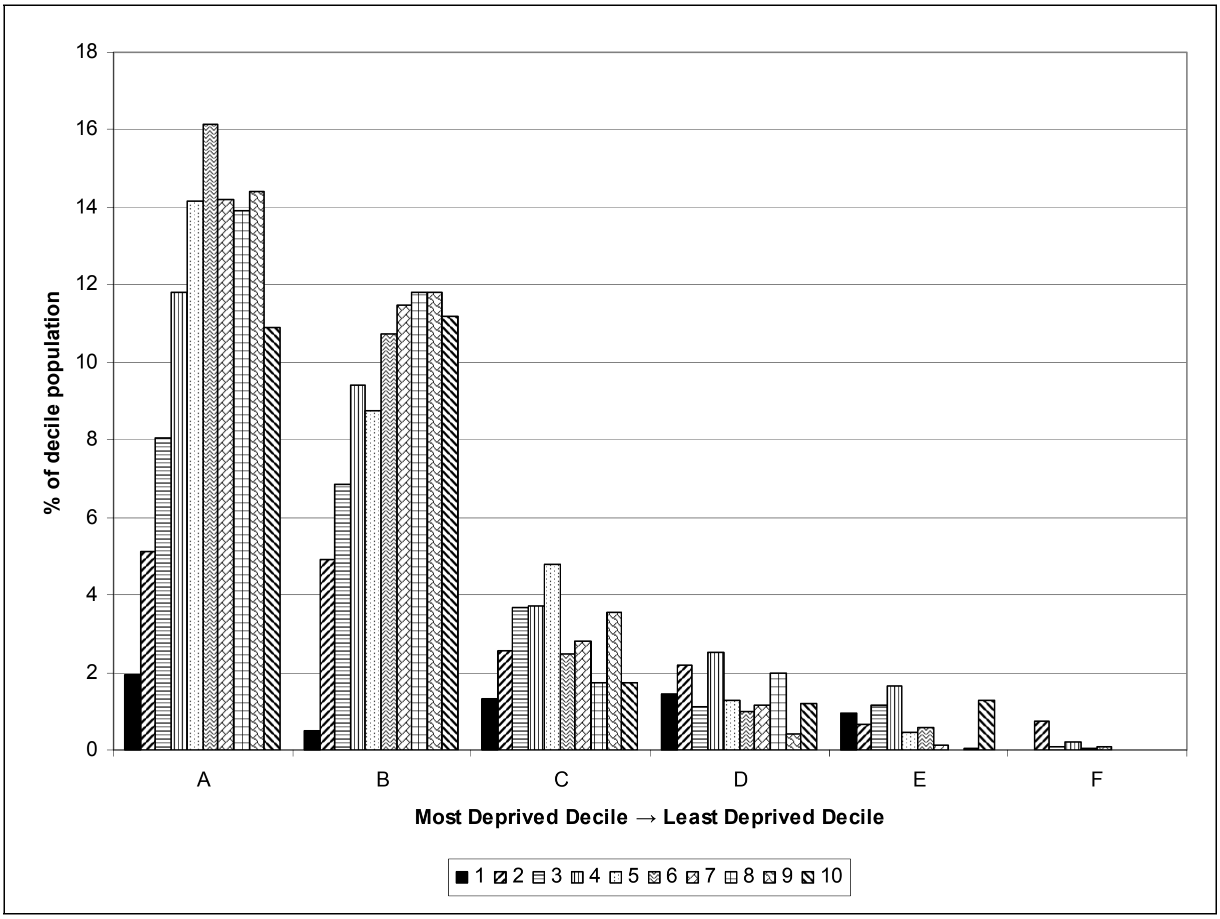


South West

Table A1.9 South West Population within 600m of rivers by GQA biology grade

Total Population		GQA biology grade						
Decile	Population	All graded rivers	A	B	C	D	E	F
1	143,140	8,851	2,797	730	1,877	2,089	1,362	
2	277,410	42,415	14,251	13,573	7,059	6,018	1,815	2,028
3	369,730	74,158	29,829	25,301	13,524	4,148	4,224	291
4	557,680	146,536	65,847	52,457	20,800	13,953	9,129	1,221
5	659,180	177,977	93,320	57,703	31,570	8,499	3,059	187
6	642,590	184,249	103,802	68,902	15,792	6,489	3,674	512
7	668,840	179,372	95,098	76,849	18,874	7,713	819	74
8	590,580	159,756	82,181	69,697	10,242	11,717	41	
9	565,040	152,785	81,406	66,811	20,091	2,224	127	
10	458,800	108,144	49,929	51,267	7,903	5,491	5,959	
South West	4,932,990	1,234,242	618,459	483,290	147,730	68,341	30,209	4,313
Percentage of decile population								
1	143,140	6.18	1.95	0.51	1.31	1.46	0.95	
2	277,410	15.29	5.14	4.89	2.54	2.17	0.65	0.73
3	369,730	20.06	8.07	6.84	3.66	1.12	1.14	0.08
4	557,680	26.28	11.81	9.41	3.73	2.50	1.64	0.22
5	659,180	27.00	14.16	8.75	4.79	1.29	0.46	0.03
6	642,590	28.67	16.15	10.72	2.46	1.01	0.57	0.08
7	668,840	26.82	14.22	11.49	2.82	1.15	0.12	0.01
8	590,580	27.05	13.92	11.80	1.73	1.98	0.01	
9	565,040	27.04	14.41	11.82	3.56	0.39	0.02	
10	458,800	23.57	10.88	11.17	1.72	1.20	1.30	
South West	4,932,990	25.02	12.54	9.80	2.99	1.39	0.61	0.09
CERI values								
dec 1 & 2	420,550	0.46	0.304	0.327	0.691	1.444	1.26	9.52
dec 1–5	2,007,140	0.84	0.728	0.655	1.496	1.504	2.69	9.28
dec 6–10	2,925,850	1.20	1.373	1.528	0.668	0.665	0.37	0.11

Figure A1.9 Percentage of South West Population within 600m of rivers by GQA biology grade



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